Residential Encroachment within Suburban Forests:

Are Ontario Municipal Policies Sufficient for Protecting Suburban Forested Natural Areas for the Long Term?

by

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Abstract

Many natural areas and systems within urban landscapes are small or narrow. Landscape ecology studies within forested and agricultural landscapes have found that small natural areas that are protected from development or resource extraction through land use planning are significantly affected by adjacent land use changes. Some eventually lose the values for which they were protected. Studies also indicate that natural area boundary structures and functions are important determinants of the extent to which external threats affect adjacent natural areas. Few studies have empirically tested whether small or narrow urban natural areas that are protected from development through municipal land use planning are significantly affected by adjacent land use changes. However, municipal planners and forest managers are concerned that activities of residents living adjacent to the forest edge, commonly referred to as residential encroachment, may be degrading the social values, and ecological forms and functions of their woodlands.

Studies have recorded evidence of human impacts within suburban forest edges, indicating that both recreation and yard-related activities are occurring and that these activities occur at significantly higher frequencies in the forest edge than in the interiors of these forests. However, no study has differentiated residential encroachment activities from those of other recreationists. In addition, although a number of municipalities have developed policies to address these activities, little is known about these policies, the extent to which they are implemented, or their effectiveness in protecting their small or narrow forested natural areas from residential encroachment activities. The principal research questions answered in this research are: 1) Do municipalities within Southern Ontario have policies for protecting natural areas from the activities of residents living adjacent to suburban forest edges? 2) To what extent are they implementing these policies? 3) What encroachment activities, if any, are occurring in Southern Ontario municipal forest edges? and 4) Are municipal boundary-related policies effective in limiting edge-resident encroachment activities?

Using a mixed method approach, the research incorporates qualitative and quantitative data collection to answer these questions. The content analysis of official and secondary plans and social surveys of key informants within six Southern Ontario municipalities identify boundary-related policies for protecting municipal natural areas from residential encroachment activities. They also determine the extent to which the study municipalities implement these policies. Field studies in 40 forests within these municipalities used unobtrusive measurements of encroachment behaviour to describe encroachment activities under two implemented municipal boundary demarcation policies, and other boundary treatments The three research methods, together with a literature review, were used to determine whether Ontario municipal policies are effective in limiting edge-resident encroachment activities within municipal forest edges.

The content analysis and interviews indicated that, in general, municipal policies were insufficient to address the edge-resident encroachment issue. Policies had been established, but not at a sufficiently authoritative policy level (i.e. the official plan level) to support their implementation by staff. In addition, policies were missing explicit goals, objectives and strategies to direct their implementation, and the municipalities had not integrated their disparate policy components into an integrated course of action through time and space. The

municipalities were successful in implementing policies to prevent edge resident encroachment within natural areas adjacent to newly developing subdivisions. However, they had infrequently implemented their policies for preventing encroachment within natural areas adjacent to established subdivisions. Furthermore, all the municipalities were not frequently implementing their policies to remediate existing encroachments within natural areas adjacent to newly developing or established subdivisions.

The unobtrusive measurement of encroachment behaviour confirmed that residential encroachment activities generated a housing effect zone of impact within municipal forest edges. The distribution of the evidence of encroachment was significantly biased to the forest border. Encroachment traces were highly prevalent within study forests, occurring in over 94% of sites and covering 26 to 50% of the sampled area. Encroachment traces were particularly intense in the first 8 metres from the forest border; but extended a mean maximum extent of 16 metres from the forest border, with 95% of the evidence of encroachment lying within 34 metres.

Boundary type significantly affected the mean frequency, intensity and maximum extent of encroachment. Mean frequencies, intensities and extents of all encroachment, and of most encroachment categories, were generally higher in sites with boundary types that allowed edge residents ready access to the forest edge. Conversely, sites with boundary treatments that had barriers to entry, such as fences or grass strips, tended to have lower encroachment levels. Sites with multiple barriers, such as those with fences, grass strips and paths, tended to have the lowest mean frequencies, intensities and mean maximum extents of encroachment.

While sites with implemented municipal post and fence policies had significantly lower mean frequencies, intensities and, in the case of fences extents of encroachment, they were not significantly different from those of sites under some of the boundary types not subject to municipal policies. They were also significantly higher than those of sites with fences and grass strips (with or without pathways). Sites with municipal posts had significantly lower mean intensities of encroachment than sites with other boundaries that enabled residents to enter the forest edge, and had significantly lower mean frequencies of waste disposal traces than fenced sites. Sites with fences also had significantly lower mean intensities of encroachment than sites with no boundary demarcation, or sites with fences and gates, and were particularly effective in reducing the incidence of yard extension encroachments, and mean maximum extents of encroachment. Despite the effectiveness of these boundary demarcation policies, and that of some of the other boundary treatments evaluated, none of the boundary treatments was effective in eliminating encroachment traces. A buffer of between 10 and 20 metres in width would be required to segregate the mean maximum extent of encroachment activities from sensitive forest edges, depending on the boundary demarcation policy, or type.

The research concludes that current municipal policies are insufficient to meet the complexity and scope of the encroachment activities occurring. Some preventative policies have been developed and are regularly implemented within natural areas adjacent to new subdivisions. However, implemented boundary demarcation policies are insufficient to eliminate, or minimize residential encroachment. Wider more complex boundary policies that limit different types of encroachment and include elements that reduce access, spatially separate, and encourage informal residential surveillance (such as fences, grass strips and pathways) can further reduce

encroachment levels. Few municipalities have established boundary demarcation policies to prevent encroachment within natural areas adjacent to established subdivisions, and study municipalities infrequently implement policies and bylaws to mitigate existing encroachments within these areas. Yet interviewees, and the results of the unobtrusive measurement of encroachment in study forest edges, indicate that encroachment activities are highly prevalent within these municipal forests. Policies at all levels, and particularly at the official plan level, are required to protect natural areas from edge resident encroachment, and other forms of post development impacts on natural areas. These policies are required to support the more rigorous enforcement of encroachment bylaws, and the negotiation, and implementation of effective buffers and boundary demarcation treatments. In consideration of these results and conclusions, the dissertation describes the implications for municipal planning policy and urban and regional planning theory, and provides recommendations for future research.

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Dedication

This dissertation is dedicated to my husband, Rory McWilliam. Words cannot express the vital role you have played in the completion of this difficult journey. I could not have done it without your constant support, encouragement and enthusiasm.

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Chapter 1
Introduction

1.1 Problem Statement

Many natural areas and systems within urban landscapes are small or narrow. Landscape ecology studies within forested and agricultural landscapes have found that small natural areas that are protected from development or resource extraction through land use planning are significantly affected by adjacent land use changes (Forman, 1995). Some eventually lose the values for which they were protected (Murphy, 2006).

Municipal planners and forest managers are concerned that activities of residents living adjacent to the forest edge, commonly referred to as residential encroachment, may be degrading the social values, and ecological forms and functions of their woodlands (D. Schmitt, City of Kitchener and T. Fleischmann, City of Mississauga, personal communications, August 30 and September 7, 2005, respectively). Studies have recorded evidence of human impacts within suburban forest edges, indicating that both recreation and yard-related activities are occurring and that these activities occur at significantly higher frequencies in the forest edge than in the interiors of these forests (Matlack, 1993). However, no study has differentiated residential encroachment activities from those of other recreationists. In addition, although a number of municipalities have developed policies to address these activities, little is known about these policies, the extent to which they are implemented, or their effectiveness in protecting their small or narrow forested natural areas from residential encroachment activities.

1.2 Research Questions and Objectives

This dissertation will answer four research questions by achieving five research objectives:

1.2.1 Research Questions

1) Do municipalities within Southern Ontario have policies for protecting suburban forest edges from the activities of adjacent residents?

2) To what extent are they implementing these policies?

3) What encroachment activities, if any, are occurring in Southern Ontario suburban forest edges?

4) Are boundary-related policies effective in limiting edge-resident encroachment activities in Southern Ontario suburban forest edges?

1.2.2 Research Objectives

1) To describe the theory of boundary planning and management, and Ontario municipal planning theory and practice, for protecting suburban natural systems from adjacent land use impacts (Chapters 3 and 4).

2) To describe municipal concerns, goals, strategies, and policies for addressing edge resident encroachment and to determine their level of and barriers to implementation within selected municipalities within Southern Ontario (Chapter 5 and 6).

3) To investigate the evidence of edge resident encroachment activities within selected Southern Ontario municipal suburban forest edges under two different implemented municipal boundary demarcation policies and other boundary treatments (Chapter 7) by:

   3.1 determining if edge resident encroachment is occurring,
   3.2 identifying the types of residential encroachment activities,
   3.3 calculating the relative frequency and intensity of encroachment activities; and
   3.4 measuring the maximum distance of encroachment from the forest border

4) To evaluate whether municipal boundary-related policies are effective in limiting undesirable edge-resident encroachment activities, and therefore in protecting small or narrow forested natural areas from this form of incremental adjacent land use impact (Chapter 8).

5) To discuss the implications of the research for municipal planning and management for the protection of suburban natural areas and systems from adjacent land use impacts (Chapter 9).

1.3 Organization of Dissertation

This dissertation contains eight chapters. Chapter two describes the study municipalities, and the research design and methods. Chapter three provides a literature review of 1) the structural and functional role of boundaries in ecological communities, highlighting its vital role in natural systems protection from adjacent land use impacts, 2) the human activities and their effects on forest ecosystems and conversely, the effects of forest ecosystems on adjacent residents, and 3) strategies and tools for limiting adjacent land use impacts and the effects of human activities on ecological communities. Chapter four provides a literature review of municipal planning theory and practice for protecting suburban natural systems in Southern Ontario. Chapter three and four fulfill the first objective of this research. Chapter four describes the policies contained within official and secondary plans aimed to protect natural areas and systems from encroachment. Chapter five deals with municipal residential encroachment policies, their implementation, and barriers to implementation, as described by key informants within the municipalities. Chapters four and five satisfy objective two. Chapter six outlines and discusses the results of the unobtrusive measurement of residential encroachment activities within the study areas. It focuses on the types, frequency, intensity and extent of residential encroachment activities under different municipal policies and boundary treatments and fulfills objective three. Chapter seven evaluates the municipal policies for limiting residential encroachment activities, through a consideration of the literature, the content analysis, the municipal interviews, and transect and quadrat sampling of residential encroachment activities. Chapter eight fulfills objective four. Chapter nine discusses the implications of the findings of this research for municipal planning policy and urban and regional planning theory, thus fulfilling the fifth and final objective of this dissertation research.

Chapter 2

Study Municipalities, Research Design and Methods

This chapter describes the research design and methods employed to achieve the research goals. Section 2.1 describes the study municipalities. Section 2.2 explains the mixed method of research design. Section 2.3 outlines the protocols used in the qualitative studies and Section 2.4 outlines the protocols used in the quantitative unobtrusive measurement of encroachment behaviour.

2.1 Study Municipalities

The local municipalities of Cambridge, Guelph, Kitchener, Mississauga, Oakville and Waterloo were chosen for this research. Initial contact with these municipalities indicated many had established, or were in the process of developing, policies to limit residential encroachment. In addition, all of these municipalities had areas of low density, single-family detached housing adjacent to their municipal forests from which to choose sampling sites.

Most of these municipalities are mid-size cities with populations ranging between 100,000-200,000 people. The exception is Mississauga, which has a population of approximately 700,000 and is one of Canada's largest cities. They are located within, or just west of, the Greater Toronto Area of Southern Ontario. Oakville lies within the Region of Halton. Mississauga lies in the Region of Peel. Guelph is a single-tiered municipality and Cambridge, Kitchener, and Waterloo are located in the Region of Waterloo (Figure 2.1).

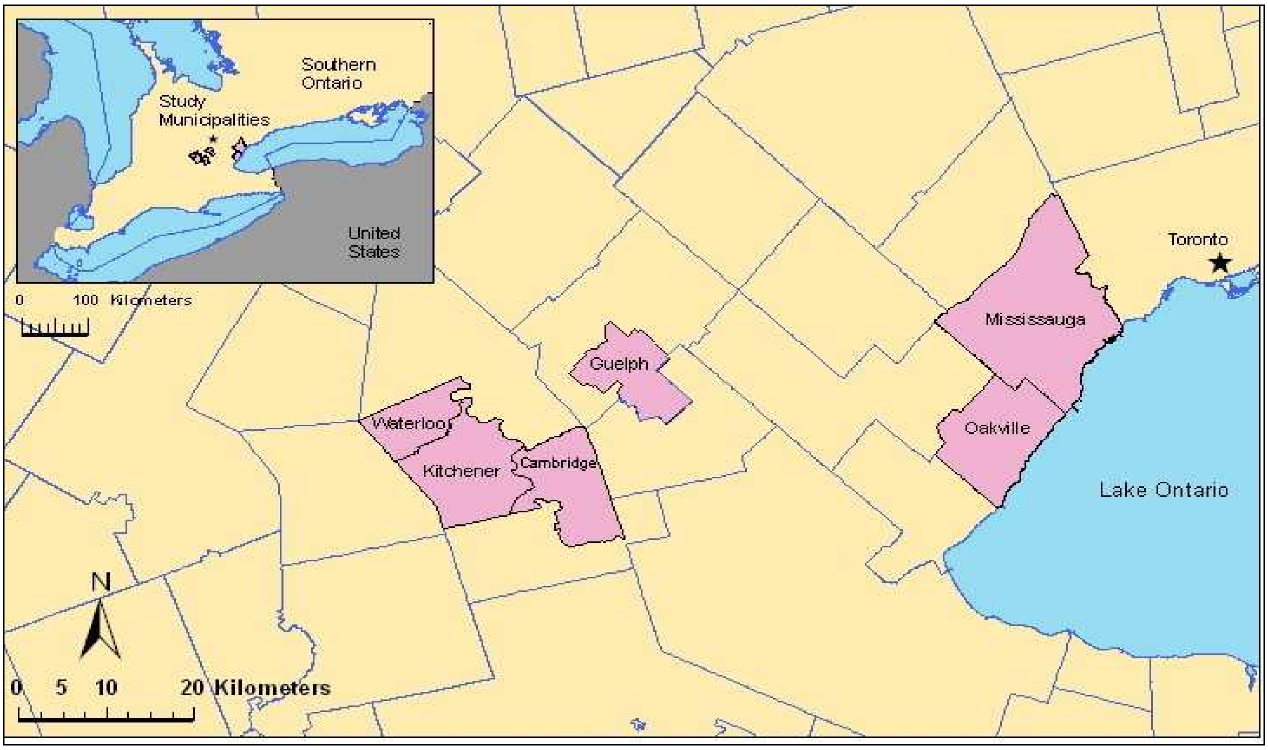


Figure 2.1 Study municipalities in Southern Ontario, Canada
(Source: (Ontario Ministry of Natural Resources, 2002))

Over the last approximately 50 years, these municipalities have accommodated growth primarily through the planning of new low-density residential neighbourhoods, industrial, or commercial lands, at the edges of their cities. Through land use planning, they were successful in protecting from development larger and more connected natural areas and systems within their municipal fabrics. However, they also developed many natural areas, and much of the surrounding agricultural land, into housing. This development pattern led to many significant economic, social and other environmental problems. These include high levels of pollution, traffic congestion, social isolation and costly municipal infrastructure systems.

Most of the land within many of these municipalities is now developed. However, the Ontario government predicts that these communities will experience high residential and employment growth within the next 25 years (Ministry of Public Infrastructure Renewal, 2006). Many of these municipalities expect an increase in their populations of between 30 and 50 percent over this period (Statistics Canada, 2002). To accommodate this growth, and to reduce the negative impacts of the previous pattern of development, these municipalities are developing new planning strategies that stress densification. At the same time, over the last approximately 15 years, planning exercises such as that involving the Oak Ridges Moraine north of Toronto, have indicated that more land, or less intensive land uses, adjacent to key ecological systems, may be required to support municipal ecological functions. While specific nodes and corridors within these municipalities are to accommodate 40% of the expected population growth, 60% is to be accommodated through the development of the remaining greenfields on the edges of these municipalities (Ministry of Public Infrastructure Renewal, 2006). These municipalities face the challenge of accommodating intensified development, while protecting natural areas and systems in both developed areas and in greenfields.

2.2 Research Design

This research employed a mixed-method design to achieve its goals and objectives. A mixed-methods design incorporates both quantitative and qualitative methods of data collection and analysis (Creswell, 2003). This design provides a better understanding of the encroachment issue. Quantitative research can reveal broad numerical trends and qualitative research can uncover rich detail regarding an issue (Creswell, 2003). Concurrent procedures integrated these quantitative and qualitative methods. A concurrent procedure is one in which 'the researcher converges the quantitative and qualitative data in order to provide a comprehensive analysis of the research problem' (Creswell, 2003). The researcher collects the data at the same time and then integrates the results of both studies at the end of the research period to answer the research question (Creswell, 2003).

In this research, I conducted personal interviews with key informants and a content analysis of official and secondary plans within the study municipalities. The results of the two qualitative methods were integrated to accomplish objectives two through five of the research. The quantitative methods unobtrusively measured human behaviour via measuring tape, and quadrat and transect sampling. They measured the relationship between municipal boundary demarcation policies and the incidence of encroachment activities in municipal forest edges. This accomplished objective six. The results from the literature review, and the qualitative and quantitative studies were then integrated to evaluate the effectiveness of municipal policies for limiting undesirable edge resident encroachment activities and accomplished objective four. Table 2.1 summarizes the steps and methods for accomplishing the objectives of this research.

Table 2.1 Steps and methods for evaluating municipal policies for limiting residential encroachment

Steps	Methods	Comments
Describe the theory of boundary planning and Ontario municipal planning theory and practice, for protecting suburban natural systems from adjacent land use impacts.	Literature Review	Objective 1, Chapters 3,4
Describe municipal concerns, goals, strategies and policies for addressing edge resident encroachment and determine their level of, and barriers to, implementation within selected municipalities within Southern Ontario.	Integrate results of content analysis and social surveying	Objective 2 Chapters 5,6
Determine if residential encroachment is occurring within municipal forest edges, and describe it under two different municipal boundary demarcation policies and other boundary demarcation types.	Conduct the unobtrusive measurement of behaviour in municipal forest edges	Objective 3, Chapter 7
Determine whether study municipality encroachment policies are sufficient for protecting suburban forests from edge resident encroachment activities.	Integrate results of literature review, content analysis, interviews and the unobtrusive measurement of behavior	Objective 4 Chapter 8
Discuss implications for municipal natural area planning and management.	Integrate results of literature review, content analysis, interviews and the unobtrusive measurement of behavior	Objective 5 Chapter 9

2.3 Qualitative Methods

Two qualitative research methods were chosen to meet these objectives because they combined to give a comprehensive profile of study municipality views, goals, objectives, strategies, policies and their implementation. The social surveys via long interviews with key informants provided an in-depth view of how municipal staff perceived encroachment and their understanding of encroachment policies and policy implementation. Qualitative methods of research are beneficial when little is known about a phenomenon (Creswell, 2003). However, this method has two drawbacks, 1) interviewees may not be aware of their municipal policies, or may not mention them in an interview; and 2) interviewers can unintentionally influence the responses of interviewees (Creswell, 2003). A content analysis of official and secondary plans increased the reliability of the results, and ensured the review of the most authoritative municipal policies.

Interviewees and official and secondary plans frequently referred to the terms ‘goal’, ‘objective’ and ‘policy’ interchangeably. In order to compare goals, objectives and policies within the study municipalities, the terms were defined according to Hodge (2003). A goal defines a general long-term direction for progress that is frequently difficult to measure. In contrast, an objective is a measurable target indicating that the goal has been achieved (Hodge 2003). Strategies are broad conceptual approaches to planning, design or management of a resource to achieve a desirable goal (Manning, 1979b). A policy is the course of action chosen to achieve an objective, or strategy (Hodge, 2003).

There is a hierarchy of policies within the study municipalities. Interviewees within the study municipalities applied different terms to these policies, or courses of action. In this dissertation, the following definitions apply. The policies that have the highest authority are official and secondary plan policies. The municipal council, and the regional and/or provincial governments, approves them. The second most authoritative policies are other municipally-approved policies (referred to here as corporate policies) that are not within official plans, nor approved by regional and/or provincial governments. Some of these policies are secondary plan policies not found within official plans. The third type of 'policy' is established by departments to implement official or corporate policies. They have even less authority than corporate policies because municipal councils do not approve them. They are one of two types. Departmental procedures are policies that are written, approved by a department, and regularly implemented. Departmental practices are unwritten policies, irregularly applied according to the discretion of individuals, or groups of individuals, within a department. A condition of development is still another type of policy that is development-specific. Planners negotiate these policies with developers. They are authoritative in terms of a specific development since they are passed by council, and are legal requirements that a developer must fulfill prior to subdivision release. Subdivision release occurs when the municipality deems that a developer has fulfilled all requirements outlined within the plan of subdivision approval. Municipalities also enact by-laws to implement policies, and sometimes develop bylaws instead of corporate policies. Similar to council-approved policies, bylaws state a course of action that municipalities may carry out under specific circumstances (Estrin & Swaigen, 1993). However, some suggest that bylaws are more authoritative than policies because municipalities can enforce them within a provincial court of law (Estrin et al., 1993).

2.3.1 Content Analysis of Official and Secondary Plans

Content analysis is the systematic analysis of recorded human communications (Babbie, 2001). It is concerned with discovering repeated themes or patterns and meanings (Del Balso & Lewis, 2001). It is an unobtrusive form of data collection because the researcher can study a phenomenon without influencing it.

A content analysis of natural heritage policies of the most recent official plans, and of some of the most recent secondary plans of the six study municipalities was performed. Secondary plans for review were selected by asking planners within each municipality to identify a secondary plan that exemplified their most recently developed natural area policies. The Doon South Community Plan (City of Kitchener, 2003) along with the accompanying Doon South Community Greenspace Plan (City of Kitchener, 2003) were reviewed for Kitchener. The Laurelwood Secondary Plan (City of Waterloo, 2004) was reviewed for Waterloo. In addition, the policy recommendations of the Forbes Creek Watershed Plan for the secondary plan of North Hespeler (Planning & Engineering Initiatives, 2002) were reviewed as recent secondary plan policies in Cambridge. Planners in Cambridge argued that the secondary plan for North Hespeler was unavailable for review, and that Cambridge had incorporated most of the recommendations of the Forbes Creek Watershed Plan into the North Hespeler Secondary Plan (J. Kirchen, City of Cambridge, personal communication, December 11, 2006). Secondary plans for Guelph, or Mississauga were not reviewed because their municipal planners argued that their official plan policies were representative of their most recently developed natural area policies (S. Hannah, City of Guelph, and M. Bracken, City of Mississauga, personal communications, December 8, 2006). In addition, a secondary plan for Oakville was not reviewed because the development planner argued their most recent secondary plans were not yet available for review, and their official plan policies accurately reflected the environmental policies within their previously developed secondary plans (R. Thun, City of Oakville, personal communication, November 21, 2006).

All of the analysed local and regional official plans pre-dated the Ontario Provincial Policy Statement (PPS) (2005) and most of the municipalities were in the process of amending them. They are not expected to have policies that are fully consistent with the PPS (2005). Municipal official plan policies generally reflect economic, social and environmental conditions just prior to their initial approval, however, municipalities must amend their official plans to be consistent with changing provincial and regional policies. All of the municipalities incorporated amendments to their official plans up to at least 2004. Table 2.2 lists the reviewed official and secondary plans, along with the year in which council first approved the plan. However, the date given for the Region of Waterloo Official Plan reflects when the Ontario Ministry of Municipal Affairs first approved it.

Table 2.2: Official and secondary plans reviewed in the content analysis

Local Municipal Secondary Plans	Local Municipal Official Plans	Regional Official Plans
Forbes Creek Subwatershed Plan 2002	Cambridge 1997[1] (2004)	Waterloo 1997 (1998)
Doon South Secondary Plan 2003	Kitchener 1995 (2005)	Waterloo 1997 (1998)
Laurelwood Secondary Plan 1993	Waterloo 1990 (2004)	Waterloo 1997 (1998)
	Guelph 1994 (2005)	(Single Tier - no regional government)
	Mississauga 2003 (2006)	Peel 1996 (2005)
	Oakville 1983 (2004)	Halton 1994 (2004)

2.3.1.1 Coding System

A coding system is a set of rules that establishes a method for systematically breaking down a recorded communication so that the person using the code can distinguish the meaning of the communication from the text. (Del Balso et al., 2001).

The coding system used to analyze the natural heritage policies in this research reflects the context of municipal natural heritage policy development. Provincial, regional and municipal governments have established policies for the protection of natural areas, and their immediately adjacent land uses. More recently, the provincial government has established policies to support some of the ecological functions of natural systems. In practice, the authority of these policies, or the degree to which municipalities comply with them, decreases with the level of government. Provincial policies are within the Ontario provincial policy statement (PPS) under the *Ontario Planning Act*, while regional and municipal policies are within their respective official plans. The municipalities are required to develop policies within their official plans that implement those of both their regional and provincial governments. In addition, plans containing more detail (e.g. details regarding land use, traffic, facilities and visual design) than the official plan, are sometimes prepared for special areas of municipalities (Hodge, 2003). Municipalities refer to these plans as secondary, district or community plans. Within this dissertation, these latter plans are referred to as "secondary plans." Some municipalities, such as the local municipality of Waterloo, incorporate their secondary plan policies into their official plans. When secondary plans are part of the an official plan, their policies only apply to their planning area and take precedence over official plan policies within these areas. The official plan policies; however, dictate a course of action for all other areas within the municipality. Some municipalities, such as Cambridge, establish these secondary plans outside their official plan. These latter policies operate more like planning guidelines than official plan or corporate policies. They do not have the legal force of those developed within an official plan (Estrin & Swaigen 1993).

Given the importance of this context for determining municipal policy content and implementation, the municipal policies were analyzed according to their level of compliance with their most recently approved provincial and regional policies. This allowed the comparison of municipal policies within the study municipalities according to a standardized set of rules.

Municipal policies were analysed for compliance with the policies within the PPS (2005) rather than those of the PPS (1997) because the policies of the PPS (2005) represent the latest evolution in natural areas and systems policies in Ontario at the provincial level. The PPS (2005) policies dealing with water have undergone significant enhancement relative to those of the PPS (1997). Together with natural heritage policies, they address the protection of current and future ecological functions of linked terrestrial and aquatic ecosystems, rather than just the features or functions of individual natural areas. Furthermore, these policies reflect a shift in focus from the features and functions of natural areas, to those of their adjacent ecosystems.

In recognition of the integration of natural heritage and water policies, the content analysis addresses both sets of policies within the municipalities. The coding system divides the policies into two categories: natural heritage areas and hydrological functions. The natural heritage areas category largely contains policies that relate to preserving and protecting terrestrial systems, while the hydrological functions category contains policies related to ground and surface water and their interconnections with terrestrial systems. Provincial or regional policies pertaining to hydrological features, such as wetlands and valleylands, were classified as hydrological function policies. There is some overlap between the two categories. For example, some provincial Areas of Natural and Scientific Interest (ANSIs) are primarily terrestrial without a significant hydrological function, while others play an important hydrological function. Both types, however, were included within the natural heritage areas policies category. Similarly, biodiversity policies were included within the natural heritage areas category even though policies included under hydrological function also determine biodiversity.

Within each of these categories, I classified policies further into three groups: basic, enhanced, and pathfinder policies. The Best Policies Working Group (1999) first classified policies in this way. They classified regional municipality policies based on their level of compliance with policies of the PPS (1997) (Best Policies Working Group, 1999). However, the required level of compliance to these policies was open to interpretation. The Best Policies Working group classified regional policies as basic if they met what the group considered the minimum provincial policy requirements. They included regional policies that are limited to implemented provincial policies 2.3.1 a, and 2.3.1b which deal with fish habitat and ANSIs (Best Policies Working Group, 1999). Enhanced policies incorporated the full range of provincial policies and those that protected regionally or locally significant areas. Pathfinder policies incorporated all of the above, in addition to regional policies not mentioned within the provincial policies.

The content analysis of this research interpreted the required policy compliance to provincial and regional policies differently than that of the Best Policies Working Group. Basic policies are defined as those that are required by regional or provincial governments, i.e. those that respond to provincial or regional policies that use words such as, ‘shall not be permitted’ or ‘shall protect, improve and restore.’ Enhanced policies respond to those suggested by either the provincial or the regional governments, i.e. those that respond to provincial or regional policies that use words such as, ‘should be,’ or 'are encouraged to.' Pathfinder policies included policies of the local municipalities that were neither required, nor suggested, by the provincial or regional governments.

The province has not defined what areas or systems constitute provincially significant woodlands, wildlife habitat, or valleylands in the PPS (2005). Therefore, I assumed that natural areas that fulfill these designations are missing from the official plans of the local municipalities.

In some instances, it was difficult to ascertain policy compliance due to the wording of the policy. The policy may indicate an intention to comply with an upper level policy, rather than indicating how it will comply. For example, the province requires municipalities to implement the ‘necessary restrictions on development and site alteration to protect all municipal drinking water supplies’ (Ontario Ministry of Municipal Affairs and Housing, 2006). A municipality may have a policy that states that it will implement restrictions on land use to protect drinking supplies, but provide no policies that specify the land use restrictions. This gets into the issue of the specificity of policies, which is beyond the scope of this review. In these cases, I assumed that the municipality has fulfilled the policy requirement even though the policy is not yet at a level of detail necessary to implement the upper level policy.

2.3.2 Social Surveying: Interviews

Social surveying involves collecting data from a sample to describe the characteristics, attitudes and orientations of a population (Babbie, 2001). Interested parties constituted the population of the social survey. Interested parties are defined as those who participate in, and are affected by, the formulation and implementation of policies (Stein, Anderson, & Kelly, 1999).

2.3.2.1 Interview Design

The instrument for conducting the surveys was the personal interview. They have a high response rate and they allow the interviewer to clarify questions and probe further into issues (Del Balso et al., 2001). However, this method is also time-consuming to analyze and the personal biases of the interviewer may unintentionally influence the answers of the respondents (Del Balso et al., 2001). To limit this bias, the interviewer must identify her own understanding and prejudices and maintain the detachment necessary to collect the data properly without influencing it (McCracken, 1988). Prior to and during the interview period, I conducted some of the environmental sampling and the literature review surrounding the possible effects of edge-resident encroachment activities and the strategies and tools for limiting these effects. This provided some insight into the encroachment issue, including ideas for strategies and tools for limiting it within forests. This prior experience influenced my judgment on the selection of questions. To address this, a member of my research committee reviewed the questionnaire for bias. In addition, I conducted an interview with the environmental planner from the City of Burlington (an interested party from a non-participating municipality) to pilot the questions and provide feedback on possible bias.

The interview design was semi-structured. This design involves asking a number of pre-determined questions in a systematic order (Frankfort-Nachmias & Nachmias, 1992). The semi-structured design has the advantage of allowing the interviewer to probe beyond the initial questions to explore further into any issue raised by the respondent (Berg, 1995). Questions asked in the interviews conducted in this research were mostly open-ended. Open-ended questions allow respondents to answer in their own words and to express whatever they feel is most important (Del Balso et al., 2001). Some closed-ended questions were also asked. These questions are easier for respondents to answer, and for the interviewer to compare and subsequently analyze (Del Balso et al., 2001). Open-ended questions were asked before related closed-ended questions so that the open-ended questions would not bias the closed ended questions (Jackson, 1999). Appendix A provides the interview guide.

2.3.2.2 Data Collection

Individuals were chosen non-randomly, through purposive and snowball sampling methods. Purposive sampling involves selecting whoever the researcher judges has the characteristics to meet the requirements of the research (Jackson, 1999). Snowball sampling identified other interested parties. This method involves asking respondents to recommend other potential interviewees (Babbie, 2001). The interview sample consisted of those judged knowledgeable and sufficiently experienced in their respective areas. Interviewees had an average of 14 years experience in their areas of expertise. The identification of participants within each municipality stopped when the answers began to become repetitive, indicating that saturation for that municipality had occurred. Through these methods, interviewees were selected from six main groups within the municipalities: 1) development planners, 2) environmental planners, 3) park planners, 4) forest and park managers, 5) bylaw enforcement managers and 6) municipal real estate managers. People from all groups were not interviewed within each municipality because individuals from one group sometimes participated in the activities of other groups. In addition to these interviewees, three planner consultants and the property manager from the GRCA were interviewed.

The University of Waterloo office of research ethics granted ethics approval. Potential participants were contacted by telephone to introduce the research, seek their agreement to participate and set up initial meetings. The telephone call was followed by an e-mail outlining the research in more detail and providing information related to ethics clearance. The email stated that none of the information collected in the interviews would be considered confidential, and that the names of the municipalities, and photographs of municipal forest edges may be published. The objectives of the initial meeting were: 1) to answer any questions regarding the research; 2) to explain the format of the interview; 3) to outline information about consent, and obtain a signed agreement from the municipality to participate; 4) to obtain written permission to take photographs of the forest edge; 5) to find out what, if any, encroachment policies had been implemented within municipal natural areas; and 6) to obtain suggestions for possible quantitative study areas. All participants were reassured that participation in the interviews was voluntary.

Twenty-six interviews were conducted between August 30th and December 6th, 2005. Interviews were conducted in person with 25 of the interested parties. Interviews lasted an average of approximately 70 minutes in length. The interviews were taped with the participant's consent. One interview was conducted over the telephone. It lasted about 20 minutes and notes were taken. This interviewee did not have the time to participate in the full interview, so questions were limited to his area of expertise in relation to residential encroachment. Tapes of the interviews were transcribed. Most participants were not interested in reviewing or verifying copies of the transcripts. However, some of the participants were contacted during data analysis and asked for additional information. Interviewees are referenced in Chapter 5 according to a code to preserve the interviewee's anonymity. Two letters and a number make up the code, for example EP1(Environmental Planner, number 1). Table 2.3 provides the meaning of the first two letters in the codes that specify the role of the interviewee in the municipality. The number represents the individual within that role interviewed.

Table 2.3 Key to interviewee codes

Code	**Role within the municipality**
EP	Environmental Planner
DP	Development Planner or Development Manager
PP	Parks Planner or Landscape Architect
FM	Forest or Park Manager
PM	Property Manager
BE	Bylaw Enforcement Officer or Manager
PC	Planner Consultant

2.3.2.3 Data Analysis

The data was analysed repeatedly for themes and sub-themes of related information. In addition, the extent to which study municipalities were implementing their encroachment policies was analysed. In this dissertation, implementation involves taking a policy and putting it into action so that the goals or intent (where there are no explicit goals) of that policy are met (Pressman & Wildavsky, 1973). Factors affecting implementation were identified according to Mitchell et al. (1997). They identify seven factors that may affect the implementation of encroachment policies: 1) tractability (resolvability of the encroachment issue), 2) clarity of policy goals, 3) commitment of those implementing policy, 4) means of implementing policy, 5) access to information, 6) cause-effect relationship assumptions, and 7) the dynamics involved in the enforcement of the policy (Mitchell, 1997).

2.4 Quantitative Methods

The unobtrusive measurement of behaviour was the quantitative method of data collection. The method uses physical evidence of human activity to reveal information about a phenomenon (Del Balso et al., 2001). It is commonly employed by industrial archeologists to study human technological activities through the examination of the waste products of technological processes, physical changes to the landscape, or abandoned structures or tools (Del Balso et al., 2001). In this research, this method involved recording evidence of edge-resident encroachment activities within municipal forest edges. The purpose of recording and analyzing this evidence was to determine the degree to which municipal boundary demarcation policies were effective in limiting residential encroachment. Boundary demarcation policies designate the property boundary between the municipal forest and private residences. Their effectiveness was evaluated by answering the following questions: 1) are residential encroachment activities occurring within municipal forest edges under implemented boundary demarcation policies and alternative boundary demarcation treatments? 2) what types of residential encroachment activities are occurring? 3) what is their relative frequency and intensity within study municipality forest edges? and 4) what is the maximum distance from the property boundary of encroachment activities within the forest edge?

The population for this quantitative research was the edge of deciduous and mixed municipally owned forests immediately adjacent to suburban housing subdivisions. Forests rather than other types of natural areas were selected because they are sensitive to human activity impacts (Bratton, Stromberg, & Harmon, 1982; Cole & Marion, 1988). In addition, municipal interviewees indicated that they were most concerned about encroachment activities within their forests (J. McNeil, City of Oakville; D. Schmitt, City of Kitchener; and T. Fleischmann, City of Mississauga, personal communications, September 27, 2004; July 15, 2004; and September 1, 2004, respectively). The unit of analysis was the study site, defined as the forest edge immediately adjacent to the private property boundary of one residence.

2.4.1 Site Selection Criteria

Site selection criteria were established, and study sites selected, through a combination of a review of the literature, electronic and paper maps, initial meetings with municipal interviewees, and potential study site visits.

2.4.1.1 Municipal Boundary Demarcation Policy Selection Criteria

Initial meetings with interviewees indicated that currently implemented municipal boundary demarcation policies consisted of fences (no gates), living fences (with or without municipal boundary posts), boundary posts, or fences with a naturalized buffer (limited largely to stream corridors, and other ‘significant’ natural areas). "Living fences" are relatively wide planted borders that, when established, may form a physical vegetative barrier between the residence and the municipal forest. Buffers, as defined by the study municipality interviewees, are areas of forest or areas naturalized to forest, between a designated natural area and private property boundaries.

A search for study sites with these implemented policies revealed many potential study sites with an implemented municipal fence policy. The majority were in Oakville where a fencing policy had been implemented since the mid 1980s. In addition, there were a few study sites, in Waterloo and Kitchener, where municipal boundary posts were implemented. Few other study sites were found with implemented boundary demarcation policies that met forest and subdivision site criteria. Most municipalities had implemented current boundary demarcation policies within the last 5 to 10 years, and site visits indicated that many of these sites were too newly implemented to allow their encroachment traces to be compared with those of older sites. However, site visits revealed many potential study sites where residents had established their own boundary demarcation treatments. In still others, boundary treatments consisted of municipal mown grass strips, with or without pathways, sometimes in concert with residential boundary treatments, or municipal fences. The municipal grass strips and paths were implemented in fulfillment of recreation policies, or to manage utility corridors.

Therefore, sites with the two implemented municipal policies, fence and municipal post were sampled, in addition to eight other boundary demarcation treatments implemented by residents and/or municipalities. This approach was taken because it resulted in a larger number of sites sampled within the maximum number of municipalities for each municipal policy, and expanded the number of alternative boundary treatments evaluated. These ten boundary demarcation treatments are listed in Table 2.4 according to whether they resulted from: 1) a municipal encroachment policy, 2) a resident and/or municipal boundary treatment unrelated to encroachment, or 3) a combination of municipal encroachment policy with resident or municipal boundary treatment unrelated to encroachment. See Section 2.4.3 for a summary of the number of study sites by policy, boundary type and municipality.

Table 2.4 Evaluated boundary demarcation treatments

Boundary Demarcation Treatment	Ownership of sites sampled
Municipal Encroachment-related Policies	
1) fence	Municipal or resident
2) Municipal post	Municipal
Resident or unrelated municipal boundary treatments	
1) no or minimal boundary demarcation	Resident
2) grass strip	Municipal
3) grass strip and path	Municipal
4) fence with gate	Resident (or municipal fence, resident gate)
5) fence with gate and grass strip	Resident fence with gate; municipal grass strip
6) fence with gate, grass strip and path	Resident fence with gate; municipal grass strip and path
Municipal Policies with unrelated municipal boundary treatments	
1) fence with grass strip	Municipal fence policy; municipal grass strip
2) fence with grass strip and path	Resident fence or municipal fence policy; municipal grass strip and path

[1]e.g. small rocks or flowerbed

2.4.1.2 Forest and Subdivision Selection Criteria

To ensure sufficient time to allow for residential encroachment, adjacent housing to the forests and their boundary treatments, had to be at least 10 years old. This criterion was based on an average subdivision construction time of five to seven years and research demonstrating maximum intensities of the most visible effects of camping activities (pedestrian trampling, and the hacking and removal of vegetation) within two to five years (Cole, 1987). The chosen housing form was relatively uniform; it had to be either single or semi-detached without shared backyards. Similarly, lot widths were limited to between 10 and 40 metres. The backyard depth could also influence encroachment, particularly where minimal. Nevertheless, backyard depth was not limited in the study sites because this would have significantly restricted their number.

To avoid overlapping encroachment within sites sampled intensively, the study site had to be a minimum of 20 metres in depth if no development existed on the opposite side of the forest, and a minimum of 40 metres in depth if development was present (see Section 2.4.2 and 2.4.2.1 for a description of the intensive sampling methods). This minimum depth responds to results of the pilot study that indicated that the vast majority of edge-resident encroachment occurred within 20 metres of the property boundary (see Section 2.4.2 for a description of the pilot study). Authorized recreational trails had to be located a minimum of five metres away from intensive study areas to avoid overlapping encroachment associated with community trail use. Research indicates that the area of impact associated with recreational trail use is approximately five metres (Cole, 1981). This was the basis for this criterion.

For sites sampled extensively, a larger minimum study site depth than the intensive study was established to reduce the risk of site depth limiting the extent of encroachment occurring (See Section 2.4.2.2 for a description of the extensive sampling method). These sites had to be a minimum of 50 metres in depth, and 100 metres if development was present on the opposing edge. For these sites, authorized recreational trails did not have to be located a minimum of five metres away from the study area since this would have significantly limited the number of extensive study sites.

All study sites had to have minimal natural barriers that might influence encroachment behaviour. Natural barriers to encroachment are site conditions that might deter a resident from entering the forest edge, such as steep topography, poorly drained soils, ditches, poisonous plants, or an abundance of biting insects. Side canopy closure may serve as a natural barrier to encroachment. For example, closed side canopies may deter residents from entering the forest border. However, sites with closed side canopies were not excluded because this would have significantly limited the number of potential study sites from the study. In addition, there is some evidence that closed side canopies do not significantly impede human activities in forest edges (Matlack, 1993). Study sites could not be adjacent to forest entry points because residents in the wider community, in addition to edge residents, may have conducted encroachment activities within these areas.

Grass strips associated with study areas had to have a maximum width of 50 metres because the pilot study indicated that after approximately 50 metres it was difficult to associate adjacent residences with the encroachment traces. Naturalizing grass strips with long grass, shrubs or trees may serve as a barrier to encroachment activities, so the criteria was established that grass strips had to be mown at least once per season.

2.4.2 Field Methods

The methods for sampling the evidence of edge-resident encroachment activities within municipal forest edges were refined during a pilot study during summer 2004. The pilot study sampled forest floor components using a quadrat/transect sampling method within several study sites with different boundary demarcation treatments. Recreation ecology research commonly measures the impacts of recreational trampling on vegetation communities using quadrats (or sample frames) and/or transects (sample lanes). This sampling method requires the researcher to visually estimate the percentage of vegetation coverage, height, bare ground cover, or the cover of individual vegetation species, within the quadrat and/or transect.

Within this research, for each quadrat sampled, the pilot study recorded the percentage cover of each forest floor component visible at 30 cm above the ground, according to the Braun-Blanquet cover scale (Braun-Blanquet, 1932). The scale assigns a number, or code, to each forest floor component, depending on its percentage cover of the quadrat (Table 2.5). Data entry charts were developed during the pilot study to record the percentage cover for each type of encroachment (encroachment traces), in addition to that of the other forest floor components (Appendix B).

Code	Scale
0	0 %
1	> 0 - 1%
2	> 1 - 5%
3	6 - 25%
4	26 - 50%
5	51 - 75%
6	76 - 100%

Table 2.5 Braun-Blanquet (1932) Cover Scale

The pilot study revealed that the vast majority of encroachment traces were within 20 metres of the private property boundary, but that more sparsely distributed traces were still occurring beyond this point. To maximize the number of study sites sampled given the time and research funds available, two sampling methods were developed to achieve the research objectives. An 'intensive sampling method' used quadrat and transect sampling to sample the first 20 metres to determine whether encroachment activities were occurring, their type, relative frequency and percentage cover of the forest floor. An 'extensive sampling method' was also developed to sample the more sparsely distributed evidence of encroachment activities located furthest from the property boundary to determine the extent of encroachment. Sections 2.4.2.1 and 2.4.2.2 describe the two sampling methods.

2.4.2.1 Intensive Sampling Method

The quadrat and transect sampling method described above was used to sample the more intensively distributed encroachment traces located within approximately 20 metres of the property boundary of a residence. Within the pilot study, different boundary demarcation policies were sampled using different numbers, and sizes of quadrats along varying numbers of transects into the forest edge. A sampling design was developed to effectively record the different patterns of encroachment traces occurring under different boundary demarcation treatments, in the least amount of sampling time. The design consisted of eleven ½ metre^2 quadrats spaced at two-metre intervals along five transects placed perpendicular to, and at equal distance along, the residential property boundary. This design resulted in 55 samples taken for each study site. The transects extended 20 metres into the forest edge. The first and last transect were placed one metre from neighbouring property boundaries to reduce the risk of recording neighbouring encroachment activities (Figure 2.2).

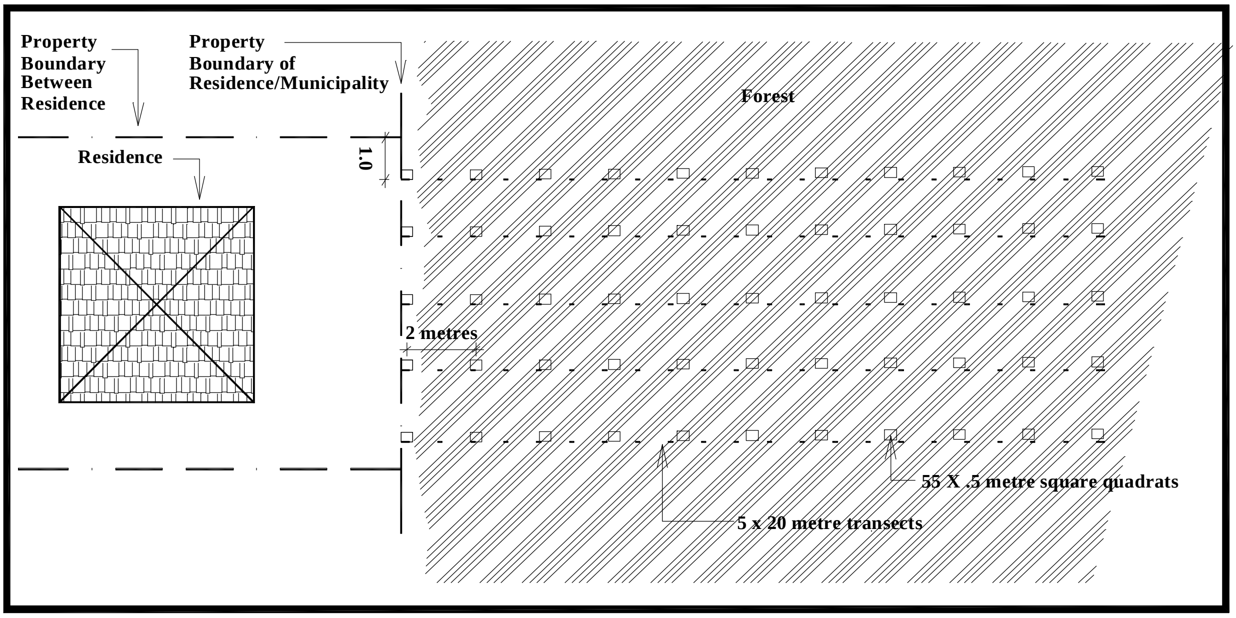


Figure 2.2 Intensive Sampling Method

2.4.2.2 Extensive Sampling Method

The design of the extensive sampling method efficiently sampled the sparsely distributed evidence of encroachment activities located furthest from the property boundary to determine the extent of encroachment. The data entry chart developed during the pilot study (Appendix B) recorded the type of encroachment located furthest from the property boundary (in sites without grass strips) and from the forest border (in sites with grass strips). For each of these traces, distance was measured to the property boundary (or forest border). Measurements were taken from the edge of the trace furthest from the property boundary (or forest border). Unauthorized pathways were not counted as encroachment traces in this study. While they were frequently the most extensive type of trace, their furthest distance could often not be measured because they frequently connected to other unauthorized and authorized pathways within the forests.

2.4.3 Number of Study Sites, Forests, Samples and Transects by Policy and Boundary Type

While an attempt was made to sample a large and equal number of study sites for each policy and boundary type within each municipality, some policies and boundary types were common, while others were less common. All sites with less common boundary types meeting site selection criteria were sampled both intensively and extensively. Intensively sampled sites with common boundary types that met study criteria were selected randomly from all forests meeting study criteria. All study sites within intensively sampled forests that met extensive site selection criteria were sampled extensively. Sampling was conducted by the researcher and a summer student between June and October (or until leaf fall) 2005 and 2006 until research funds were expired. A total of 186 sites were sampled intensively, within 40 forests, for a total of 10,225 samples (930 transects); and 358 sites were sampled extensively once, within 35 of the intensively sampled forests. Table 2.6 and 2.7 provide summaries of the number of extensively and intensively sampled study sites, forests, samples and transects per policy or boundary type, respectively.

Table 2.6 Number of extensive study sites and forests by boundary demarcation type

Boundary Demarcation Type	**Cambridge**	**Guelph**	**Kitchener**	**Mississauga**	**Oakville**	**Waterloo**	**Total**
Municipal encroachment related policies	# Sites (# forests)	# Sites (# forests)	# Sites (# forests)	# Sites (# forests)	# Sites (# forests)	# Sites (# forests)	# Sites (# forests)
1) Boundary Post	0	0	1 (1)	0	0	16 (4)	17 (5)
2) Municipal Fence	0	38 (2)	0	18 (1)	46 (7)	0	102 (10)
Resident Fence	4 (2)	0	8 (3)	5 (3)	0	2 (1)	19 (9)
Total Fence	4 (2)	38 (2)	8 (3)	23 (4)	46 (7)	2 (1)	121 (19)
Total all policies	4 (2)	38 (2)	9 (4)	23 (4)	46 (7)	18 (4)	138 (23)
Resident or municipal boundary treatments unrelated to encroachment							
No boundary demarcation	6 (2)	0	28 (6)	16 (3)	0	28 (2)	77 (13)
Grass Strip, Path	0	0	3 (2)	0	0	5 (1)	8 (3)
Fence, Gate	13 (2)	4 (1)	39 (8)	22 (5)	4(4)	12 (3)	96 (24)
Fence, Gate, Grass Strip	0	0	5 (2)	0	0	0	5 (2)
Fence, Gate, Grass Strip, Path	0	4 (1)	20 (2)	0	0	0	24 (3)
Total No Policy Types	19 (2)	8 (2)	95 (11)	38 (5)	4(4)	45 (5)	209 (29)
Municipal policies with boundary treatments unrelated to encroachment							
Municipal fence, grass Strip, Path	0	1 (1)	0	0	7 (1)	0	8 (2)
Resident fence, grass strip, path	0	1 (1)	0	0	0	2 (2)	3 (3)
Total partial Types	0	2 (2)	0	0	7 (1)	2 (2)	11 (5)
Total all Types	23 (2)	48 (3)	104 (11)	61 (6)	57 (8)	65 (5)	358 (35)

Table 2.7 Number of intensive study sites, forests, samples and transects by policy and boundary demarcation type

Boundary Demarcation Type	Cambridge		Guelph		Kitchener		Mississauga		Oakville		Waterloo		Total	
	# sites[1]	# samp[2]	# sites	# samp	# sites	# samp	# sites	# samp	# sites	# samp	# sites	# samp	# sites	# samp
Municipal encroachment related policies														
1) Municipal Boundary Post	0	0	0	0	1 (1)	55 (5)	0	0	0	0	11 (4)	605 (55)	12 (5)	660 (60)
2) Municipal Fence	0	0	6 (2)	330 (30)	3 (1)	165 (15)	4 (1)	220 (20)	16 (6)	880 (80)	0	0	29 (10)	1595 (145)
Resident Fence	2 (2)	110 (10)	0	0	2(1)	110(10)	4 (2)	220 (20)	0	0	1 (1)	55 (5)	9 (6)	495 (45)
Total Fence	2 (2)	110 (10)	6 (2)	330 (30)	5 (2)	275 (25)	8 (3)	440 (40)	16 (6)	880 (80)	1 (1)	55 (5)	38 (16)	2090 (190)
Resident or municipal boundary treatments unrelated to encroachment														
No boundary demarcation	4 (2)	220 (20)	0	0	14 (7)	770 (70)	13 (4)	715 (65)	0	0	2 (2)	110 (10)	33 (15)	1815 (165)
Grass Strip	0	0	0	0	2 (1)	110 (10)	0	0	0	0	0	0	2 (1)	110 (10)
Grass strip, Path	0	0	0	0	0	0	4 (1)	220 (20)	0	0	3 (1)	165 (15)	7 (2)	385 (35)
Fence, Gate	9 (2)	495 (45)	0	0	14 (6)	770 (70)	14 (5)	770 (70)	2 (2)	110 (10)	7 (3)	385 (35)	46 (18)	2530 (230)
Fence, Gate, Grass Strip	0	0	0	0	9 (3)	495 (45)	4 (2)	220 (20)	0	0	4 (1)	220 (20)	17 (6)	935 (85)
Fence, Gate, Grass Strip, Path	0	0	3 (1)	165 (15)	7 (2)	385 (35)	5 (1)	270 (20)	0	0	0	0	15 (4)	820 (75)
Municipal policies with boundary treatments unrelated to encroachment														
Municipal Fence, Grass Strip	0	0	0	0	0	0	0	0	3 (1)	165 (15)	0	0	3 (1)	165 (15)
Municipal Fence, Grass Strip, Path	0	0	0	0	0	0	0	0	8 (1)	440 (40)	0	0	8 (1)	440 (40)
Resident Fence, municipal grass strip, path	0	0	0	0	0	0	3 (1)	165 (15)	0	0	2 (2)	110 (10)	5 (3)	275 (25)
Total Fence, grass strip, path	0	0	0	0	0	0	0	0	0	0	0	0	13 (4)	715 (65)
Total Partial Policy	0	0	0	0	0	0	0	0	0	0	0	0	16 (5)	880 (80)
Total All Types	15 (2)	825 (75)	9 (3)	495 (45)	52 (10)	2860 (260)	51 (8)	2800 (255)	29 (8)	1595 (145)	30 (6)	1650 (150)	186 (40)	10,225 (930)

[1] The number in brackets is the number of study forests in which the study sites were sampled; [2] the number in brackets is the number of transects sampled.

2.4.4 Study Forests and Subdivisions by Municipality

2.4.4.1 Municipality of Cambridge Study Sites

Two study forests were chosen within Hespeler, located in northeastern Cambridge (Figure 2.3). Winston Blvd. Woodlot and Woodland Park are second growth, dry-fresh sugar maple/beech deciduous forest types, approximately 2 and 5 hectares in area, respectively. Typical understory species include choke cherry and alternate-leaved dogwood. Sites are of moderate or low slope with no natural barriers to encroachment. Side canopies range from open to semi-closed. Both forests have significant amounts of anthropogenic disturbance related to recreational use.

Subdivisions surrounding woodlots are characterised by single-family detached housing from 19 to 56 years old. Study lots are approximately 16 metres wide by 33 to 38 metres long. Yard depth is between 8 and 21 metres. Gross district housing density is low at nine houses per hectare. Table 2.8 summarizes this information. The map numbers within the left-hand column locate the natural areas in Figure 2.3. Appendix C provides information on the boundary types by study site address, municipal management regimes, bylaw enforcement, and detailed information about one site as an example of a site with a fence with gate boundary type.

Table 2.8 Cambridge study sites and subdivisions

Map #	Natural areas/Street	Sample date (yr)	Forest Area[1] (ha)	Forest type[2]	Age of Sub.[3]	House type	Housing Density (houses/ha)
1	Winston Blvd. Woodlot @ Pezzack St.	2005	2.32	Dry-fresh sugar maple-beech deciduous forest	19	Detached	9
	Winston Blvd. Woodlot @ Winston Blvd.	2005	2.32	Dry-fresh sugar maple-beech deciduous forest	19	Detached	9
2	Woodland Park. @ Kribs St.	2005	4.81	Dry-fresh sugar maple-beech deciduous forest	56	Detached	9
	Woodland Park @ Thomas St.	2005	4.81	Dry-fresh sugar maple-beech deciduous forest	29	Detached	9

[1] Source of information: Region of Waterloo 2006 aerial photographs; [2] Classification according to OMNR Ecological Land Classification for Southern Ontario, 1998; [3] the ages of the subdivisions were calculated from the subdivision registration date.

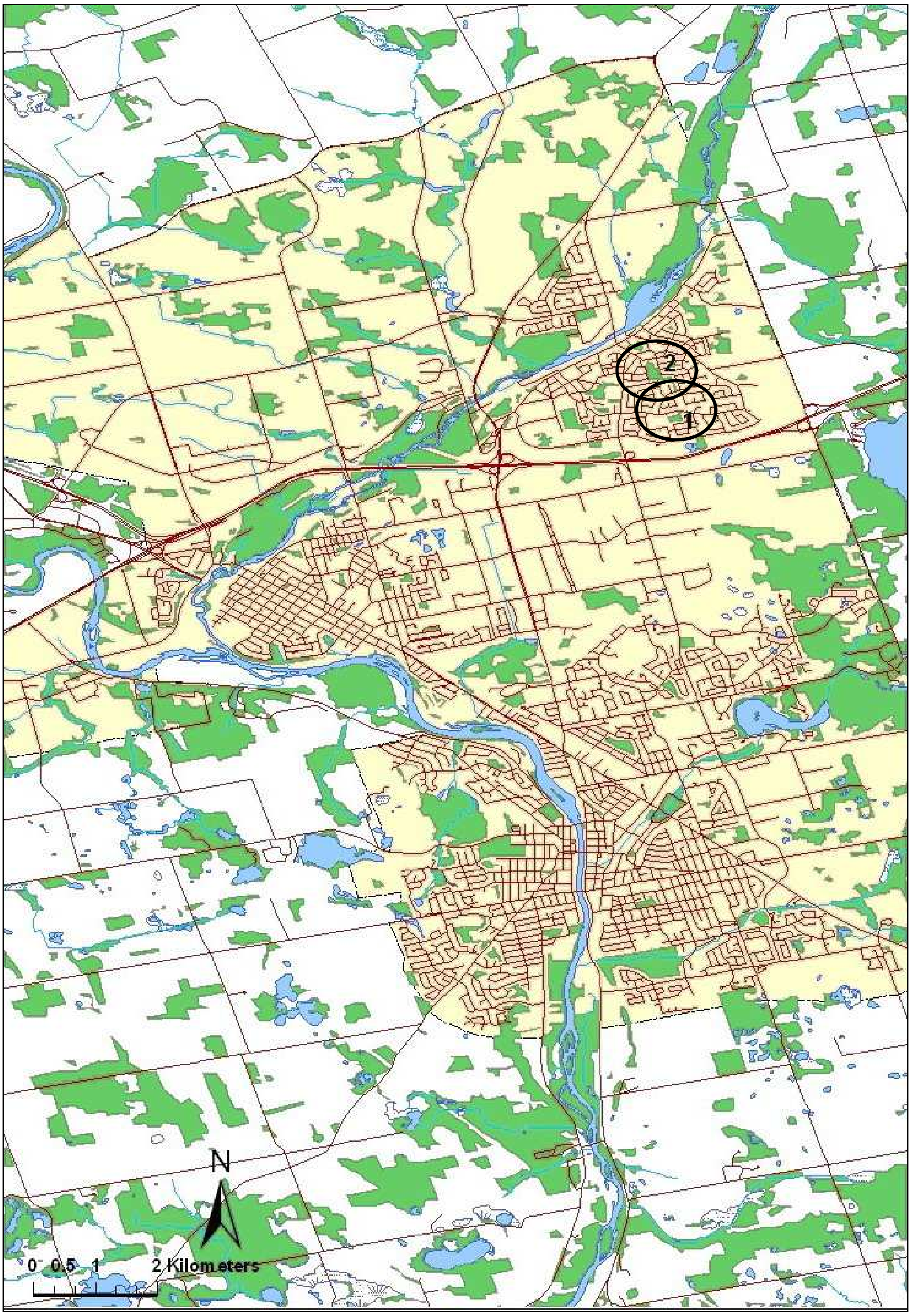


Figure 2.3 Study forests in Cambridge, Ontario
(Source: (Ontario Ministry of Natural Resources, 2002))

2.4.4.2 Municipality of Guelph Study Sites

Three forests and subdivisions were chosen within Guelph. Figure 2.4 illustrates their location. The Hanlon Creek Park and Crane Park are forested river corridors. Both are fresh-moist white cedar- hardwood mixed forest types. The dominant tree species is white cedar; however, european buckthorn dominates the outer forest edge of both natural areas. Marksam Park is a fresh-moist sugar maple-hardwood deciduous forest type. The dominant species is sugar maple with beech, green ash, and red maple. Understory species include alternate-leaved dogwood and elderberry. All three sites have moderate or low slopes without natural barriers to encroachment.

The adjacent housing is single-family and detached, between 20 and 30 years old. Residential lots along Koch and Stephen Drives measure approximately 8 metres by 35-40 metres in depth, with rear yard housing setbacks of 11-18 metres. Table 2.9 summarizes this information. The map numbers within the left-hand column locate the natural areas in Figure 2.4. Appendix C provides information on the boundary types by site address, municipal management regimes and bylaw enforcement, and detailed information about a site with a fence, gate, grass strip and path boundary type.

Table 2.9 Guelph study forests and subdivisions

Map #	Natural areas/streets	Sample date (yr.)	Forest Area[1] (ha)	Forest type[2]	Age of Sub.[3]	House type
3	Crane Park @ Dovercliffe Rd.	2004	15.00	Fresh–moist white cedar– hardwood mixed forest	33	Detached
4	Hanlon Creek Pk. @ Koch Dr.	2005	7.23	Fresh–moist white cedar– hardwood mixed forest	21-31	Detached
5	Marksam Pk. @ Stephen Dr.	2005	2.44	Fresh–moist white cedar– hardwood mixed forest	24	Detached

[1] source of information: Municipality of Cambridge; [2] Classification according to OMNR Ecological Land Classification for Southern Ontario, 1998; [3] the ages of subdivisions were calculated from the subdivision registration date.

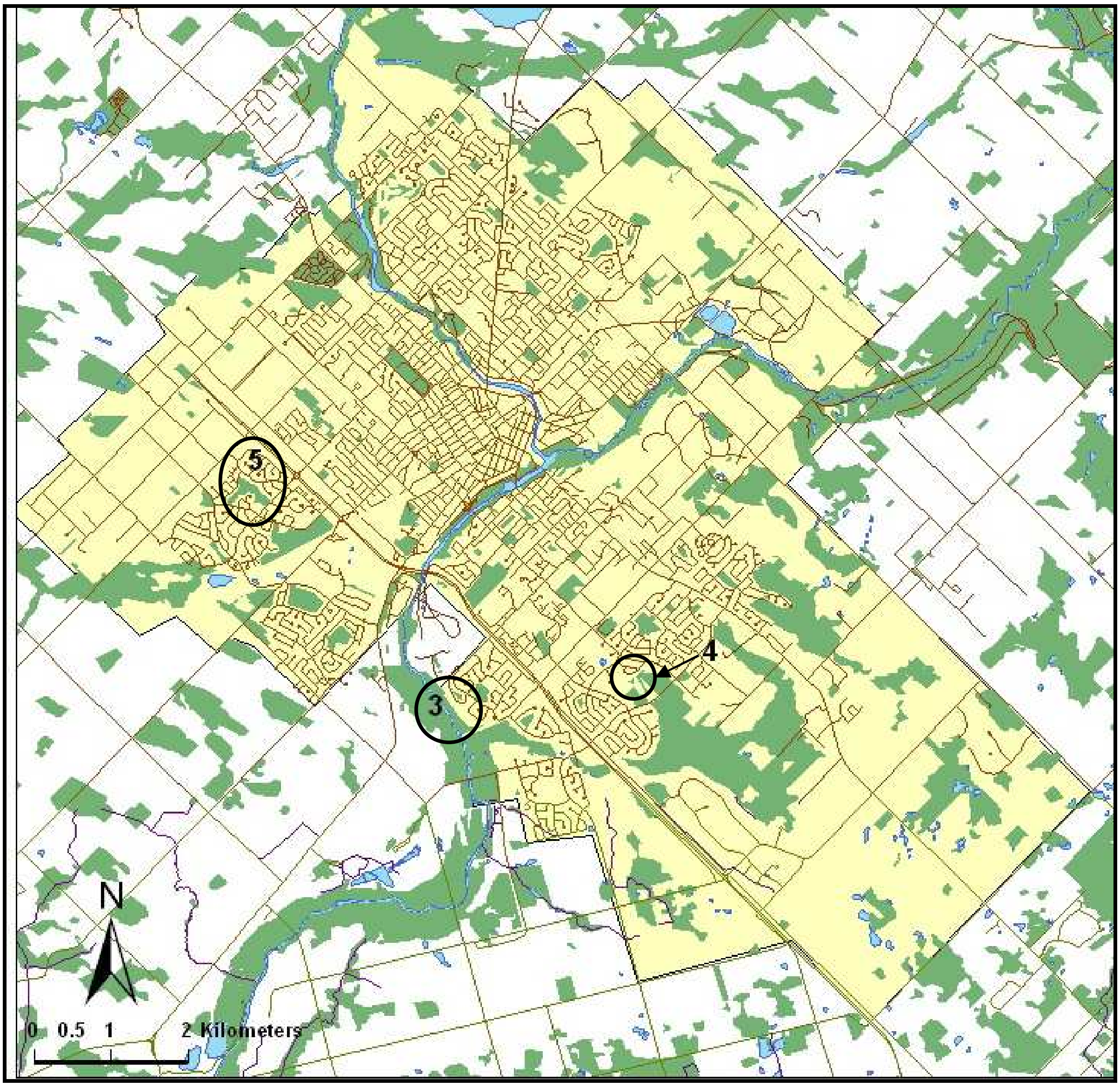


Figure 2.4 Study forests in Guelph, Ontario
(Source: (Ontario Ministry of Natural Resources, 2002))

2.4.4.3 Municipality of Kitchener Study Sites

In the municipality of Kitchener, 11 forests were chosen for sampling. Figure 2.5 illustrates their locations. Forests range from approximately 1 to 44 hectares in size. Five of the natural areas are terrestrial deciduous eastern forest fragments (Monarch Woods Park, Arrowhead Park, Chicopee Conservation Area; Georgian Park and Idlewood at Idlewood Drive) with sugar maple and american beech as dominant tree species. Buckthorn dominate two of the natural areas (Forfar Park and Country Hills Park). One of the natural areas is a lowland deciduous eastern forest fragment (Meinzinger Park), characterized by a mixture of willow spp., manitoba maple, poplar spp., and buckthorn. Stanley Park Conservation Area and Idlewood at Wren Place are deciduous swamps with silver and red maple as dominant tree species. The wetlands that characterize these areas are not located within the study areas. Both areas are ESPAs and Idlewood has a provincially significant wetland. Tilt's bush is a sugar maple/hemlock mixed forest, an ESPA and has a provincially significant wetland.

Continuous, single-family housing, between 25 and 50 years old, characterizes most of the adjacent subdivisions. Lots measure approximately 39 metres long by 17 metres wide, with backyard depths of approximately 16 metres. Gross district housing density is low, ranging from 5 to 14 houses per hectare. Table 2.10 summarizes this information. The map numbers within the left-hand column locate the natural areas in Figure 2.5. Appendix C provides information on the boundary types by site address, municipal management regimes and bylaw enforcement, and detailed information about a site with a fence boundary type.

Table 2.10: Kitchener study forests and subdivisions

Map #	Natural areas/streets	Sample Date	Forest Area[1] (ha)	Forest type	Sub. Age[2]	House type	Housing Density
6	Arrowhead Pk. @ Arrowhead Cr.	2005	26.35[3]	Dry-fresh sugar maple deciduous	37	Detached	9
7	Chicopee Conservation Area @ Underhill Cr.	2005	3.5		35	Detached	8
8	Country Hills Pk. @ Country Hills Dr.	2005	.06	Buckthorn	33	Detached	14
9	Forfar Park @ Carson Rd.	2005	9.25	Buckthorn	39	Detached	14
9	Forfar Park @ Manchester Rd.	2005	9.25	Buckthorn	25	Detached	7
10	Georgian Pk. @ Marketa Cr.	2005	1.38	Dry-fresh sugar maple – beech deciduous	48	Detached	6
10	Georgian Pk. @ Matthew Ct.	2005	1.38	Dry-fresh sugar maple – beech deciduous	31	Detached	6
11	Idlewood Park @ Idlewood Dr.	2004	16.84	Fresh-moist sugar maple – hardwood deciduous		Detached	8
12	Idlewood Park @ Wren Pl.	2004	22.16	Maple organic deciduous swamp	40	Detached	8
13	Meinzinger Pk. @ Southmoor Dr.	2005	5.97	Fresh-moist deciduous forest	50	Semi-detached/	7
14	Monarch Woods Park @ Stoke Cr.	2004	12.8	Fresh-moist sugar maple – hardwood deciduous	28	Detached	5
15	Stanley Park @ Hickson Dr.	2004	30.41	Maple organic deciduous swamp	46	Detached	14
15	Stanley Park @ Halliwell Dr.	2004	30.41	Maple organic deciduous swamp	46	Detached	14
16	Tilt's Bush @ Sabrina Cr.	2005	43.66	Fresh-moist sugar maple-hemlock mixed forest	27	Detached	9
16	Tilt's Bush @ Bechtel Dr.	2005	43.66	Fresh-moist sugar maple-hemlock mixed forest	29	Semi-detached	9

[1] Source of data: Grand River Watershed viewer; [2] Subdivision age = year of subdivision registration (source: Region of Waterloo Registrar); [3] Density = # houses/ha for district (source of district populations and areas: City of Kitchener, 2003. Planning Community Demographics: a profile of 2001 Census data by neighbourhood in the City of Kitchener, City of Kitchener, Kitchener; [4] Natural areas composed of a .67ha natural area. However behind and connected to this area is a 25.68ha regional plantation

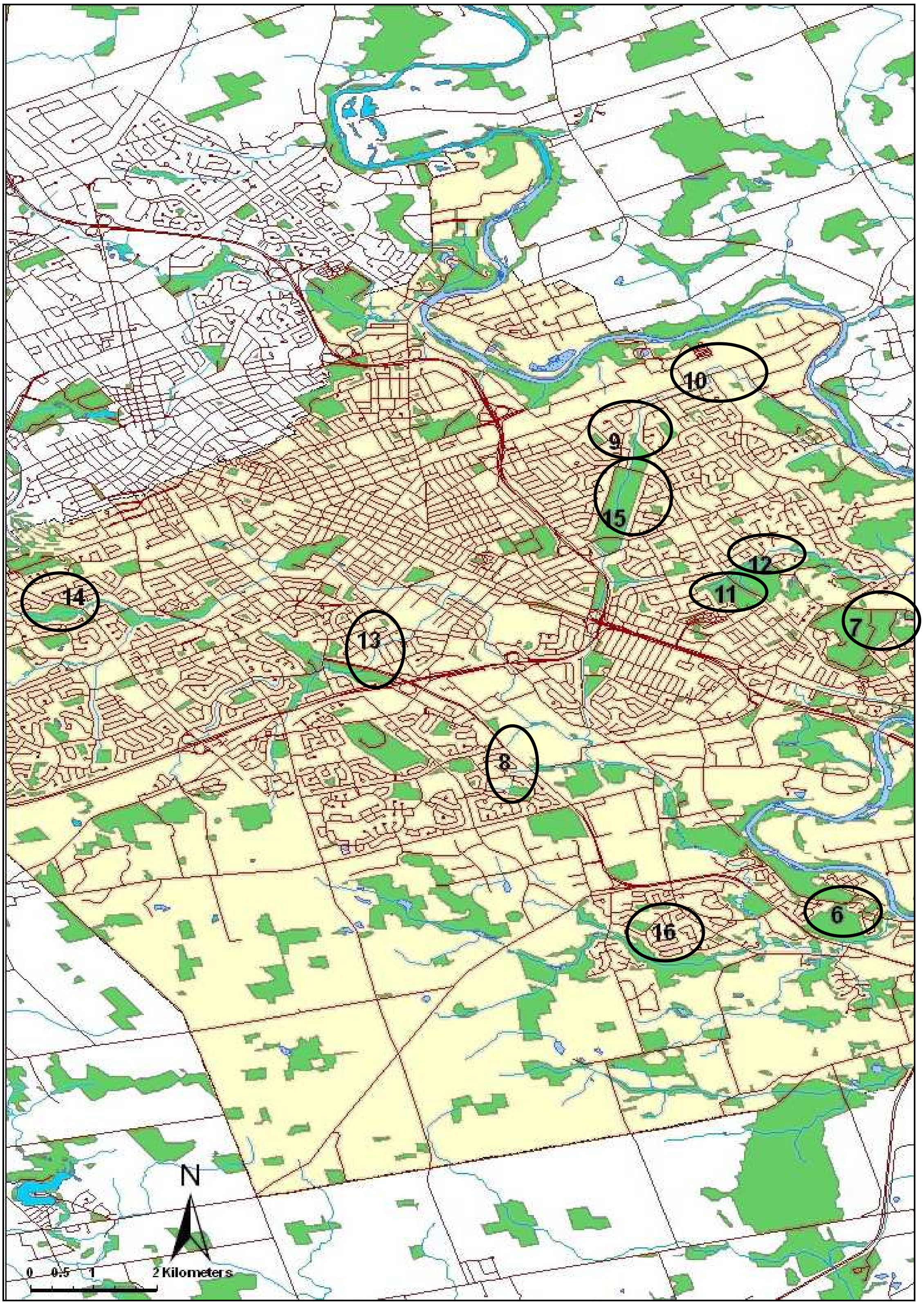


Figure 2.5 Study forests in Kitchener, Ontario
(Source: (Ontario Ministry of Natural Resources, 2002))

2.4.4.4 Municipality of Mississauga Study Sites

Eight forest fragments ranging from approximately 1 to 7 hectares in area were sampled in Mississauga (Figure 2.6). Half the sites are terrestrial deciduous eastern forest remnants, and the other half are corridors of lowland eastern deciduous forest. All natural areas are level, with some areas of rolling topography, and minimal natural barriers to encroachment activities. Dominant species in the terrestrial forest fragments are sugar maple or burr and white Oak, sometimes with american beech. Two of the forests, Britannia Woods, and Deer Run Park, are significant natural areas. The dominant species in Creditview Park are red and white ash, with some scattered swamp white oaks and sugar maple. Little ecological information is available for Dellwood Park. Dominant species in the lowland forests of Applewood Creek and Camilla Parks are willow spp., red ash or white birch. Willowcreek Park is a mixed forest with eastern hemlock as a dominant canopy species. Dominant species within the understory are manitoba maple, white elm, and european buckthorn. Mississauga naturalized Applewood Creek and Camilla natural areas in the last 30 Years.

Most of the adjacent subdivisions have continuous single-family detached housing, ranging from 47 to 11 years old. Mean gross district housing densities range from 6 to 19 houses per hectare. Table 2.11 summarizes this information. The map numbers within the left-hand column locate the natural areas in Figure 2.6. Appendix C provides information on the boundary types by site address, municipal management regimes, encroachment bylaw enforcement and detailed information about a site with no, or minimal boundary demarcation.

Table 2.11 Mississauga study forests and subdivisions

Map #	Natural areas/streets	Sample date (yr.)	Forest Area (ha)[1]	Forest type	Sub. Age	House type	Housing Density[2]
17	Applewood Hills Park @ Grand Forks Dr.	2005	7	Fresh-moist willow lowland deciduous	42	Detached	19
18	Applewood Hills Park @ Greybrook Cr.	2005	3	Fresh-moist willow lowland deciduous	27	Semi-detached	19
19	Applewood Hills Park @ Lonefeather Cr.	2004	5	Fresh-moist willow lowland deciduous	40	Detached	19
19	Applewood Hills Park @ Frederica Dr.	2004	5	Fresh-moist willow lowland deciduous	47	Semi-detached	19
20	Britannia Woods @ Turnberry	2004/ 2005	6	Fresh-moist sugar maple – hardwood deciduous	11	Detached	16
21	Camilla Park @ Camilla Road	2005	6	Fresh-moist ash lowland deciduous	45	Detached	17
22	Creditview Park @ Wakefield & Buckingham	2005	1	unknown	24	Detached	16
23	Deer Run Park @ Deer Run Rd.	2004/ 2005	3	Fresh-moist oak-sugar maple deciduous	26	Detached	16
23	Deer Run Park @ Deer Run Ct.	2004/ 2005	3	Fresh-moist oak-sugar maple deciduous	26	Detached	16
24	Dellwood Park @ Dexter Cr.	2005	1	unknown	21	Detached	6
25	Willowcreek Park @ Fieldgate Dr.	2004	6	Fresh-moist white birch mixed	41	Semi-detached	19
26	Tom Chater Memorial Pk. @ Colonial Dr.	2005	4	Fresh-moist sugar maple-hardwood deciduous	15	Detached	13
26	Tom Chater Memorial Pk. @ Kelso	2005	4	Fresh-moist sugar maple-hardwood deciduous	20	Detached	13

[1] Area does not include adjacent natural areas divided by roads, or associated active recreation areas; source: area estimated from Mississauga 2006 aerial photographs; [2] Density = # houses/ha (source: City of Mississauga 2005. Housing Matters: Density Planning District Summary)

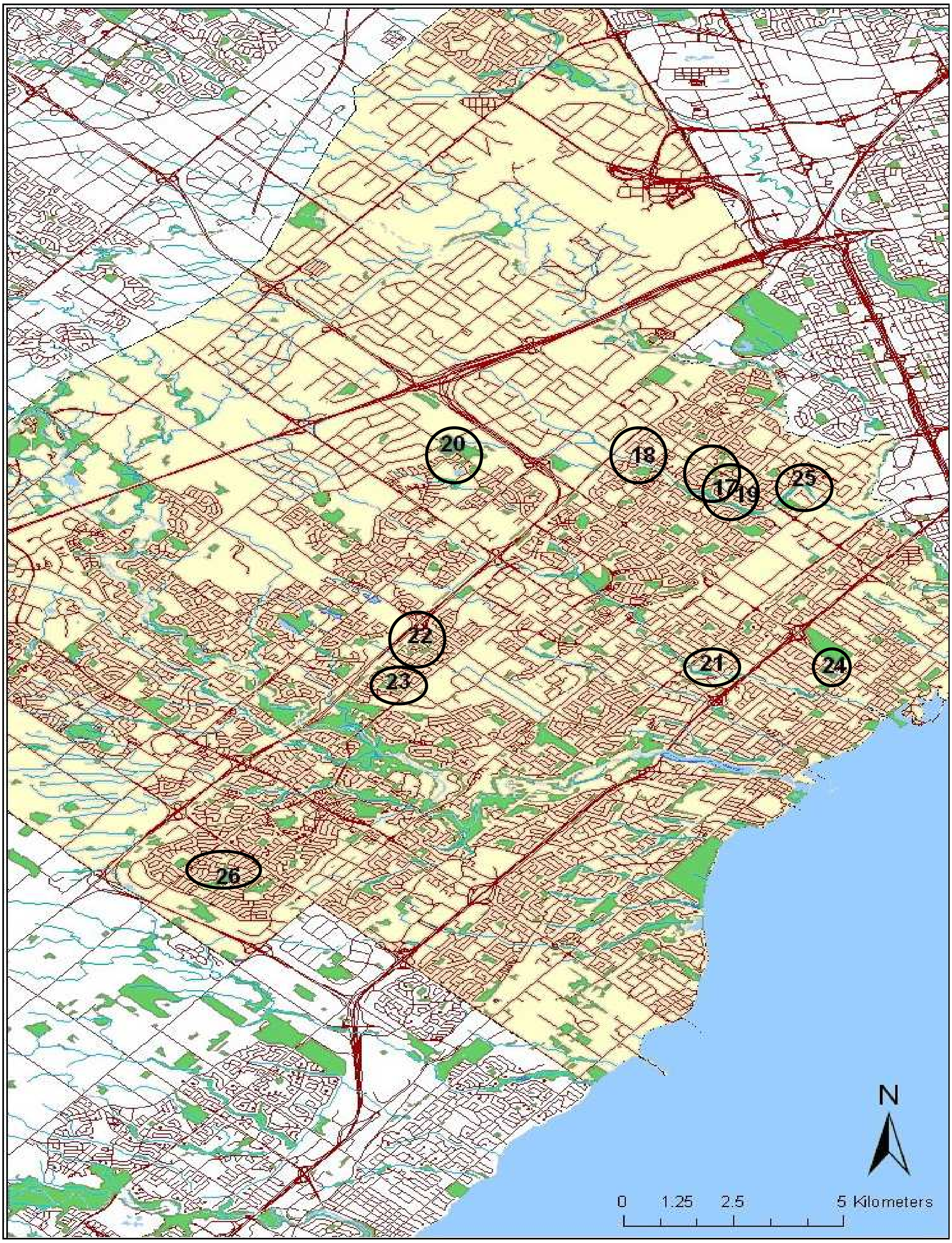


Figure 2.6 Study forests in Mississauga, Ontario
(Source: (Ontario Ministry of Natural Resources, 2002))

2.4.4.5 Municipality of Oakville Study Sites

Nine forests were chosen for sampling in Oakville. The natural areas are between 3 and 12 hectares in area. Five of the sites are terrestrial deciduous eastern forest remnants (Beechnut Park, Clearview Woods, Oakville Park, Pelee Woods, and Sedgewick Park); one is a mixed forest (Village Wood) and three are forest fragments associated with stream corridors (Fourteen Mile Creek, McCraney Creek Trail, and Margot Park) (Figure 2.7). Approximately half of the fragments (Clearview woods, Fourteen Mile Creek, McCraney Creek Trail and Pelee Woods) are oak-hardwood forests with relatively open canopies. Dominant canopy species include red oak, and sugar maple, with some white ash and black cherry. Beechnut Park is a sugar maple-beech deciduous forest. Village Wood Park is a hardwood-hemlock forest with hemlock and red oak or sugar maple as dominant canopy species. Both Margot and Oakville Parks are very disturbed and dominated by european buckthorn with a few white ash.

Subdivisions are between 15 and 51 years old with continuous single-family, detached housing. Table 2.12 summarizes information about the study natural areas. The map numbers within the left-hand column locate the natural areas in Figure 2.7. In Figure 2.7 the forest labeled 34 is not in the study and is marked with an 'X.' Appendix C provides information on the boundary types by site address, municipal management regimes, encroachment bylaw enforcement, and detailed information about a site with a fence, grass strip and path boundary type.

Table 2.12: Oakville study forests and subdivisions

Map #	Natural areas/streets	Sample date (yr.)	Forest Area[1] (ha)	Forest type	Sub. Age[2]	House type
27	Beechnut Park @ Aspen Forest Dr.	2004	2.6	Dry-fresh sugar maple-beech Deciduous	26	Detached
28	Clearview Woods @ Sir. David Dr.	2005	2.6	Dry-fresh oak hardwood deciduous	22	Detached
29	Fourteen Mile Creek @ Stationmaster Lane	2004	5.8	Dry-fresh oak hardwood deciduous	19	Detached
30	Margot Park @ Margot St.	2005	2.8	European buckthorn (some white ash)	24	Semi-detached
31	McCraney Creek Trail @ Deerwood Tr.	2004	10	Dry-fresh oak hardwood deciduous	21	Detached
32	Oakville Park @ Queensbury Cr.	2005	7.7	European buckthorn (some white ash)	23	Detached
33	Pelee Woods @ Oakmead Pl.	2005	2.1	Dry-fresh oak hardwood deciduous	15-20	Detached
35	Village Wood Pk. @ Chalmers St.	2005	16	Dry-fresh hardwood-hemlock mixed	28	Detached

[1] Source: City of Oakville Maps/GIS; [2] Subdivision age = year of subdivision registration (source: Town of Oakville Website)

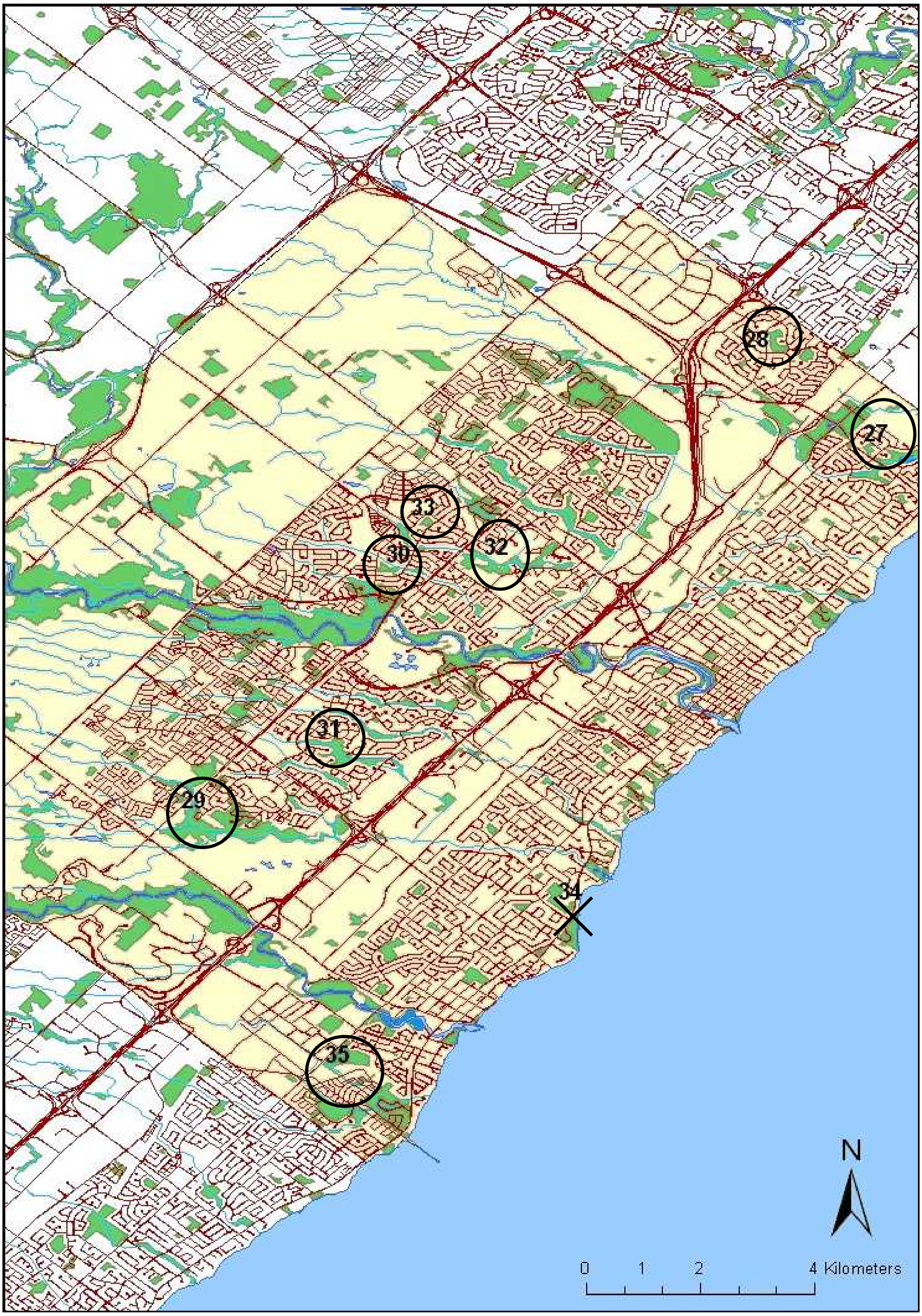


Figure 2.7 Study forests in Oakville, Ontario
(Source: (Ontario Ministry of Natural Resources, 2002))

2.4.4.6 Municipality of Waterloo Study Sites

Within the City of Waterloo, six forests were sampled, between .03 and 10 hectares in size (Figure 2.8). Most of the natural areas are sugar maple or sugar maple/american beech deciduous forests with closed canopies. Dominant species are sugar maple and beech, with some white ash and black cherry. Moses Springer Park and Anndale Park along Anndale Court are both regenerating stream corridors with sugar maple or black ash as dominant species. Continuous single-family detached housing, between 20 and 40 years old, surround most of the forests. Gross district housing densities are between 7 and 12 houses per hectare. Table 2.13 summarizes information about the study natural areas. The map numbers within the left-hand column locate the natural areas in Figure 2.8.

Appendix C provides information on the boundary types by site address, municipal management regimes and encroachment bylaw enforcement. In addition, it provides detailed information about sites with a municipal post, fence, gate and grass strip, and grass strip and path boundary types at Sugar Bush Park, Moses Springer Reserve and Anndale Park, respectively.

Table 2.13 Waterloo study forests and subdivisions

Map #	Study Sites	Sample year	Forest Area (ha)[1]	Forest type	Sub. Age[2]	House type	Housing Density[3]
36	Anndale Pk. @ Anndale Ct.	2005	10	Fresh – moist ash lowland deciduous	28	Detached	8
36	Anndale Pk. @ Guildwood Place	2005	10	Dry-fresh sugar maple –beech deciduous	20	Detached	8
36	Anndale Pk. @ Old Abbey Rd.	2005	10	Dry-fresh sugar maple –beech deciduous	19	Detached	8
37	Sparrow Park @ Blackforest Park	2005	5.5	Dry-fresh sugar maple deciduous	22	Detached	11
37	Sparrow Park @ Northlake Dr.	2005	5.5	Dry-fresh sugar maple deciduous	21	Detached	11
38	McCrae Pk. @ Hemingway Pl	2005	3.6	Dry-fresh sugar maple deciduous		Detached	7
38	McCrae Pk. @ McCrae Pl.	2005	3.6	Dry-fresh sugar maple deciduous		Detached	7
39	Moses Springer Pk. @ MacKay	2005	.03	Fresh-moist sugar maple – lowland ash deciduous	50	Detached	9
40	Sugar Bush @ 480 Parkwood	2004	9.5	Dry-fresh sugar maple deciduous	43	Detached	7
40	Sugar Bush @ Longwood	2004	9.5	Dry-fresh sugar maple deciduous	42	Detached	7
40	Sugar Bush @ Greenbrier	2004	9.5	Dry-fresh sugar maple deciduous	40	Detached	7
41	Twin Oaks Pk. @ Parklawn Pl.	2005	4.4	Dry-fresh sugar maple beech	40	Detached	12
41	Twin Oaks Pk. @ Twin Oaks Cr.	2005	4.4	Dry-fresh sugar maple beech	38	Detached	12

[1 1] Source of data: Grand River Watershed viewer; [2] Subdivision age = year of subdivision registration (source: Region of Waterloo Registrar); [3]Density = # houses/ha

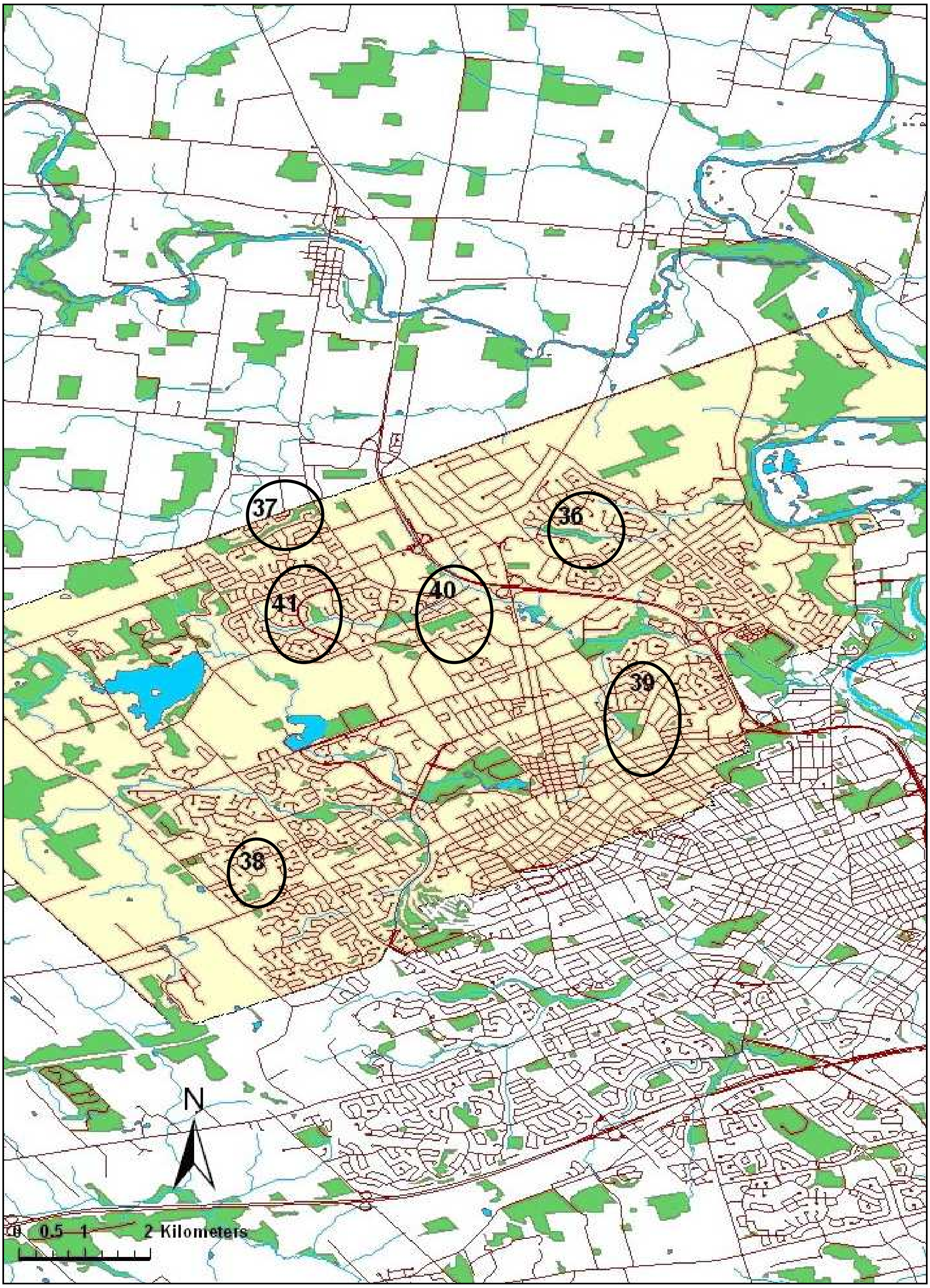


Figure 2.8 Study forests in Waterloo, Ontario
(Source: (Ontario Ministry of Natural Resources, 2002))

2.4.5 Data Analysis

Encroachment trace types were categorized by assumed encroachment motive. Frequencies and intensities of encroachment traces for all and each encroachment trace type and category were calculated for all and each boundary type. The frequency of encroachment is the number of encroachment traces recorded in the quadrats. Intensity of encroachment is a qualitative indicator of the level of encroachment. It is calculated by summing the frequencies of each encroachment trace by their cover scale. Mean frequencies and intensities were plotted against distance to compare their distributions within the first 20 metres of the forest edge. The literature considers data from the Braun-Blanquet cover scale 'semi-quantitative' because of its reliance on the visual judgment of the investigator, and the large intervals among the scale values, which increase the opportunity for error (Kent & Coker, 1992b; Mueller-Dombois & Ellenberg, 1974). Nevertheless, this method remains a proven method for describing spatial variations in vegetation (or other forest floor components like encroachment traces) particularly where there is large variation in the vegetation community (Kent et al., 1992b). The potential for error was reduced in this research by training the research assistant to arrive at the same classification codes as the principal researcher and, where possible, through large sample sizes.

The data collected are not interval or ratio data because the cover categories are not equally spaced. In addition an assumption required for parametric significance tests is violated (the sets of data from the different boundary types do not have equal variances). This means that nonparametric tests rather than parametric are appropriate to determine the statistical significance of the results (Foster, 1998). The intensity data is ordinal because the cover scale categories are ordered, rather than merely categorical as in the case of nominal data (Morgan & Griego, 1998b). In addition, the data come from different sites, and more than two sets of data (boundary types) are being compared. Therefore, the Kruskal-Wallis test for independent samples is an appropriate non-parametric test (Foster, 1998). It was used to test the null hypotheses of random distributions of the intensity of all and different categories of encroachment traces for all boundary types relative to the forest border, and whether boundary type significantly altered mean frequencies, intensities and extents of encroachment. This test, and the Mann-Whitney U test, are commonly used in recreation ecology where the cover scale data is collected (Cole, 1986; Cole et al., 1988).

To determine which boundary types, and categories of encroachment, led to significantly different frequencies, intensities and extents of encroachment, another non-parametric test, the Kolomogorov-Smirnov two-sample test, was conducted. A Mann-Whitney U test could also have been (Morgan & Griego, 1998a). However, the Kolomogorov test more robust than the Mann-Whitney test (i.e. the test is more likely to yield correct conclusions even when some of its assumptions are not met) and is easier to use properly (S. Murphy, personal communication, June 5, 2007). This is important since it cannot be assumed that the samples are independent which is an assumption of for all these statistical tests (S. Murphy, personal communication, February 1, 2006). This is a common problem of vegetation sampling in general and is related to sample proximity (Kent & Coker, 1992a).

A Spearman correlation test was used as a non-parametric test to determine whether the mean frequency or intensity of waste disposal encroachment was correlated with study fence heights.

The next chapter provides a literature review of 1) the structural and functional roles of boundaries in ecological communities, 2) human activities and their effects on forest ecosystems, 3) the effects of forest ecosystems on adjacent residents, and 4) strategies and tools for limiting the effects of human activities on ecological communities.

Chapter 3

Theory of Boundary Planning for the Protection of Suburban Natural Systems from Adjacent Land Use Impacts

Chapter 3 reviews the literature dealing with the theory of boundary planning for the protection of suburban ecosystems from adjacent land use impacts. Section 3.1 describes the effects of housing landscape elements on adjacent forest landscape elements. Section 3.2 outlines the effects of suburban forest landscape elements on housing landscape elements. Section 3.3 describes the activities and effects of edge residents on adjacent suburban forest landscape elements. Section 3.4 outlines the theory of the structure and functional roles of boundaries between ecosystems. Section 3.5 described the boundary model of natural area protection. Finally, section 3.6 outlines strategies and tools for planning and managing internal boundaries in backcountry nature reserves used for recreation.

An ecosystem is a more or less homogenous area of interacting organisms that can be defined at any scale (Forman, 1995). A suburban landscape is defined spatially as a mix of landscape elements repeated over a kilometers-wide area. A landscape element can be a patch, corridor or area of matrix (Forman, 1995). In a suburban landscape, they may consist of un-built landscape elements (e.g. forested natural area, stream corridors, stormwater management facility or school playground) or a built landscape element (e.g. housing, commercial or industrial development, or road).

3.1 Effects of Residential Landscape Elements on Adjacent Forest Landscape Elements

At the macro-scale lack of planning has fragmented the suburban landscape, leaving small, narrow and unsupported forested fragments (Riley & Mohr, 1994) leaving them open to species extinction and vulnerable to adjacent land use impacts (Murphy, 2006). At the micro-scale, multiple biotic and abiotic flows cross the border between adjacent housing into the adjacent forest fragment. Each flow event may be insignificant, or its effects subtle and therefore difficult to measure. However, they occur frequently, and their effects are often cumulative, taking long periods to appear. This makes them difficult to identify and address. Long-term studies over decades may be required to measure noticeable impacts, but planning and management decisions need to be made today to avoid and manage these micro-scale interactions so that the forms, functions and values for which these areas were protected are not lost (Murphy, 2006). The following is a summary of the literature on the effects of residential areas on adjacent suburban forest fragments.

3.1.1 Alterations in Hydrological and Chemical Regimes

The construction of housing subdivisions significantly alters surface and groundwater regimes through the replacement of porous vegetated areas with impervious roads, sidewalks, buildings and mown grass areas. Increasing the imperviousness of surfaces increases the quantity, and rate of flow of water, nutrients, pesticides and other pollutants following storm events (Brander, Owen, & Potter, 2004). This water then enters natural areas and stream corridors, causing flooding, erosion of soils, and the pollution of water which degrades the habitat of aquatic and semi-aquatic organisms, and can threaten human health (Beck, 2005; Donohue, Styles, Coxon, & Irvine, 2005; Kominkova et al., 2005). Although storm water management facilities have been designed to reduce these impacts, they may only serve to slow down the release of pollutants into a storm drain system. If the contaminated water enters riparian areas, particularly if these areas have been canalized, or otherwise made dysfunctional, it can filter into, and contaminate, ground water (Donohue et al., 2005; Kominkova et al., 2005).

Studies indicate that pollutants associated with residential land uses include nitrates (found in fertilizers) (Exner, Burbach, Watts, Shearman, & Spalding, 1991) and fecal coliforms and fecal streptococci (U.S. Environmental Protection Agency, 1995). Fewer studies have pinpointed the source of these pollutants. However, studies have found a (Murphy, 1992)correlation between excessively high fecal coliform levels in stream tributaries and housing density, population, development, percentage pervious surface, and domestic animal density (Young & Thackston, 1999). Fecal bacterial counts within surface water collected from individual lawns can be very high, particularly where there are resident dogs (Young et al., 1999). Fewer studies have measured the impacts of these excessive chemical, particulate or bacterial levels largely because they are very complex (for example, each species and individual, may react differently to different levels) and often take a long time to accumulate to measurable levels (Mayer, Snodgrass, & Morin, 1999). Studies indicate that impacts include the anatomic alteration of frogs (Mayer et al., 1999; Reeder et al., 2005; U.S. Environmental Protection Agency, 1995), and the alteration of fungi and invertebrates within soils and water that in turn lead to alterations in plants and animals (Cousins, Hope, Gries, & Stutz, 2003; Pickett et al., 2001).

3.1.2 Alteration of Soil and Vegetation Communities

Many studies have measured the impacts of human trampling on the vegetation and soils of urban or suburban forests (Bagnall, 1979; Hoehne, 1981; Levenson, 1981; Littlemore et al., 2003; Manning, 1979a; Moran, 1984; Sauvajot, Buechner, Kamradt, & Schonewald, 1998).

Trampling impacts soils, soil dwelling biota and vegetation in interrelated ways. It removes forest litter, exposes the underlying mineral soils, compresses the organic soil layer and reduces the pore space for water and air (Monti, 1979). The compaction of soil causes oxygen, nutrient and water shortages that in turn negatively affect soil dwelling biota (Malmivaara-Lamsa & Fritze, 2003). Soil dwelling biota are also reduced where trampling leads to changes in the vegetation, the quality of the leaf litter, and changes in the humus pH, in addition to soil compaction (Malmivaara-Lamsa et al., 2003). As the trampling intensifies, the number of shade-intolerant and disturbance-insensitive species increases, with an increase in species diversity reaching maximum levels at medium levels of disturbance (Levenson, 1981). At higher levels of disturbance, the number of individual plants can diminish, plant species diversity may decrease and composition may alter. Disturbance-sensitive or shade-tolerant species (most of which are native herbaceous species) may be lost, and disturbance-insensitive or shade-intolerant species (often exotic or native weedy species) may increase (Hoehne, 1981). Compaction and a reduction in plant coverage increases water run-off and soil erosion, particularly within steeply-sloped and poorly-drained areas where the top organic soil has been removed and the mineral soil beneath exposed (Cole, 1988; Littlemore et al., 2003).

Many of these studies found a reduction in native shade-tolerant species and an increase in the number of exotic and native, light and disturbance-tolerant species in all fragment sizes through time or relative to similar rural forests (Bagnall, 1979; Hoehne, 1981; Levenson, 1981; Manning, 1979a; Florgard, 2000). The proliferation of exotic species within forests is linked to the local extinct of native forest species, and poses a threat to species at risk that live in Canada's urban areas (Murphy, 2006). Managing the spread of non-native vegetation is very expensive in many urbanized municipalities within Southern Ontario (P. Lyons, City of Mississauga, personal communication, September 15, 2005). All forest edges serve as entry points for exotic plant species (Laurance, 1991; Levenson, 1981; Moran, 1984). Vectors such as wind, water and animals (including human) carry these species into forests from adjacent lands (Saunders, Hobbs, & Margules, 1991). Where housing is the adjacent land use, residents deliberately or inadvertently introduce exotic species into adjacent forests (P. Lyons, City of Mississauga, personal communication, September 15, 2005). Some biologists call for the curbing of human activities and land uses adjacent to sensitive forests as a means of mitigating the spread of exotics (Hobbs & Humphries, 1995). Others recommend the planting of ecotypical plant species in street, yard, and commercial plantings within the surrounding urbanized ecosystem as a means of reducing the reservoir of exotic species' propagules (Levenson, 1981).

3.1.3 Alteration of Wildlife Communities

Most studies of the relationships between wildlife and housing have involved birds. Studies indicate that forests with adjacent housing have a decreased bird species richness and diversity and an increase in biomass and density, and dominance of a few species relative to similar forests within rural areas (Beissinger & Osborne, 1982; DeGraaf & Wentworth, 1981; Friesen, Eagles, & MacKay, 1995; Gotfryd & Hansell, 1986; Jokimaki & Huhta, 2000). The diversity and abundance of interior forest birds (birds that only nest in the interior of forests and are rarely found near the edge (Freemark & Collins, 1992) decreases as the number of houses within 100 metres of the forest border increases independent of forest area. Even smaller fragments (e.g. four ha.) without adjacent housing were found to have higher neotropical bird species diversity and abundance than larger (e.g. 25 ha) fragments with adjacent housing (Friesen et al., 1995).

The specific factors associated with housing that lead to these negative impacts have not been identified. Some researchers argue that increases in the number or density of predator species within urban areas relative to non-urban areas, contribute to reduced native bird species richness (Engels & Sexton, 1994; Wilcove, 1985). For example, Engels and Sexton argue that certain native bird species are negatively affected by increased nest predation and nest parasitism by urban predators, such as blue jays (Cyanocitta cristata), and brown-headed cowbirds (Molothrus ater). They argued that urban development introduced blue jays into a previously forested area where they did not exist, leading to the decline of an open-nesting songbird, the golden-cheeked warbler (Dendroica chrysoparia) (Engels et al., 1994). Other ecologists suspect that predators such as free-roaming domestic cats (Felis domestica) may be important contributors to the decline of native bird species diversity in urban areas. Approximately 30% of urban American households own domestic cats (Coleman, Temple, & Craven, 1997) and they have large hunting home ranges of between 1.7 and 2.6 hectares in area (Haspel & Calhoon, 1993). One study indicated that each cat living in small towns consumes an average of 14 wild animals annually, 20% of which are birds (Coleman et al., 1997).

Fewer studies have looked at the effects of housing on other forms of wildlife. Vogel found a curvilinear-inverse relationship between deer species diversity and abundance and housing density. Deer using intensively developed areas were nocturnal, had different habitat-use patterns, and were mostly white-tailed deer (Vogel, 1989). Other studies indicate that some forms of native wildlife, such as some species of deer, coyotes, raccoons, skunks, muskrats, field mice, gulls, Canada geese, and foxes increase in abundance in urban areas and become irritants to human populations (e.g. causing property damage or spreading diseases, such as Lyme disease and Rabies) (Atwood, Weeks, & Gehring, 2004; Broadfoot, Rosatte, & O'Leary, 2001).

3.2 Effects of Forest Landscape Elements on Adjacent Residential Ecosystems

Few studies have determined the effects of forests on immediately adjacent housing or residents. Most have recorded the positive effects of forests on people in general. Other positive values of adjacent forests to humans include improved human health (Faber-Tayler, Kuo, & Sullivan, 2001; Wells, 2000; Kaplan, 1995), improved air quality (Scott, Simpson, & McPherson, 1999), micro-climate (Brown & Gillespie, 1990; 1995); and increased property values with proximity to open space (Geoghegan, Wainger, & Bockstael, 2007; Furuseth, 1989; Zacker, Bourey, Punacher, & Lagerway, 1987).

Negative consequences are also possible. Many studies have measured the negative effects of natural areas, or living adjacent to these areas. These include: 1) hazardous hydrological events, such as increased flooding of properties (Cox et al., 1996); 2) property damage by wildlife (Ontario Soil and Crop Improvement Association, 2000); 3) smell and noise-related disturbances from wildlife (Carles, Barrio, & de Lucio, 1999); 4) irritation from insects or diseases (Cromley, Carter, Mrozinski, & Ertel, 1998); 5) the invasion of privacy (Parsons, 1995); or poor aesthetics (Bixler & Floyd, 1997); and 6) increased crime levels (Esseks, Schmidt, & Sullivan, 1999), or fear of crime (Jorgensen, Hitchmough, & Calvert, 2002).

3.3 Activities and Effects of Adjacent Residents on Suburban Forest Edges

Studies have recorded residential encroachment activities noting their prevalence within suburban forest fragments (Dougan, 1984; 2002; Ouellet & Suffling, 1992; Ouellet, 1996; Taylor, 1992; Matlack, 1993). However, relatively few have identified encroachment motivations, patterns, intensities, extents, and effects on forest features, functions and values. An understanding of edge-resident encroachment behaviour will better inform municipal natural area protection strategies and tools.

Evidence of adjacent resident activities (e.g. grass clippings, woodpiles, yard debris, construction rubble and firewood gathering) and of recreational activities (e.g. children’s forts, damaged trees, fire rings and campsites) were recorded within suburban forests with adjacent suburban housing (Matlack, 1993). The evidence of yard-related activities were significantly more frequent in the forest edge than in the forest interior, with 95%

of the evidence within 19 metres of the forest border (Matlack, 1993). Matlack concludes that both yard and recreation activities are significantly more frequent in forest edges adjacent to housing than in the interior of forests, recording 95% of the evidence of yard and recreation activities within 70 metres from the forest border. However, evidence of this housing impact zone is weak. Although Matlack found that the evidence of combined yard and recreation activities was significantly more frequent in the forest edge than the forest interior, he did not find the evidence of recreation activities, by themselves or as a group, to be significantly more frequent in forest edges adjacent to housing (Matlack, 1993). Matlack recorded this evidence within 40 eastern deciduous forests, 100 to 300 metres in width, ranging from 0.7 to 20 hectares in size. At least 10 detached residential units were located within 100 metres of the forest border on one side. Matlack located the evidence by randomly walking through the fragments and measuring the distance from the evidence to the nearest forest border, footpath, road and residence (G. Matlack, personal communication, March 11, 2004).

Although few studies have measured the effects on the natural features and functions resulting from edge resident encroachment activities, observations of these activities have led researchers to conclude that effects may include: 1) loss of native vegetation, 2) hacking of trees, 3) soil compaction, 4) erosion, 5) loss of forest habitat, 6) loss of woody debris, 7) alteration of nutrient cycles, 8) extension of micro-climatic edge and therefore possible loss of interior forest habitat (Taylor, 1992; Matlack, 1993).

Some municipalities have increased their liability coverage to protect themselves from the safety risks associated with encroachment activities (Dougan, 2002). For example, a recreationist may fall from a structure constructed within the forest edge by an adjacent resident. This indicates that there are financial impacts to municipalities and therefore to the public resulting from residential encroachment activities.

Few studies have measured the effects of encroachment on the equity, recreational and aesthetic values of forests. Studies that have identified the effects of degrading human activities on these values suggest that they may be degraded through encroachment activities. Research within both rural and forested landscapes indicate that recreational activities that result in the deposition of litter, damage to vegetation, fire rings, trail erosion, and widening and muddiness, degrade the spiritual and aesthetic values that enhance the recreational experience (Brown & Haas, 1980) Research also indicates that the accessibility of public forests is important (Tyrvaiinen, Pauleit, Seeland, & De Vries, 2005). Most people within communities want to live close by a natural area so that they can use it frequently. However, edge residents who encroach into community-owned forests have greater access to their resources. This erodes the equity values inherent in community-owed forests.

Human health may also be affected by encroachment activities that degrade natural systems that perform vital ecosystem services to human communities (Cairns & Pratt, 1995; Tzoulas et al., 2007). For example, encroachment activities within riparian zones designed to slow down and filter storm water may degrade the ecosystem services performed by this area, for example, by creating pathways that prevent the sheet flow of water through the riparian zone (Cairns et al., 1995; U.S. Environmental Protection Agency, 1995). Studies also indicate that waste materials discarded in forests by residents, such as tires, or empty containers, can be used as a breeding ground for mosquitoes carrying viruses such as West Nile virus (Carlson, Keating, Mbogo, Kahindi, & Beier, 2004; Medlock, Snow, & Leach, 2005; Rainham, 2005).

3.4 Structural and Functional Roles of Boundaries between Landscape Elements

Landscape elements are composed of edge and interior habitat areas (Forman, 1995). An edge is the outer portion of a landscape element in which influences from the adjacent ecosystem prevent interior environmental conditions from developing (Forman, 1995). Between landscape elements, boundaries consist of the edges of adjacent landscape elements and the border between elements. Forman (1995) defines a border as the "line" separating the edges of two adjacent landscape elements (Forman, 1995). In this dissertation, the "line" is defined by the spatial limit of forest vegetation that has some form of saum (see below for definitions of forest vegetation anatomy). Housing/forest boundaries are made up of housing and forest landscape element edges and the housing/forest border (Figure 3.1). There are also boundaries between spatial units at coarser and finer scales. For example, circular boundaries may be formed between clearings made by children's tree forts and the surrounding forest vegetation.

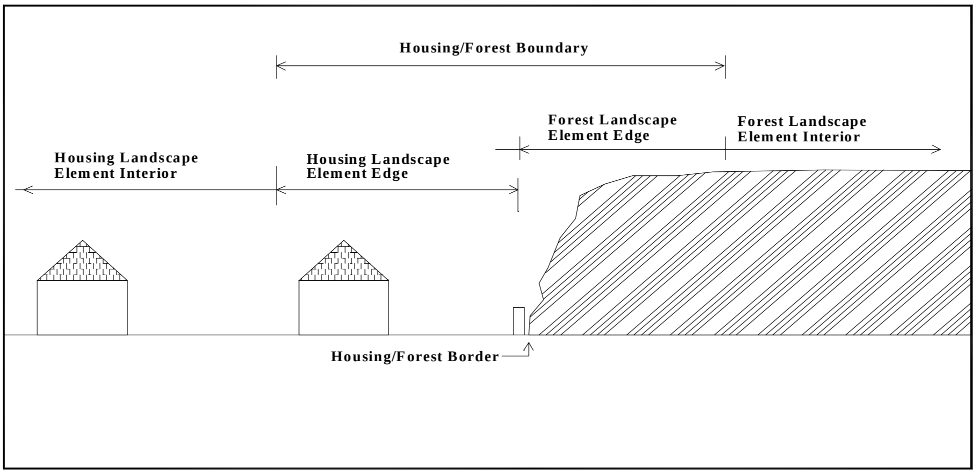


Figure 3.1 Conceptual illustration of elements of the housing/forest boundary
(Adapted from the boundary theory of Forman (1995))

Boundaries perform five ecosystem functions: habitat, conduit, source, sink, and filter that allow them to play a key role in controlling biotic and abiotic flows, such as heat, wind, water, vegetation and animals within and across boundaries into the adjoining interiors of landscape elements (Wells, 2000; Smith & Hellmund, 1993; Forman & Godron, 1986; Bennett, 1990; 1991).

They provide habitat for many life forms. Relative to the interior areas of landscape elements, edges can be characterized by high species diversity, density and biomass of wildlife, plants and other forms of life, including humans. This is referred to as the "edge effect"(Leopold, 1933). These species mainly consist of edge species (i.e. those that mainly or only occupy the edges of an ecosystem) and generalist species (those that occupy either the edge or the interior of an ecosystem). Less frequent are the interior species that occupy mainly, or only, the interior of an ecosystem. Most edge and generalist species are common in landscapes because most are not limited to edge areas, while interior species are less common because many are limited, or more limited, to their interior habitats (Forman, 1995). Large, compact or wide ecosystems tend to have more interior, and more habitats, and less edge habitat than small, elongated ecosystems, and therefore tend to be more biodiverse. When rare in a landscape, large patches are often responsible for maintaining landscape-scale biodiversity and vital ecosystem processes not performed, or not performed as well, by small patches, including water quality and quantity protection for aquifers, streams and lakes (Hobbs, 1993). Boundary properties control the width of edge habitat that determines the amount of interior habitat available for threatened species.

Boundaries also function as important conduits for different biotic and abiotic elements. They facilitate, and sometimes impede, the dispersal of species through a local ecosystem, such as a forested patch or corridor, or from patch, or corridor to patch across a landscape. This function is particularly important for less vagile species and metapopulations ("assemblages of sub-populations which interact in space and over time across landscapes") (Ahern, 1995), and for the recolonization of interior species that have gone extinct in large patches. The conduit function of boundaries is also of key importance to humans in urban landscapes. Boundaries that are corridors frequently encompass waterways that ensure water quality and quantity within cities and/or provide non-polluting, healthy modes of human transport and entertainment that connect residential, commercial and industrial areas and contribute to neighbourhood identity. Popularly referred to as 'Greenways' in North America or 'ecological infrastructure in Europe', edge corridors (and other natural area systems that may include boundary patches, or patches and corridors with interior habitat) have become popular concepts for open space planning throughout Europe and North America for achieving these multiple functions. Planners and designers frequently assume that all the functions of these open space systems are compatible, both with each other, and with surrounding land uses; however, there is little empirical theory to support these assumptions (Forman, 1990; Smith et al., 1993; Vos & Opdam, 1993).

Boundaries, and their edges, also function as receptacles and sources of biotic and abiotic elements. Elements from the edge of one local ecosystem (edge functioning as a source) may move into the edge of the adjoining local ecosystem (edge functioning as receptacle or sink). For example, yard waste may be dumped into, or a domestic cat may hunt within the forest edge, which then becomes a receptacle for the yard waste, or a sink for the forest bird that is killed by the cat.

Lastly, a boundary and each of its edges functions as filters. All boundaries are 'semi-permeable membranes' (Forman, 1995). They prevent some biotic and abiotic elements from passing, and allow others to pass or partially pass through holes in the edge (or boundary), or through chemical interaction (Forman, 1995). They also affect the rate at which elements pass.

Microclimate, soils, animals and humans determine the structural properties of the boundary that, in turn, determine its filtering function (Forman, 1995). A boundary's structure is described in terms of its width, vertical and horizontal properties. Its vertical properties include its height, density and stratification. Its horizontal properties refer to its length, curvilinearity, and whether it has nodes (i.e. small, embedded alien ecosystem patches), or lobes or coves of its own ecosystem extending out into an adjacent ecosystem) (Figure 3.2). Manipulating these structural properties in the boundary as a whole, and within each edge and the border influences a boundary's filtering capacity (Forman & Moore, 1992; Giles, Jr., 1978; Yahner, 1988). However, many researchers have focused their research on understanding the properties of only one side of the boundary (usually within the ecosystem that contains the threatened species or function) and the border (for example see Forman, 1995). These structural properties change through time and across space (vertically and horizontally) and therefore require management if desirable filter functions are to be maintained through time (Forman, 1995). For example, a riparian buffer (a type of edge with an important filtering function) may be designed to filter sediment; however, overtime the buffer can be inundated with sediment, preventing it from performing this function (Lammers-Helps & Robinson, 1991).

The structural properties the most determine permeability for a particular biotic or abiotic element is dependent in large part on the vectors that carry them (Forman et al., 1986; Forman et al., 1992; Forman, 1981; Weins, 1991). There are five vectors that transport these elements: wind, water, flying wildlife, terrestrial wildlife, and humans (including their machines). The most is known about filters associated with the first two vectors, wind and water. They require outside energy gradients to drive them. The rate at which they flow across the boundary depends on their kinetic energy. To filter wind and water the boundary needs to slow their movement. This is commonly the purpose of riparian buffers, which are located in the edges of natural areas bordering waterways. Their widths, soils, topography and vegetation function to slow down and filter incoming stormwater.

The existence of a different microclimate (exposure to heat, light, moisture, winds) within the housing area alters the microclimate in a forest edge. This changes the abiotic conditions under which forest plants, animals and insects would be expose to prior to the generation of the forest border. Keeping this distance to a minimum is important if the planning or management goal is to provide a supportive environment for native forest organisms, and discourage exotic or non-forest native species. Small or narrow fragments have large amounts of edge exposed to these different microclimatic conditions relative to their more protected interiors. They are particularly vulnerable to the affects of these flows and their ecosystems can become completely altered following adjacent land use development (Murphy, 2006), particularly if the filtering capacity of their boundaries have been compromised, restored and managed.

The distance into the forest edge at which microclimate is altered depends, in part, on the exposure. Differences in microclimate penetrate further into edges that face into the sun and wind. This distance can be reduced by maintaining or managing vegetation within the boundary. For example, the vertical structure of a forest edge is made up of four vegetation layers: the saum (the herbaceous layer of the forest floor); the mantel (the dense shrub and understory tree layer); the veil (side-canopy or the foliage of canopy trees connecting the mantel with the canopy) and the canopy. The saum, mantel and veil serve as filter light, heat and wind (Forman, 1995). In addition, studies indicate that there is no edge effect, or increase in wildlife associated with edge habitat, when the mantel is missing (Forman, 1995; O'Meara, Monkler, Stelter, & Nagy, 1981). Following the creation of a new forest border, the re-development of the saum and mantel and their species composition are determined by the position of limit of chronic disturbance (such as a residential boundary) boundary) relative to tree architecture. Studies indicate that if the limit of disturbance is positioned at the tree trunk, the mantel often does not form, nor the saum. However, if the limit of development is placed at the canopy dripline, they both will develop (Forman et al., 1986; O'Meara et al., 1981; Ranney, Bruner, & Levenson, 1981).

Studies indicate that boundary structures that affect permeability to wildlife and humans are more complex. Transportation across boundaries for these vectors depends on internal energy. Studies indicate permeability for components carried by these vectors depend on: 1) the vertical structure of boundary vegetation, 2) the abruptness, or rate at which boundary structures change from one side of the boundary to the other, 3) the suitability of the edge or interior habitat (or its attractiveness or value to humans) 4) the density of a species population within the edge or interior habitat, and 5) the location of human-created boundary relative to one produced by a change in the physical environment, such as a stream, or ridge (Ambrose, 1987; Buechner, 1987a; Buechner, 1987b; Correll, 1991; Schonewald-Cox, 1988; Stamps, Buechner, & Krishnan, 1987; Weins, 1991; Wiens, Crawford, & Gosz, 1985).. In general, the more complex the boundary, in terms of both vertical (i.e. many layers) and length (i.e. curvilinear, many lobes, nodes and coves) the more permeable the boundary to these vectors (and the elements they carry, such as seeds) and the further they penetrate into the adjacent ecosystem (Forman, 1995; Forman et al., 1992; O'Meara et al., 1981;).

Abrupt and straight boundaries tend to reduce permeability (Ambrose, 1987). Landscape ecologists hypothesize that borders generated by human activities, such as housing development, are largely straight or 'hard' (Klee, 1964). This contrasts with boundaries generated by differences in physical environment (such as different soils) or by natural disturbance (such as by wildfire), which are hypothesized to be largely curvilinear with nearby tiny patches of one or both ecosystem types (Forman, 1995), and are referred to as 'soft.' (Klee, 1964) (Figure 3.2).

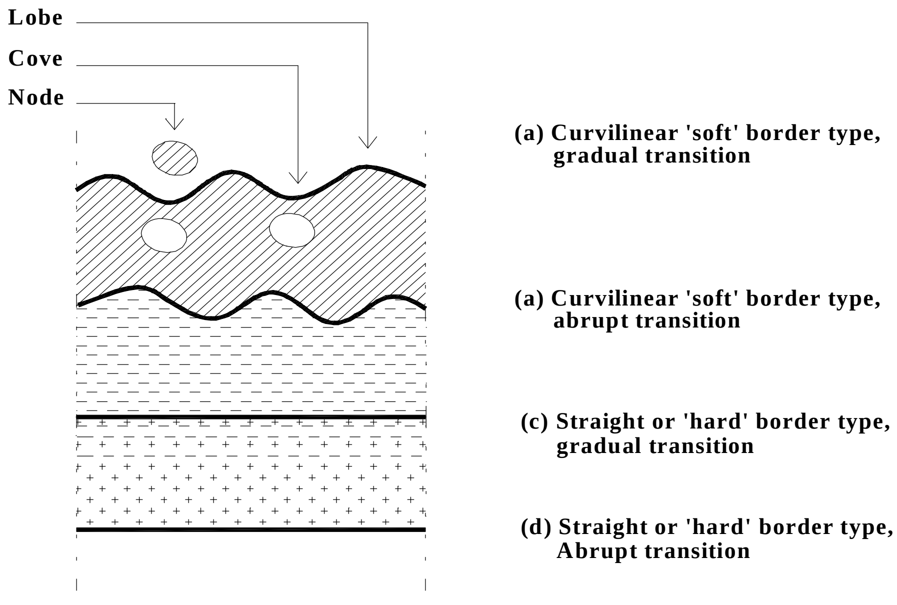


Figure 3.2 Conceptual illustrations of boundary patterns between ecosystems
(Adapted from Forman (1995))

3.5 The Boundary Model of Natural Area Protection

"The boundary model" was developed by Schonewald-Cox and Bayless (1986) as a framework for understanding the filtering functions of boundaries for the protection of nature reserves or natural areas from the direct and indirect cross border impacts of adjacent human land uses. The model asserts that each edge within the boundary is composed of a series of filters that protect the values within the adjacent ecosystems and that the condition of these filters indicates the extent to which a natural area is protected, "We treat the boundary as a skin, whose condition can indicate the health of the entire ecosystem" (Schonewald-Cox, 1988).

In this model, sociological filters are added to the filters provided by the structural properties of the boundary. The extent to which a natural area can be protected against the impacts of external land uses is dependent on 1) the structural and human-generated boundary filters, 2) the extent to which they are upheld through time, 3) the degree of similarity between the adjacent ecosystems, and 4) the degree of similarity between the values and land use objectives of the adjacent landowners (Schonewald-Cox, 1988). Sociological filters might include the property line, a law, or law enforcement. For example, a property line only exists on paper. It is not physically tangible, i.e. animals, plants, soil, water, air and other biotic and abiotic flows do not recognize it. The human response to this filter determines its protective functions. People who do not obey the rules of conduct (for example those who extend their yards into a municipal forest), have breached this filter. When this happens, physical, biological and anthropological habitat changes and edges, or "generated edges" physically form and dissipate at varying distances from the property line into the ecosystem edge (Schonewald-Cox & Bayless, 1986). These changes may affect the structural filters within the boundary and increase or decrease their filtering capacity for other abiotic and biotic elements flowing into, out of and along the boundary. For example, a resident may not respect the administrative boundary and decide to extend her garden into the forest edge. She removes the shrubby closed forest edge understory and installs a lawn under the forest trees. The extent of the lawn may mark the extent of this generated edge. This might alter the distance into the forest edge in which microclimate and vegetation differ from those of the interior of the forest. These new microclimatic and vegetative generated edges may serve as filters to species that require interior forest habitat.

All these edges change in space and time along the length and breadth of the forest. For example, housing construction planners may have used the administrative boundary to determine the forest vegetation edge, thus giving this boundary a physically tangible form. Subsequently, a resident might decide to encourage the forest vegetation edge to extend onto her property and a neighbour could choose to expand his yard into the forest, thereby shifting the forest and residential yard vegetation to either side of the administrative boundary. The administrative boundary remains the same, but the generated edges shift (Figure 3.3).

If some of the filters that protect a boundary are not upheld by the owners and administrators of an ecosystem, then protection of the ecosystem will, in part, be determined by the adjacent landowners, some of which may decide to disregard any of the filters that protect the adjacent ecosystem (Schonewald-Cox, 1988).

The number or impermeability of filters, in addition to the amount of resources required to uphold them (such as law enforcement) increase with the dissimilarity of the adjacent ecosystems (Ambrose, 1987; Diamond, Bishop, & van Balen, 1987; Schonewald-Cox, 1988). For example, a residential yard characterized by frequently maintained mown grass and carefully placed borders of exotic plants might be planned along side a municipal forest that is characterized by a lack of maintenance, randomly growing trees, shrubs, plants, branches and human waste. Under these circumstances, this theory suggests that without strong filters, the forest will become more like the residential garden over time not only because of the visual and functional differences between the ecosystems, but also because of the differences between their level of maintenance or care.

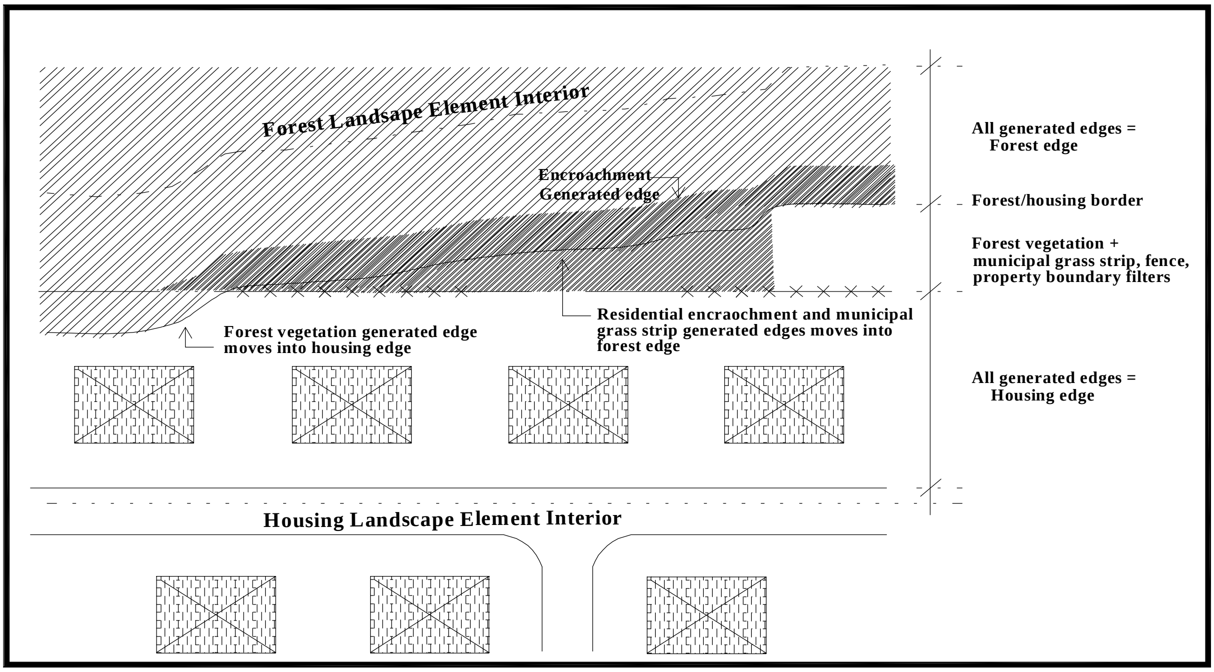


Figure 3.3 Conceptual illustration of housing and forest edge boundary relationships according to the Boundary Model of natural area protection
(Based on The Boundary Theory of Schonewald-Cox and Bayless (1986))

Similarly, the degree of similarity between the land use and protection objectives of the adjacent landowners influences the required filters, and resources required to implement the filters. If a landowner is aware of and agrees to how a natural area will be used and protected, then he is more likely to respect the filters, and may play an active part in enforcing them. Land use goals and protection objectives of nature reserves are often not communicated to adjacent landowners (Schonewald-Cox, 1988). These latter two theories point to importance of understanding what motivates people to alter adjacent natural areas, whether advertently or inadvertently. Nassauer (1999) argues that planners, designers and managers will be more successful in implementing policies or designs that achieve ecological objectives if human needs, including cultural preferences and desires, are met (Nassauer, 1999). If we understand how people perceive a natural area, and what motivates them to interact with it, then we can plan and design environments (or boundaries) that fulfill the needs of adjacent residents, while protecting and enhancing the ecological functions of adjacent natural areas.

3.6 Strategies and Tools for Managing Internal Boundaries in Backcountry Nature Reserves

3.6.1 Factors Influencing the Effects of Human Activities on Forest Ecosystems

Strategies and tools developed within recreation ecology research rely on an understanding of the factors that contribute to the impact of recreational activities on forest ecosystems. The scope of these effects is a product of the intensity of the activity and its areal extent (Cole, 2003). The intensity of the effect of activity is, in turn, determined by the frequency of the event; the type of effect; the behaviour of the effect (or the way in which the activity or effect occurs); and the season and the ecosystem in which the activities take place (Cole, 2003).

Research manipulating these variables establishes the degree to which they influence the total effect of recreational activities. Lessons learned from the research have led to the formulation of a variety of strategies to protect the ecological values of backcountry forests while maintaining standards necessary for a variety of recreational experiences (Manfredo, Driver, & Brown P.J, 1983). See Section 2.3 for a definition of strategy. Tools (and policies) implement strategies. They are described here as direct or indirect. Direct tools, or policies, in terms of planning or managing human activity impacts in forests, seek to regulate the effects of activities by denying recreationists or residents the opportunity to conduct an activity or to conduct it in an unacceptable way. Indirect tools seek to regulate the effects of activities by encouraging people to refrain from activities, or to perform them in a way that avoids unacceptable levels of degradation (Gilbert, Peterson, & Lime, 1972).

3.6.2 Strategies for Limiting the Spatial Extent of Human Activity Impacts

Backcountry recreational research defines the area of effects (of human activity impacts) as the space over which the effects occur (Cole, 1993). For many types of effect, the area occupied by the activity is approximately the same as the area of effect (Figure 3.5). In contrast, the relationship between frequency of use and intensity of use is curvilinear. This means that the frequency of activities within an area has to be significantly reduced before a reduction in intensity of use is achieved (Figure 3.4). These relationships suggest that, in terms of encroachment activities, strategies that reduce the area of housing adjacent to forests would lead to a greater reduction in total impact than strategies that reduce the frequency of encroachment activities. Research measuring the impacts of recreational activities on vegetation, soil, and some species of wildlife, have demonstrated these relationships (Cole, 1981). The consistency of this finding led to a consensus among many backcountry researchers and managers that controlling the area of effects is the most effective strategy for reducing the total impact of recreational activities, within all but very lightly used areas (Cole, 1981; Mieczkowski, 1995).

3.6.2.1 Concentration Strategies

There are two related strategies for limiting spatial extent of recreational impacts in recreation ecology: concentration and segregation. The first seeks to concentrate the human activities in limited areas, if possible where they can do the least damage to ecological and social values, or in areas that are already in use. At the scale of an individual forested park, this might involve zoning to concentrate use in particular areas that are resistant or resilient to the effects of the activities, and in areas where camping activities have already taken place. Within such areas, activities might be further restricted to as small an area as possible. This might involve clustering campsites or placing them close to trails in a linear pattern, thereby reducing the distance within which effects penetrate the forest. Campsites and trails may also be designed to minimize their area of effect by clear delineation of their spatial limits through surface hardening or the placement of physical or natural barriers, such as areas of dense prickly vegetation. Indirect tools, such as education and the provision of trails and entry points, can also be used to encourage concentration of use (Farrell & Marion, 1998).

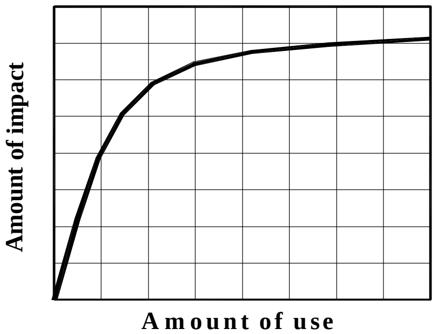


Figure 3.4

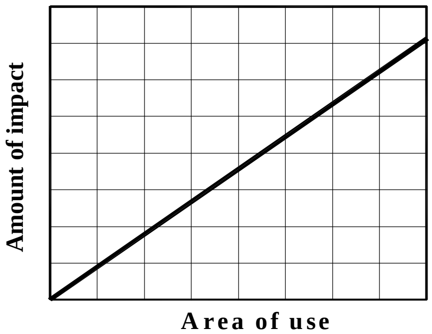


Figure 3.5

Figure 3.4 Generalized model of asymptotic relationship between the amount of use and impact
Figure 3.5 Generalized model of linear relationship between the area of use and impact
(Adapted from (Cole, 1993)

A containment strategy to mitigate edge resident activities could be implemented at multiple scales. Housing patterns and densities could be focused adjacent to areas of forest or forest edges that are least sensitive or most resistant and resilient to edge housing and recreational activities in general. The density of housing could be increased in areas of existing housing and other more supportive land uses could replace housing adjacent to sensitive natural areas. Housing might be arranged in concentrated patterns to reduce the length of forest edge in contact with housing. Limits to edge resident activities could be established through boundary markers and barriers, or concentrated along edges with natural barriers to activity, such as poorly drained areas. When vegetation forms a natural barrier, there is some evidence that trampling is reduced (Magill, 1970). However, Matlack found that the presence of a closed canopy forest border did not significantly impede edge resident activities within the forest edge (Matlack, 1993).

3.6.2.2 Segregation Strategies

A second strategy separates the areas where the recreational impacts occur from adjacent areas of social and ecological sensitivity. Recreation research suggests that buffers might be placed around campsites to provide sufficient room to accommodate their effects without damage to adjacent sensitive areas. In addition, certain forests or forest areas can be closed either permanently or during certain times of the year, where and when ecosystem resistance or resilience to activity effects are low (Clark & Stankey, 1979; Cole, 1981; Stankey, Cole, Lucas, Peterson, & Frissell, 1985; USDI National Park Service, 1997).

In forested landscapes, segregation strategies at coarse scales accommodate species with the largest area requirements (such as the wide-ranging Florida panther). Seasonal or non-seasonal buffer zones restrict humans, roads and other structures (Bruinderink, Van de Sluis, Lammertsma, Opdam, & Pouwels, 2003) within certain distances of the species' core habitats (Fernandez-Juricic, Jimenez, & Lucas, 2001). Within suburban landscapes, many of the space-requiring and disturbance-sensitive species found within backcountry forests are missing or rare. However, birds, amphibians, or large herbivorous mammals, such as white-tailed deer, have been promoted for this role (Lofvenhaft, Bjorn, & Ihse, 2002). A segregation strategy was recently recommended in support of the natural area corridor in North Hespeler in Cambridge, Ontario, to buffer the habitat of white-tailed deer and the area's hydrological functions (Planning & Engineering Initiatives Ltd., 2002). However, some ecologists argue there is insufficient information about the habitat needs of these species in suburban landscapes. Studies have largely taken place within rural landscapes and have not accounted for the effects of urban or suburban land uses (Dougan, 2003).

Most segregation strategies within urban landscapes involve the use of relatively-narrow, vegetated buffers to segregate hydrological corridors and wetlands from the negative impacts associated with alterations in hydrological and chemical flows from adjacent urban land uses (e.g. Ontario Ministry of Natural Resources, 1987). However, when municipalities place buffers adjacent to edge housing the concern arises that human activity effects within these buffers may impede the designed buffer function. Human activities, or adjacent land uses, may increase the amount of incoming pollution beyond expected levels, remove or alter vegetation designed to reduce the velocity, or filter, water. They may also compact or erode the soil, channelize drainage water, or reduce the porosity of the buffer (Norman, 1996; Schueler, 1987; U.S. Environmental Protection Agency, 1995). The addition of pathways may also lead to some of these impacts on buffer function (U.S. Environmental Protection Agency, 1995). The U.S. Environmental Protection Agency recommended that no land use be allowed in the buffer that could reduce the designated function of the buffer, particularly uses such as playing fields and structures (U.S. Environmental Protection Agency, 1995). Where such restrictions are not possible, it advocates practices that reduce the channeling of flow associated with pathways, physical barriers such as fences or dense and high or prickly vegetation, or wider buffers. (U.S. Environmental Protection Agency, 1995).

Some biologists recommend buffers as a means of controlling the spread of undesirable exotic plants within natural areas that are highly vulnerable to invasion, such as watercourses and riparian areas (DeFerrari & Naiman, 1994). In such ecosystems, the introduction of an invasive species at any one point can lead to its rapid dispersal throughout the system. In addition, it is recommended that dispersal agents, such as pedestrians, pets, roads or vehicles, be restricted from these areas to reduce the spread of these plants (Amor & Stevenson, 1976; Amor & Piggin, 1977; Lonsdale & Lane, 1991).

3.6.3 Strategies for Limiting the Intensity of Human Activity Impacts

3.6.3.1 Frequency Reduction Strategies

Traditionally, backcountry forest managers attempted to reduce the total impact of recreational activities by limiting the intensity of effects, primarily through a reduction in the frequency of campsite use. This strategy was frequently supplemented by attempts to lessen the effects of particularly damaging types and behaviours of use especially during times of the year in which ecosystems were least resistant. “Carrying capacities” were adopted to establish use levels within areas with different sensitivities. Use levels were set at frequencies below those causing unacceptable levels of effect. These strategies were also recommended for the mitigation of recreation effects within urban forests (Hoehne, 1981). However, a curvilinear relationship was found to exist between the number of times a campsite was used and the intensity of the most visible and easily measured types of effect, such as forest litter removal, loss of woody debris, incidence of hacked trees, soil compaction, vegetation loss and camp fire effects (Cole, 1987; Cole & Monz, 2004) (See Figure 3.4). This relationship suggests that only a low level of use is required to generate near-maximum levels of intensity for these effects. Once reached (estimated to take two to five years in a “typical campsite”), much higher frequencies of use are required to significantly increase these levels of intensity. However, other variables, such as mineral soil exposure in forests with low litter production, and tree damage, tend to continue to degrade over time because it takes them much longer to recover than the effects of vegetation loss and soil compaction (Cole & Landres, 1995).

A similar curvilinear relationship was found to exist between recreational activities and some species of wildlife. For example, elk and moose moved away from cross-country ski trails, but the distance they moved did not increase with the number of skiers (Ferguson & Keith, 1982; Zacker et al., 1987). It is not clear whether this pattern applies to the relationship between human disturbance and the intensity of effect on birds. The number of species and abundance of neotropical birds have been found to decrease significantly when the number of houses jumps from between eight and 15 to more than 25 within 100 metres of the forest edge. However, it is not known whether the trend continues when the number of houses is greater than 25 (Friesen et al., 1995; Zacker et al., 1987).

Within backcountry forests, apart from within areas with very low levels of use, reducing the frequency of use has not resulted in significant reductions in the intensity of effects. Campsites that had unacceptable levels of impacts were closed and new ones opened. However, researchers found that it resulted in an expansion in the total area of use because recovery from camping impacts took many times longer than it took the effects to occur (Cole and Monz 2004). For example, whereas the near-maximum effects of human activity are estimated to occur within two to five years, signs of recovery from exposure of mineral soils and soil compaction were visible within Kings Canyon National Park after 15 years, while pre-disturbance vegetation communities had still not recovered (Cole 2003).

Limiting the amount of encroachment activity might be achieved at the municipal scale by zoning adjacent land uses that are known to lead to lower frequencies of encroachment. At the housing edge scale, indirect actions might be implemented, such as resident education, stewardship programs or a segregation strategy to make it less convenient for residents to encroach. For example, a wide active recreation area or stormwater management area could be designed between the housing and the forest edge. Such a strategy might also involve more direct actions such as by-law enforcement. Restrictive boundaries such as fences and dense, prickly forest edge vegetation might be installed. In addition, pathways and entryways could be designed to increase forest edge surveillance by staff and residents.

3.6.3.2 Dispersion Strategies

Mitigation strategies that result in the expansion of the areal extent of effects are referred to as dispersal strategies. Their intent is to spread the activities over space so that the effects of the activities in any one area occur at an acceptable intensity. From an ecological point of view, this may mean reducing the frequency of use in an area to the level at which the forest ecosystem can recover to pre-use conditions within an acceptable time. In terms of recreational values, this might mean reducing frequency of use in one area to maintain the recreational values (solitude or naturalness) within an adjacent area (Dailey & Redman, 1975).

Strategies to disperse the effects of activities can be implemented at a number of scales, and can involve both direct and indirect management tools. For example, direct tools might be campsite and trail use restrictions or, at coarser scales, area or forest use restrictions. Within a forest, these restrictions can be enforced at entryways, but also through restricting certain use capacities for facilities such as parking lots. Once these capacities are reached, other areas of the park, or other parks, meet surplus demand for recreation and thus use is dispersed. In backcountry areas, this strategy has most often been implemented through indirect means, such as requesting campers to disperse voluntarily. For example, park visitors may be asked to camp a certain distance from sensitive resources or from other campers. Studies indicate, however, that this tool has often been ineffective in achieving camper dispersal due to non-compliance or other factors that influence the choice of campsites (Eschelberger, Leonard, & Adler, 1983).

Dispersal strategies could be implemented using direct tools by reducing the frequency of effects of adjacent residents at many scales. At the scale of the subdivision, the number of houses immediately adjacent to the forest could be decreased and yard widths increased. At the scale of the individual lot, non-restrictive boundary treatments could be implemented to encourage residents to disperse encroachment activities within the forest edge rather than concentrate them in specific areas.

3.6.3.3 Strategies that Alter the Type of Effect

Within backcountry areas, each type of effect is known to cover a different area and to have different rates of occurrence and recovery. In addition, more significance is placed on some types of effect, depending on the management goals of the forest and, in the case of housing edge effect, the goals of the adjacent landowners. In addition, significance may vary according to the time of year and the ecosystem. Thus, planners, designers and managers may wish to focus on specific types of effect or to develop different strategies for each.

Mitigation strategies might focus on the types of impacts that affect rare or irreplaceable social and ecological values. For example, strategies aimed at maintaining native species diversity within forests frequently focus on protecting rare species or those most vulnerable to human disturbance. Species of wildlife are sensitive to adjacent land use effects or human activities at different scales. For example, some biologists argue that coarser scale effects, such as landscape fragmentation (Donovan, Lamberson, Kimber, & Thompson III, 1997), are responsible for high population densities of generalist mammalian predators of birds within forest edges. Therefore, trying to mitigate the edge effects on these species at the site scale will be ineffective (Heske, Robinson, & Brawn, 1999; Marini, Robinson, & Heske, 1995).

Other strategies focus on the types of effect that are easiest to mitigate. This might be influenced by the cost associated with the rate of occurrence, recovery and the cooperation of residents. For example, the spread of exotic vegetation associated with residential yards may be seen as a significant ecological problem; however, it may be difficult to convince residents of the need to remove invasive plants from their yards. The application of herbicides, a common tool for controlling invasive exotic plants, may not be widely acceptable within residential communities. In addition, removing these plants can be very costly, particularly when they have spread over large areas. Mitigation of this type of effect may be ignored or deferred. Alternatively, mitigation strategies may focus on controlling invasive exotic plants within newly invaded areas, where only small populations exist, or adjacent to newly established housing areas where the use of invasive exotic garden plants is not yet entrenched (Hobbs et al., 1995; Chippendale, 1991).

Some types of ecological effects may only be significant in certain natural areas. For example, within small forests surrounded by housing, rare and irreplaceable plants and wildlife may not exist. Therefore, the emphasis may be on strategies to prohibit activities that degrade social attributes, rather than those ecological within these forests.

Certain recreational and edge resident activities produce specific harmful effects. For example, adjacent resident swimming pools may be associated with an increased risk of water pollution within forest edges. Direct action such as reducing yard sizes to prevent swimming pool construction, or indirect action, such as educating residents in the proper disposal of wastewater, can reduce the incidence of problems. Alternatively, harmful activities may be restricted to forest edges or parts of forest edges. Barriers erected at access points or boundaries between housing and forest borders can allow certain activities, while restricting others. A narrow grass strip between the private property boundary and the forest border may discourage yard extension and dumping activities, while still allowing private access to recreational pathways within or adjacent to the forest. Indirect controls could include signs prohibiting certain activities and monitoring of sites by forest managers or residents. Attention to the needs of residents could be used as a tool to mitigate waste disposal problems. For example, municipal, or regional governments provide curbside pick-up of organic debris such as branches, leaves, Christmas trees, compost and other waste. Such services may discourage, or encourage, the disposal of some waste materials within forest edges.

3.6.3.4 Strategies that Alter the Behaviour of Effect

Reducing or controlling the effects of particularly degrading behaviour is another method of reducing the total impact on the environment. Individual patterns of recreational behaviour differ widely. Particularly degrading types, intensities and areas of effect can sometimes be blamed on certain classes of users. For example, in backcountry recreation areas, campers who cook their food and generally enjoy wood fires are more likely to gather woody debris and hack tree limbs than those who use stoves. Unfortunately, while researchers involved in recreation effects acknowledge that the behaviour of the individual producing the effect may be as significant in determining total intensity as other factors, it has seldom been studied (Cole, 2003).

Many recreation managers and ecologists believe that using indirect management tools, such as education, to influence people's behaviour has great potential for the long-term mitigation of recreation activity effects (Cole, 2003). In theory, visitors may be unlikely to act in inappropriate ways when they are unaware of the link between inappropriate behaviour and the resulting ecological or social problem (Cole, 1993). Visitors may also be less likely to behave inappropriately if they are aware of the appropriate way to act and have a sense of commitment to caring for the forest. An effective program is assumed to be one in which educated visitors are aware of and act upon these areas of knowledge (Cole 1993).

Other indirect tools, such as site design, may also be used to curb inappropriate behaviour among residents. Defensible space theory argues that neighbourhood perception influences the occurrence of anti-social activities within a community. A negative neighbourhood image may attract criminal activity (Geason & Wilson, 1989; Newman, 1972). Therefore, forest edges that residents view as degraded, or ugly, may attract encroachment activities, such as the dumping of waste, that degrade them further.

Environmental crime prevention literature also suggests that areas with low levels of community surveillance are more likely to attract crime (Geason et al., 1989; Newman, 1972; Rubenstein, Murray, Motoyuma, & Rouse, 1980). Therefore, secluded forest edges with adjacent housing may invite more intensive encroachment behaviours. Newman (1972) recommended that public spaces be designed to maximize resident surveillance opportunities. Furthermore, he argued that the definition of territorial limits is important in discouraging anti-social activities because this allows residents to take ownership of their spaces and to feel that they have the authority to defend them against unacceptable activities. These theories were developed further by Rubenstein et al. (1980) who suggested that spaces could be designed to encourage social cohesion and interaction, thus promoting "social surveillance" or the active involvement of residents in monitoring a space for unacceptable activities. These theories have encouraged the development of community monitoring programs, such as "neighbourhood watch."

Recognition that environmental design and police monitoring alone were insufficient to deter crime has led to designs that encourage active management, not just surveillance, by the public. The "manageable space" theory suggests that spaces be physically designed to allow for their management by residents (Perlgut, 1981). Municipalities could develop programs to encourage the cooperation between forest managers and edge residents to improve the management and monitoring of the forest edge.

Fulfilling resident needs is another indirect strategy for reducing undesirable resident behaviours. Strategies that residents perceive as responding to their needs and concerns are more likely to be supported than those they perceive as punitive (Nassauer, 1999). For example, some resident encroachment activities may occur in response to housing edge effects. Forest edge vegetation may be encroaching into a resident's property. In response, a resident may remove some of the forest edge vegetation to prevent this from occurring. Forest management staff may reduce the impacts on forest vegetation by periodically removing a narrow strip of vegetation adjacent to the private property boundary. In return, residents may feel that the municipality has met their needs and cease to encroach. Attempts to mitigate conflicts between adjacent landowners and some of the large American parks have pointed to the importance of securing adjacent landowner support, rather than a reliance on regulations, to protect park values. Park managers found that if the adjacent neighbour was able to exert more political influence than park agencies, then encroachment levels of adjacent landowners tended to be higher (Schonewald-Cox, 1988). This suggests that it is important that residents and regulators work together toward the development of boundary areas that satisfy both housing and forest values.

3.6.3.5 Strategies that Alter the Season of Effect

Some recreational activities produce greater intensities of effect during certain seasons. For example, activities that result in the trampling of vegetation and soils have a greater impact in the spring than other times of the year. In the spring soils are saturated, plants are growing rapidly, and trampling can lead to greater soil compaction, erosion and vegetation loss, than at other times when soils are drier or plant growth has slowed or stopped. Likewise, animals are more susceptible to disturbance during certain times of the year, such as when having their young (Cole, 1993). Within forest edges with adjacent residences, time of year might dictate when encroachment activities are likely to occur. For example, residents may fertilize their lawns and gardens during the early months of the growing season, drain their swimming pools in the fall, and dispose of Christmas trees in early January.

Within backcountry recreational forests, direct management tools for reducing the impact of seasonal effect involve restricting activities during certain seasons or within areas of the forest in which season is a significant factor. Susceptible areas may be avoided by appropriate design of trails and facilities. For example, boardwalks could be placed over trails where seasonal flooding is a factor to prevent them from becoming overly muddy or widened, and to discourage the development of alternative trails. Restricting access within urban forest fragments is difficult, given their high level of accessibility. To mitigate edge-resident effects on forests during certain seasons, direct management tools might include restricting housing or limiting density adjacent to forests or forest edges where season is a factor.

Indirect tools to control seasonal effects might include designing the forest border and edge to withstand or filter these effects. For example, additional vegetation planted along the edge could reduce the disturbance to sensitive wildlife during certain times of the year, or riparian buffers could reduce the effects of lawn chemicals. Educational programs might encourage residents to alter their activities during sensitive seasons, or services such as leaf pick-up could be geared to the relevant times of year.

3.6.3.6 Strategies that Alter the Ecosystem of Effect

The characteristics of the ecosystem within which activities occur can influence the intensity of effect. Some ecosystems or ecosystem components are more resistant or resilient to impacts, or recover more quickly from them. For example, meadows are less vulnerable to trampling than close-canopied forests (Cole, 1987). Individual plants and soils with certain characteristics are also more or less vulnerable to trampling. For example, mid-height plants with an erect growth form and plants with woody, brittle or delicate stems and leaves tend to be more susceptible to damage from trampling than tall or very short vegetation, those that grow in tufts or flat to the ground and those with tough or flexible stems. Also, soils with moderate levels of moisture tend to be less susceptible to erosion than drier soils which have less vegetation to hold the soil in place, and less vulnerable to becoming muddy than wet soils (Cole, 1993; Cole, 2003). The topography of the site might also influence the intensity of effect. For example, trails located on steep slopes are more likely to generate soil erosion and vegetation loss, than those on flat ground.

Management strategies should respond to the ecosystem in which they occur. The idea is to zone recreational uses, based on their expected effects, within areas of the forest most able to resist or be resilient to those effects. This form of zoning is commonly used within management frameworks for large forested parks, and is the basis for such strategies as the U.S. Forest Service's recreation opportunity spectrum (ROS) (Clark, Hoekstra, Boersma, & Kareiva, 2002), the Limits of Acceptable Change (LAC) (Stankey & Schreyer, 1987), and the U.S. National Park Service's Visitor Experience, and Resource Protection (VERP) (USDI National Park Service, 1997).

Suburban forests also possess characteristics that make them more or less resistant or resilient to edge-resident encroachment. For example, terrestrial forests with open canopy edges may be less resistant to edge-resident encroachment than poorly drained wetland forests with closed canopy edges. The former ecosystem, with no natural barriers to encroachment, can expect higher levels of activity and require greater protection.

Zoning similar to that practiced within some backcountry forests could be applied within municipalities to match up the capabilities of forests and forest edges with adjacent land uses and their anticipated effects. For example, forests of high ecological value or having low resistance or resilience might be paired up with adjacent housing patterns and densities, or other types of land use, associated with fewer effects. This matching could be accomplished at multiple spatial scales. Forests with high social value but lower ecological value (or with high resistance or resilience) might be paired with housing patterns or densities linked to high levels of activity, such as schools. Indirect strategies for mitigating these effects might focus educational, stewardship and monitoring programs locally within areas of high ecological values.

3.6.4 Integrated Strategies for Limiting Human Activity Impacts at Multiple Scales

Multiple-scaled and integrated strategies are increasingly applied to the management of large, forested parks and are more effective in reducing the impact of recreation on these ecosystems than single-strategy approaches (Leung and Marion 1999). These management techniques may include both direct and indirect approaches, using multiple strategies at different spatial and temporal scales. For example, some of the American National Parks are managed according to “at large camping policies” where, at coarse scales, campers are allowed to camp in any area (dispersion strategy), but at finer scales containment strategies are applied. However, Shenandoah Park in the United States developed strategies according to zones rather than scale. It relied on indirect actions, such as educational programs, where impacts were less intense and they expected visitors to respond, and direct actions, such as designated-site camping (concentration strategy) in higher impact areas (Leung & Marion, 1999).

Landscape ecology, ecosystem management, boundary and ecosystem planning theory indicate that effective planning and management of natural areas in support of biodiversity and key ecosystem functions needs to occur at multiple spatial and time scales (White, Preston, Freemark, & Kiester, 1999; Allen, Bandurski, & King, 1993; Grumbine, 1994; Tomalty, Gibson, Alexander, & Fisher, 1994; Schonewald-Cox et al., 1986; Schonewald-Cox, 1988). Protection of forested natural areas from the negative impacts of adjacent land use activities occurs not only in the boundary area, but also in the adjacent and more distant landscape elements, depending on the ecological flow of concern. This means that boundary protection needs to occur over wider spatial units, and longer periods than at the scale of the housing/forest boundary, and during and after subdivision development.

3.7 Summary

Chapter 3 reviewed the literature dealing with the theory of boundary planning for the protection of suburban ecosystems from adjacent land use impacts. It described the effects of housing landscape elements on adjacent forest landscape elements, including the alteration of hydrological and chemical regimes, soil and vegetation, and wildlife communities. It described the activities and effects of edge residents on adjacent suburban forest landscape elements. It also outlined the positive and negative effects of suburban forest landscape elements on housing landscape elements. The positive effects on resident health, and property values were outlined. Some of the negative effects were also listed, including property damage due to flooding and wildlife, irritation from insects or disease, the invasion of privacy from recreational forest users, poor aesthetics and increased crime or fear of crime.

The structural and functional roles of boundaries within landscape elements were summarized. Key functions were outlined including: habitat, conduit, source, sink and filter functions. In addition, the chapter summarized the effects of boundary structure on generated edges within the forest. The Schonewald-Cox and Bayless (1986) boundary model of natural area protection is advanced as a framework for understanding the vital filtering function played by boundaries in the protection of natural systems.

Lastly, the chapter outlines strategies and tools developed for managing the internal boundaries created by backcountry recreationists within forest ecosystems. Segregation and concentration strategies are described that reduce the areal impacts of recreation. Strategies are also offered that reduce the frequency, disperse the impacts, and alter the type, behaviour, season and ecosystem of effect, in order to reduce the intensity of recreation impacts. Finally, strategies are offered that advocate the use of multiple strategies at different spatial scales within the forest ecosystem. Suggestions are provided regarding how these strategies can be applied to managing edge boundaries between housing and forest landscape elements.

The next chapter reviews municipal planning theory and practice for protecting natural systems in Southern Ontario suburban landscapes.

Chapter 4

Municipal Planning Theory and Practice for Protecting Southern Ontario Suburban Natural Systems

This chapter presents a review of the literature on the evolution of municipal planning theory and practice for protecting suburban natural systems in Southern Ontario. Sections 4.2, 4.3 and 4.4 describe the theory and practice of planning of urban natural areas in Ontario between the years following World War Two and the present. They outline the major forces in each period that influence the planning of natural areas and systems. This is followed by the legislative context for natural area planning with a highlighting of any changes relative to the previous period. The chapter then describes the theoretical basis for planning urban natural systems. The practice of planning is then discussed, highlighting the principal municipal land use planning tools developed for natural system protection, their implementation and effectiveness. Section 4.5 summarizes this literature review.

Natural areas and systems are defined as components of the natural environment with features most like those that would exist in the absence of human disturbance (Francis, 1980).

4.1 Introduction

The planning of natural areas has undergone dramatic change in the last 60 years. Dorney and Rich (1976) were the first to conceptualize this transition in terms of the response of planning to pre-development ecosystems. They described four progressive levels of complexity in the integration of built form and the natural environment: 1) flat earth planning, 2) contour planning, 3) feature and constraint planning and 4) eco-planning and design. Tyler added to this model by describing this evolution in terms of municipal planning practice (Tyler, 2000). She described three municipal planning frameworks: 1) thematic spatial 2) activity-based regulation, and 3) ecosystem. These frameworks roughly coincide with Dorney and Rich’s levels of urban development. Dorney argued that, in general, urban planning practice within North America proceeded from the first to the second and third levels between the early 1970s and the late 1980s (Dorney, 1987). Between the mid 1980s and the present, practice moved from the third into the fourth, ecosystem-based planning level.

The following sections document this transition in three time periods, roughly coinciding with those of Dorney and Rich’s, and Tyler’s conceptual models: 1) 1945 to the 1960s, 2) 1960s to the 1980s, and 3) 1980s to 2007.

4.2 Natural System Planning from 1945 to the 1960s

Following the Second World War, cities all over the world began to experience dramatic increases in urban population and commercial and manufacturing development (Hodge, 2003). Ontario municipalities focused on ensuring that the necessary infrastructure was in place to support land development, and on arranging land uses spatially so that they did not conflict (Tyler, 2000). Tyler refers to this municipal planning framework as “Thematic Spatial.” This type of planning was largely reactive, allowing developers to take a lead role in determining the future form of the municipality through incremental site-by-site development. Few Canadian municipalities had comprehensive plans prior to the 1970s (Hodge, 2003).

4.2.1 Legislative Context

The *Ontario Planning Act*, enacted in 1946, gave municipalities the explicit authority and the tools to manage urban land use planning and development (Planning Act Review Committee, 1977). Namely, it gave municipalities the authority to: 1) establish themselves as planning areas (usually as municipalities), 2) develop official plans, 3) develop a system of subdivision control, 4) enact zoning by-laws, and 5) develop a planning board composed of a body of citizens to advise council on planning decisions. It also specified how the public could be involved in the municipal planning process and established an appeal procedure for municipal planning decisions (the Ontario Municipal Board or the ‘‘OMB’’) (Hodge, 2003). Between 1946 and 1965, the number of planning areas, official plans and zoning by-laws increased dramatically. In 1946, there were only 36 municipalities established as planning areas, with only one having an official plan, and one having a zoning bylaw. By 1965, 236 municipalities had been established as planning areas, with 57 having official plans and 48 having zoning bylaws (Hodge, 2003).

An official plan provides a municipality with a plan specifying the direction and quality of development for the entire municipality for a future period. The zoning bylaw is considered the primary tool for ensuring continual compliance with the objectives of the official plan (Hodge, 2003). Zoning bylaws specify the use for the land, the coverage of the land by structures and the height of those structures (Hodge, 2003). The subdivision control process specifies how developers can apply for a permit to allow a tract of land to be subdivided into lots. Through this process, many agencies make comments and recommendations as to whether the proposal is compatible with the official plan and the zoning bylaw, and whether is meets design standards that are determined by each municipality. Certain conditions of approval may be specified prior to plan approval dealing with such issues as the conservation of resources or flood control (Estrin & Swaigen, 1978)

The first *Ontario Planning Act* gave municipal governments little responsibility for ensuring a healthy natural environment. In fact, there was no mention in the Act of the natural environment (Melymuk, 1976). The environmental regulations of the Ontario provincial and federal governments (who had the responsibility for the natural environment at this time) were not focused on urban areas, but on resource regions, and the impacts of the exploitation of oil, gas, forestry, fishing and mining sectors on the habitats of sensitive species of wildlife (Tyler, 2000). They also focused on reducing the impacts of existing “point source” pollution by regulating the emission of contaminants from industrial manufacturing (Estrin et al., 1993).

Under the *Ontario Planning Act* (1970) municipal governments obtained some authority to prevent the construction of buildings in flood-prone areas, and in hazardous areas defined by prohibitive public infrastructure costs (Ontario Ministry of Municipal Affairs and Housing, 1970, s 35 (1) (3)). It did not give them the authority to prevent other forms of development on these lands, such as agriculture, forestry, recreation or conservation activities, that might result in their degradation by such means as removal of vegetation. Similarly, the Act did not

give municipalities authority to regulate development within other natural areas such as those with groundwater recharge functions, significant wildlife or historical values (Planning Act Review Committee, 1977).
The municipalities were assisted in their efforts to preserve natural areas by the conservation authorities, who, under the *Conservation Authorities Act* of 1946, had more authority to preserve and protect natural areas than the municipalities had under the *Planning Act* until 1995.

Conservation authorities were established in response to the widespread soil loss and floods that resulted from drought and deforestation in the 1920s and 30s. Their mandate was broad: to implement a wide variety of programs for the conservation, restoration and management of Ontario's water, land and natural resources (Province of Ontario, 1946). Under the *Conservation Authorities Act* (1946), local municipalities could group together to manage their resources on a watershed basis. Conservation authorities identified and purchased natural areas (sometimes together with other agencies), provided recreational opportunities, assisted in the management of private natural areas, and promoted reforestation (Estrin et al., 1978).

According to the *Conservation Authorities Act,* the authorities could make regulations "prohibiting or regulating or requiring the permission of the authority for the construction of any building or structure in or on a pond or swamp or in area susceptible to flooding during a regional storm, and defining regional storms for the purpose of such regulations" (Province of Ontario, 1946). While their main task was flood control, particularly after they became administered by the Ministry of Natural Resources in the early 1970s (Reid, 1986), they could develop programs and regulations aimed at conserving their area's "natural resources." For example, according to the 1970 *Planning Act,* municipalities had to have "regard" for "the conservation of natural resources and flood control" in the review of subdivision proposals (Ontario Ministry of Municipal Affairs and Housing, 1970). Applications for subdivision approval were circulated to the conservation authorities for comment, and these comments significantly influenced the outcome of many (Estrin et al., 1978).

However, a survey of conservation authority managers conducted in 1975 by the Planning Act Review Committee indicated that many conservation authorities had difficulty implementing their mandate. Managers said they often met resistance to their building and fill restrictions from landowners, developers and local councils where the floodplain had already been developed or purchased. Some said they had inadequate financial resources to purchase lands outside floodplain areas. Others argued that municipal bylaws supported engineering practices, such as the exclusive use of storm water sewer systems, which exacerbated the negative impacts of development on the natural area. And still others felt that their authority to preserve and protect areas outside floodplain areas was not strong enough to allow them to implement regulations with respect to natural areas beyond floodplains (Planning Act Review Committee, 1977).

The Ontario Provincial government oversaw municipal land use planning primarily through their approval of official plans. However, a 1975 review of the 'Official Plans Policy Manual' (used by the Provincial Ministry of Housing as a guide) found little consideration of environmental policies. In fact, the study found that the Ministry of Housing did not view these issues as their responsibility, but as that of the Ministry of the Environment and Natural Resources, and the Ministry of Agriculture and Food. Yet, these latter Ministries acted in an advisory capacity only in the review of official plans. Interviews with representatives of these ministries indicated that their environmental recommendations were frequently overruled by officials from the Ministry of Housing, who were seen to be more concerned with encouraging economic growth (Planning Act Review Committee, 1977).

4.2.2 Natural Systems Planning Theory

Between World War Two and the late 1960s, the philosophical basis of ecology as an important foundation for planning human activities continued to develop from its earlier roots in the late 1800s.

During the late 1800s in Chicago, Jens Jensen, a landscape architect, and Henry Cowles, an ecologist, promoted the use of native plants, and the conservation of unique and ecologically significant landscapes in urban areas (Zube, 1986). In addition, in the early 1900s, landscape architects began to design connected park and open space systems largely for their recreational and aesthetic qualities. Some were designed around hydrological corridors. For example, Olmsted and Vaux developed a plan for the Back Bay Fens and the Muddy River in Boston in 1878. A procedure for analyzing the social and biophysical characteristics of planning areas was also developed during this time with Warren Manning's overlay technique of mapping in 1913 (Zube, 1986). The Garden City Movement was also an important influence in the development of ecological planning. The movement was exemplified by the ideas of the British urban planner, Ebenezer Howard, who promoted the deliberate planning of cities, each ecologically self-sufficient and surrounded by agricultural land (Howard, 1898). In addition, Patrick Geddes, a Scottish botanist and physical planner, introduced the theory that changing the spatial form of cities could also change social processes, and the idea of regional planning using social and biophysical land surveys (Geddes, 1968; 1979).

In the early 1900s, Benton MacKaye, an American forester, planner and conservationist, and Mumford, an American historian, were influential in the development of the ecologically based planning perspective. They developed the idea of human ecology as the necessary basis of planning. In addition, they promoted the integration of regional planning with human ecology, defining planning as the "putting into practice of the optimum relation between humans and the region." (MacKaye, 1940, p. 351). MacKaye and Aldo Leopold were among the first to promote the idea of land preservation for recreation and conservation (MacKaye, 1940; Leopold, 1933); and Leopold was one of the pioneers of ecosystem management (Grumbine, 1994). The Ecological Society of America was another pioneer; it was one of the first to call for a core reserve/buffer zone approach to the design of nature sanctuaries in North America (Shelford, 1933). Others recognized that the existing large forested parks were not fully functioning ecosystems because of their inadequate size and inappropriate boundaries (Wright & Thompson, 1935).

The Odum family also made significant contributions to the development of ecological planning theory between the 1950s and 1970s. H.W. Odum, a sociologist, promoted regionalism and regional planning (Odum, 1965). His sons, H.T. and E. Odum, were biological ecologists who advocated the use of the bio-ecology concepts into public policy and land use planning (Steiner, Young & Zube, 1988). E. Odum argued that human ecology is determined by the integration of man's cultural and natural environments (Odum, 1953; 1971) and H.T. Odum modeled ecological energy systems and contributed to the theory of energy management within ecosystems (Odum, 1971).

4.2.3 Natural Systems Planning Practice

Up to the late 1960s, the theory of urban planning was based on the belief that urban land is private property waiting to be developed into social and economic land uses (Tyler 2000). Resolving conflict between land uses was a major preoccupation of planners during this time (Tyler 2000). Planners held to the principle that the best way to prevent conflicting land uses was to segregate them (Filion et al., 2000).

Planners, and others involved in urban land development, also held to the principal that urban areas are not ecosystems, but human-generated and controlled areas (Tyler, 2000). The environment in cities was assumed limited to parks and hazard lands (Dorney, 1987). Planners, architects and landscape architects subscribed to the belief that developing most natural areas, as long as it can be done economically, will maximize the social and economic forms and functions of cities. Most urban natural areas or systems during this time were viewed as engineering problems, most of which could be solved through the ingenuity of engineers (Dorney, 1987). Planners practiced “flat earth planning” during this time period (Dorney & Rich, 1976). This term refers to a development process by which land uses are laid out in a rigid grid pattern irrespective of the pre-existing natural ecosystem. Construction takes place after leveling the land, scraping off the top soil, removing the existing vegetation, and replacing it with exotic nursery stock (Dorney, 1987).

Many planners, architects, and landscape architects valued natural areas as parks for their recreation and aesthetic functions. These values reflected those of the public parks developed during the 19th century romantic movement in Europe and the United States (Hough, 1989), such as the Royal Parks in London, and Olmsted's Central Park in New York City. Planners and designers believed these parks improved human health by providing space for recreation and relaxation (Hough, 1989). These values were reflected in the City beautiful planning movement prominent in North America during the early part of the century that advocated the use of beauty and monumental grandeur in city design to counteract urban blight and inner-city poverty (Hodge, 2003).

Prior to the late 1970s, local municipalities in Ontario mainly designated natural areas in their official plans as conservation, hazard land and open space, although a few included other types of natural areas, such as sites with rare or endangered species, or aesthetically-valued areas (Planning Act Review Committee, 1977). Conservation lands generally referred to flood-prone areas and to hazard lands, those where the cost of providing infrastructure was prohibitive. The land use designation “open space” was often used as a temporary designation to hold natural areas undeveloped until the municipality decided to sell them (Estrin et al., 1978). These land use designations restricted all land uses except recreation, forestry, agriculture and conservation uses. While buildings or structures could be restricted, other uses or activities that could result in their degradation, such as the removal of vegetation, were not. These uses were assumed compatible (Planning Act Review Committee, 1977).

Three environmental management strategies were commonly used by municipalities to support the application of hazard and conservation land use regulations: 1) evocation of conservation authority regulations; 2) requesting developers to perform studies (regarding the likely impacts of hazard lands on the proposed land use);

and 3) applying pollution control standards (Planning Act Review Committee, 1977). Other strategies less commonly applied included 1) tree preservation policies; 2) land acquisition; 3) dedications, setbacks, or scenic easement requests; 4) prohibition of all development; 5) study, or plan requests, as part of development approval process; and 6) provincial agency comments on anticipated impacts of development (Planning Act Review Committee, 1977).

In the 1970s, few municipal official plans in Ontario had environmental goals to guide land use planning, or stated how they were related to the achievement of other economic or social goals. Similarly, the purpose of natural area land-use designations was frequently unstated. For example, while 25% of the 133 official plans reviewed included a conservation land use category, only 15% of these provided an environmental objective for this category (Planning Act Review Committee, 1977). Even fewer municipalities had environmental goals associated with other urban land uses, such as residential areas, suggesting a low awareness of or lack of importance attributed to the negative environmental impacts associated with some urban land use. Goals attached to these land uses were primarily focused on minimizing point source pollution. Impacts on aesthetics and "irreplaceable resources" were associated with rural residential areas (Planning Act Review Committee, 1977).

Local municipalities did not always implement hazard and conservation land use restrictions. For example, a majority of planners who participated in a 1975 questionnaire survey said that while municipalities had the authority to protect floodplains through the Planning and Conservation Authority Acts, many municipalities failed to exercise this authority. Some indicated that there was a lack of consensus on how floodplains should be protected and a lack of political will to implement this authority. For example, a survey questionnaire of municipal mayors found that environmental concerns ranked seventh out of eight in importance relative to concerns such as finance or housing (Planning Act Review Committee, 1977).

A study of conservation authorities and their role in municipal planning confirmed this finding. Many had difficulties implementing development restrictions in floodplains. They lacked the support of municipalities to implement the restrictions, and municipal bylaws and engineering practices frequently did not support planning and design methods to mitigate the impacts of development on adjacent watercourses. For example, while zero lot drainage was known to reduce alterations in water quantity and quality as a result of adjacent land use development, many municipal bylaws stated that lots must be drained to the road allowance and storm water managed by the storm water sewer system (Planning Act Review Committee, 1977).

4.3 Natural Systems Planning from the 1960s to the 1980s

Beginning in the 1960s, an increasing number of people became aware of the serious problems in ecosystems at all scales and challenged many of the assumptions about resource management in forested and rural areas. Scientists conducted studies that indicated that an increasing number of species and even ecosystems were going extinct or threatened and that human activity was largely responsible. Land-use planning and management decisions were identified as playing key roles in determining biodiversity. An increasing number of scientists found that the conventional approach of leaving biodiversity to take care of itself, and focusing human efforts on managing land for human resource use, was leading to unacceptable declines in biodiversity and ecosystem degradation (Grumbine, 1994). The public began to demand that biodiversity be conserved through conscious planning and management (Grumbine, 1994).

Meanwhile, the Bruntland Commission effectively communicated the international scale of the biodiversity issue and popularized the concept of “sustainable development" as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development (WCED), 1987). The challenge for achieving sustainable development, or sustainable planning and management of the land began a dialogue between ecologists, geographers, planners, landscape architects and many other professions.

Many cities in Southern Ontario were expanding rapidly during this period according to a new dispersed form of urban expansion following the Second World War. Together with the accelerated rate of expansion and lack of adequate land use planning controls, this dispersed form led to severe planning problems of air, water and soil pollution, congestion, housing shortages, high infrastructure costs and loss of natural areas and countryside close to where people lived, particularly within the more populous areas of Southern Ontario (Hodge, 2003). The public began to be concerned about the negative impacts of urban human land uses, and their own behaviour, on environmental health (Tyler, 2000). These concerns fueled public debate regarding the merits of both individual developments, and the expansion of cities into the countryside.

4.3.1 Legislative Context

Despite the existence of provincial and federal regulations to reduce pollution in the resource regions, substantial environmental degradation continued to occur. The regulations, and the Provincial and Federal governments’ efforts to implement them, were regarded as inadequate to address many of the impacts (Estrin et al., 1978). In response, the Ontario Parliament passed the *Environmental Assessment Act* (the “*EAA*”) in 1975. This Act required an assessment of not only the environmental, but the social and economic impacts of Provincial projects, and “major” private projects, prior to development approval. Rather than assuming that a project would proceed and attempting to reduce the resulting negative impacts, one of the goals of the assessment was to determine if the project should proceed at all, and if so, how its negative impacts could be eliminated or minimized. Whereas decision-makers had previously assumed that economic gain could only be acquired by environmental losses, and vice versa, the passage of this Act indicated that such an outlook was unacceptable (at least in some cases) and that land uses had to ensure the short and long term protection of social, environmental and economic values (Estrin et al., 1993). This approach to land use planning reflected “sustainable development” principles, and the passage of this legislation is considered the first Canadian step toward its achievement in planning and environmental management (Estrin et al., 1993).

While the *EAA* was originally enacted to evaluate these projects within the resource regions of Ontario, the focus of environmental discourse began to shift to the major urbanizing areas of Southern Ontario in the 1970s (Tyler, 2000). The responsibility for the environment filtered down to the municipalities in 1980 when the scope of the *EAA* was extended to major municipal and private projects. However, it was only applied to “major” private projects (Ontario Ministry of Municipal Affairs and Housing, 1975) and residential subdivision developments were exempt (Estrin et al., 1978). Even so, the Act and the assessment tools that were developed (Dorney, 1978; Eagles, 1981), altered the way in which many urban planners approached natural area planning developed (Dorney, 1977; 1978; Eagles, 1981) Planners and designers began to conduct a biophysical analysis of a development site to determine the site's biophysical opportunities and constraints as part of the planning and design process.

Concerns regarding increasing environmental pollution in all geographic locations led to the establishment of regulations to control point source pollution irrespective of geographic location (Tyler, 2000). Tyler refers to this stage in the evolution of municipal planning as “activity-based regulation,” referring to the many environmental quality standards and the regulation, and in some cases preservation, of natural areas beyond those identified previously by the lower-tiered municipalities (Tyler, 2000). Urban planners increasingly sought to manage and control the development of the land through establishing development standards, and conditions of development, and the use of official or master plans and zoning to ensure the harmonious distribution of land uses was downplayed (Tyler, 2000). Planners increasingly adhered to the normative theory that establishing development standards, and conditions of development, would ensure that environmental quality standards are maintained with land development.

A revision to the *Planning Act* in 1973 gave municipalities, which had official plans, an additional process by which to ensure that development met the objectives of the official “site plan” approval. Through this process, site plans are reviewed and “development control” provisions could be applied. These provisions allowed municipalities to place additional restrictions on the development of a property or specify additional requirements prior to plan approval or the issuance of a building permit. Provisions might involve landscaping, grading, easements, or fencing, and are negotiated with developers (Estrin et al., 1978). These provisions were site-specific and in addition to those required by the zoning bylaw and those specified through the subdivision control process (Estrin et al., 1978).

The provincial government established upper-tier municipalities (hereafter-referred to as regional municipalities) within some areas of Ontario. These larger municipal bodies contained lower tier local municipalities, and the official plans of lower-tier municipalities had to conform to those of the regional municipalities (Estrin et al., 1978). The regional municipalities were among the first to incorporate natural area designations (beyond hazard lands, conservation lands or open space) and environmental management strategies into their official plans. When the first regional official plans were reviewed by the Ministry of Housing, their authority to impose even these limited planning controls on individual property rights was challenged (Eagles, 1984) and was not upheld until 1976, when the OMB approved the official plan of the Regional Municipality of Waterloo. However, the 1983 revision of the Act (see below) still failed to allow municipalities to prevent development from occurring within these areas, unless the lands were deemed too hazardous, or had prohibitive infrastructure costs (Ontario Ministry of Municipal Affairs and Housing, 1983).

It wasn’t until the 1983 revision to the *Planning Act* that the regional and local municipalities were given explicit authority to designate environmentally valued areas, and to develop supporting environmental management strategies such as: requesting environmental impact statements, purchasing lands (or acquiring them through donation), negotiating the transference of development rights and limiting density (Eagles, 1984). Development control provisions could also be negotiated, such as those related to grading or landscaping (allowed since the 1973 revision to the *Planning Act*).

The 1983 Act revision also provided the legal framework for the development of provincial policies that all municipal governments had to “have regard to” in decision-making. The Provincial Policy Statement (PPS) is a policy document that is used alongside the *Planning Act* to provide policy direction to the lower-tier municipalities with regard to areas of land use planning and development of interest to the Provincial government (Ontario Ministry of Municipal Affairs & Housing, 2006). However, neither the *Planning Act* nor the Provincial Policy Statements contained goals to guide municipal decision-making. Designated goals were intentionally left out to encourage individual municipalities to form their own (Estrin et al., 1993). The four policies developed between 1983 and 1992 included: the Mineral Aggregate Resource Policy (1986), Flood Plain Planning Policy (1988), Land Use Planning for Housing Policy (1989) and the Wetlands Policy (1992). The PPS consultation process with interest groups and the public was lengthy; however, the resulting policies received a higher level of public support than they would have if they had been imposed (Estrin et al., 1993). Unfortunately, few issues relating to the natural environment were covered beyond wetlands and floodplains. To fill this gap, a number of provincial government departments produced guidelines, but these did not have the public and political support or the legal authority of the provincial policies and the review of plans and development applications were subject to long and costly delays when their application was contested (Estrin et al., 1993).

Nevertheless, the development of regional governments, provincial interest and Policy Statements during this time increased the spatial and temporal scale of planning. The development of regional governments allowed planners to deal with environmental, social and economic issues that crossed municipal boundaries. Relative to the urban-centre and site-by-site perspective of local municipal planners, regional planners focused on broader-scaled issues that involved both urban and rural areas of multiple municipalities.

4.3.2 Natural Systems Planning Theory

4.3.2.1 Substantive Theory

Starting in the late 1960s, both procedural and substantive theories began to develop in earnest to support the integration of urban land use planning with urban ecology. Driven by the Conservation society movement, planners, landscape architects and other professionals involved in land development began to promote the utilitarian values of natural areas, such as their hydrological functions, recreational, aesthetic and to a lesser extent, their lumber production values (Eagles, 1984; Spirn 1984; Hough, 1989). In addition, they promoted their intrinsic values. Many believed that nature, particularly areas of high ecological diversity, had a right to exist, and that protecting these areas from human activity impacts was the right thing to do (Tyler, 2000; Eagles, 1984).

Theories from systems ecology and biogeography started to be integrated with urban planning theory. Planners and landscape architects began to conceptualize cities as urban ecosystems (Dorney & Rich, 1976; Dorney, 1987; Eagles, 1984; Spirn 1984; Hough, 1989). The characteristics of healthy and stable natural systems were defined as ecosystems characterized by: 'high information content; low entropy; quality as opposed to quantity production; feedback population control; high diversity; complex life cycles and species interactions' (Odum 1971). These healthy system characteristics were compared with those typifying urban areas. Many of the characteristics of urban systems differed from those of 'natural' biological systems. They were non-cyclical and led to undesirable consequences, such as species extinctions, and unassimilated waste by-products that polluted urban environments (Eagles, 1984). Preserving natural diversity by protecting environmentally sensitive areas from development, enforcing environmental quality standards, and conserving resources, were thought to be ways of 'compensating' for some of the non-cyclical flows occurring in urban areas, thus moving urban ecosystems to more mature, and therefore healthier, states of equilibrium (Eagles, 1984).

Theories within the field of island biogeography influenced environmental planning theory during this time. These theories described the relationships between species diversity and 1) the size of oceanic islands and 2) their spatial relationships with other islands and mainland areas. They found that species diversity was higher on islands that were 1) larger, 2) closer to other islands, 3) clustered (or equidistant from other islands) rather than arranged in a linear pattern, 4) connected to other islands by protected linear habitats, 5) circular rather than linear in shape (MacArthur & Wilson, 1967). Beginning in the late 1970s, planners and landscape architects began to promote natural area systems planning based on these theories to protect native species diversity within suburban landscapes (Davis & Gleck, 1978; Eagles, 1984; Dorney, 1987; Spirn, 1984).

Theories from island biogeography merged with those from geography, conservation biology and other sciences over the 1970s to form a cohesive body of theory in support of the field of landscape ecology in the early 1980s (Forman, 1995). However, it was not until the late 1980s and early 1990s that planners began in earnest to integrate theory from landscape ecology into planning theory and methods (Berger, 1987, Steiner & Osterman, 1988; Golley & Berlot, 1991; Ahern, 1995; Forman, 1995).

Nevertheless, scientists at this time were concerned about continuing declines in native biodiversity within terrestrial landscapes. Large parks were established within the United States and Canada, and efforts were made to protect individual species after they were in decline, but both of these approaches were found to be inadequate. There were not enough parks (Crumpacker et al., 1988). They were too small to support viable populations of some species (Clark & Zaunbrecher, 1987). Many were degraded through previous, and ongoing, human uses and were negatively impacted by human land uses beyond their borders (Noss, 1994). These fragmented 'natural' terrestrial ecosystems were conceived as habitat islands surrounded by large areas, or a "sea" of unsupportive habitats for some species. Ecologists began to test island biogeography theories within terrestrial landscapes. They found that many of the theories could explain changes in species diversity within the natural areas of terrestrial landscapes (Diamond, 1975; Pickett & Thompson, 1978; Ranney et al., 1981; Noss & Harris, 1986).

Some ecologists began to point to the impacts of adjacent landscape components, and the matrix, on the forms and functions of natural system components. They pointed to the importance of the edges of patches, and surrounding land use characteristics, in explaining changes in species diversity within forests (Swingland & Greenwood, 1983; Janzen, 1983). These studies found that ecological flows from adjacent land uses, such as the movement of generalist animals, or exotic plant species, into forest patches, significantly altered native species composition and diversity within the forest.

The findings of all of these studies prompted the planning of course scaled nature reserve systems within forested and agricultural landscapes (Diamond, 1975; Pickett & Thompson, 1978; Ranney et al., 1981; Noss & Harris, 1986).These systems were conceived as cores, stepping-stones, corridors, and buffers in support of high native landscape-scaled species diversity.

4.3.2.2 Procedural Theory

Planning terms began to be integrated with urban ecology terms during this time. Ecology-based planning was most often referred to as 'environmental planning' (Coleman & MacNaughton, 1971; Lang & Armour, 1980; Eagles, 1984; Dorney, 1987). Most scholars defined environmental planning broadly. For example, Eagles defined it as a "logical process involving the resolution of the social and ecological needs in the ordering of human actions' (Eagles, 1984, p. 19). However, in terms of what planners did, Dorney described environmental planning as a "paper exercise that begins a development process, a government process, or policy formulation process. Environmental planning includes goal setting, information analysis, hearings, and approvals."(Dorney, 1987, p. 15).

There was a proliferation of planning procedures for conducting environmental planning at this time, and most limited the activities of planners to the activities described by Dorney (MacNeill, 1971; McHarg, 1967; Dorney, 1987; Eagles, 1984). Nevertheless, Dorney argued that implementation was vital to successful planning (Dorney, 1987). He included plan implementation under the heading "environmental protection" rather than environmental planning. Although Dorney did not detail these activities, environmental protection activities included plan implementation, or facility construction, the management of a facility (e.g. a natural area or a subdivision), monitoring of a facility, and research (Dorney, 1987). Dorney argued that environmental planning and environmental protection are two vital phases in 'environmental management,' which Eagles (1984, p. 21) defined as "the entire process of planning, conserving and managing the environment and its resources."

This framework for the environmental management of urban and suburban landscapes was similar to that being promoted for less developed landscapes. From the 1930s onward scientists began to be concerned that the practice of resource management within these less developed landscapes was leading to declines in native biodiversity at all scales. For example, Frank and John Craighead found that the habitat needs of certain species, such as grizzly bears (*Ursus arctos*) could not be met inside the boundaries of protected areas (Craighead, 1979). Scientists, managers and others began to argue that the management of these resources could not continue to focus only on maximizing production of goods and services (e.g. maximizing lumber production or recreational visitor days). They argued these resources could only be sustained over time if the basic ecosystem patterns and processes that defined ecosystem integrity within these landscapes were maintained (Grumbine, 1994). They referred to this type of management as 'ecosystem management' (Grumbine, 1994).

Arguments for environmental management of suburban landscapes shared a similar philosophy. Proponents argued that planning and managing urban ecosystems required an ecosystem perspective as well as different temporal perspectives (Odum, 1983; Dorney, 1987). Dorney argued that environmental management required short-term goals embedded within a long-term vision, and the adoption of an adaptive management approach (Dorney, 1987). Adaptive management theory argues that ecosystem management activities need to be adapted through time so they can respond to 1) ecosystem change, and 2) advances in ecosystem management techniques revealed through research and monitoring (Holling, 1978).

Integral to all environmental planning procedures were methods of classifying, describing and analyzing the biophysical and cultural components of planning areas, and many were developed during this time (McHarg, 1969, Hills et al., 1970; Cassie et al., 1970; Dorney, 1977 and others). These methods were largely topological or vertical approaches to analyzing planning units (Ahern, 1999). For example, in McHarg's method, biophysical and social attributes were mapped as vertical layers, starting at the 'bottom' with bedrock, then soils, hydrological patterns and so on up to the 'top' map layers that described components, such as vegetation, wildlife, and social systems (McHarg, 1969). Land capabilities and their suitability for different land uses were assigned (McHarg, 1969). Most of the methods described the planning unit as static rather than dynamic, and most could only be used at one, or a few scales (Dorney, 1987).

4.3.3 Natural Systems Planning Practice

New developments began to be planned and designed in response to the pre-existing ecosystem. For example, developers and designers incorporated the pre-existing topography of the land into their developments, rather than leveling the land and imposing an artificial pattern, such as a grid (Dorney et al., 1976). Planners and ecologists developed methods to protect the values of rural vegetation remnants prior to and during development (Dorney et al., 1986; Sharpe et. al., 1986). Dorney & Rich (1976) referred to this type of planning as “Contour planning,” This early stage of environmental planning practice evolved into “feature and constraint” planning (Dorney et al., 1976), where not only is the pre-existing topography respected, but remnants of the pre-existing ecosystem are incorporated as "features" in the predominantly constructed landscape. Despite these advances, natural areas were still planned and managed as independent, static “green spaces” that had to be integrated into the surrounding built form (Tyler, 2000).

Other professionals, such as landscape architects, archaeologists, historians, physical geographers and hydrologists began to join those traditionally involved in planning to form multi-disciplinary planning teams (Dorney, 1987).

In Ontario, municipal planners considered the acquisition of a natural area the best way to protect it over the long term (Ainsworth, 1986), many municipalities had limited financial resources (Planning Act Review Committee, 1977). Some municipalities managed to purchase such areas in conjunction with other public and private agencies, such as the conservation authorities, or field naturalist clubs and others accepted land donations in return for income tax deductions (Ainsworth 1986). Conservation easements were also emerging as a tool at this time. Conservation easements are a type of contract that permits a transfer of some property rights, such as the right to develop the land, between a landowner and an agency (Quigg, 1978). However, they were mostly negotiated for rural natural areas (for example Hilts 1984). Other tools, such as landowner contact, stewardship and management agreements between landowners and agencies (Hilts & Kirk, 1986) were, likewise, primarily being used to preserve and protect rural natural areas.

In the mid 1970s, municipal land use planning was used for the first time in Ontario to protect natural areas from development, and this was considered a major advance in natural area protection (Richards, 1982). A variety of policies were established for lands important for ensuring water quality and quantity and lands that had minimally disturbed, rare species or wildlife habitat, high recreation values, unusual or visually important landforms or high agricultural values (Planning Act Review Committee, 1977). A wide variety of labels was applied to these designations including: Environmentally Sensitive Policy Area (ESPA) or Environmentally Sensitive Area (ESA) (Ainsworth, 1986).

By 1975, a few Ontario regional municipalities had incorporated these additional land use designations into their official plans but none of these plans had been provincially approved (Planning Act Review Committee, 1977). However, by 1985, 14 out of 54 regional municipal official plans had these designations approved by the Province (Ainsworth, 1986). Most of these regional municipalities were located in the most populated areas of Southern Ontario. These natural area designations did not prevent the development of these areas, but rather specified the kinds and intensity of development permitted. In zoning bylaws, these areas were sometimes given the zoning of the natural area designation, such as “environmentally sensitive area.” Alternatively, they were zoned in combination with other land use designations, such as residential. This meant that, in addition to the policies applicable to the residential designation, other policies relating to the “environmentally sensitive area” designation applied. A variation of this latter type of designation was “environmentally sensitive policy areas.” Such areas existed where an agreement between the municipality and the owner to preserve the area from development or degradation had been made (Estrin et al., 1993).

Each type of designation specified regulations for the use of the land and the siting and construction of its buildings including their density, height, bulk, setbacks and parking. These designations could serve to preserve natural areas by reducing their market value (through density reductions or by specifying a less lucrative land use) thereby discouraging developers from purchasing or developing the land (Estrin et al., 1993; Hilts, 1983; Hilts, 1984). They could also result in increased support for their preservation among private land owners, planners, politicians and the public; expanded knowledge of natural area values, thereby helping agencies to make purchasing decisions (Hilts, 1983) and a slowing down of their degradation through development (Hoffman, 1985). These designations were also thought to lead to more sensitive subdivision and site planning conditions of approval, such as tree saving, ground water recharge provisions or the requirement of environmental impact assessments and mitigation measures to protect adjacent natural features (Hilts, 1983; Hilts, 1984).

In 1985, 50% of Ontario's regional municipalities required developers to pay for and prepare some kind of assessment of the potential environmental impacts of development (Ainsworth, 1986). While some of these municipalities hired environmental planners, others relied solely on conservation authorities, or the Ontario Ministry of Natural Resources to assess environmental studies and to advise them on other environmental issues (Ainsworth, 1986). A smaller number of regional municipalities (Waterloo, Halton and, later, Niagara) also established environmental advisory boards. Regional councils appointed these boards and they were composed of community volunteers with expertise in environmental issues. They were responsible for reviewing the assessments prepared by the consultants and advising council on mitigation measures and approvals (Ouellet, 1996).

Research on these management tools appears to focus on identifying the natural area policies within official plans and zoning bylaws, and the extent to which they were present within municipalities. Few evaluated the extent to which municipal councils were willing to implement these policies when development applications involving official plan and rezoning amendments were made, or once implemented, their effectiveness in preserving or protecting natural areas.

By 1986, only one municipality, the Regional Municipality of Waterloo, had conducted a study of the effectiveness of these new environmental land use categories (Ainsworth, 1986). A 1983 Regional Municipality of Waterloo study assessed the environmental impacts on their Environmentally Sensitive Policy Areas (ESPAs) between 1976 and 1983. It found that a great deal of incremental degradation had occurred within most of the ESPAs, including timber removal, grazing, draining, dumping, intrusion of roadways and paths and removal of rare species (Regional Municipality of Waterloo, 1984).

A study by Ouellet (1996) evaluated the implementation and the effectiveness of the Region of Waterloo's ESPA policies between 1976 and 1991. She analysed the minutes of the Region's Ecological Advisory Committee, who reviewed development applications for these areas, to determine the extent to which ESPA policies were able to preserve the region's 69 ESPAs from development. She found that 44 developments either had occurred within some of these areas, or were under consideration. Roughly, 41% of these were residential in nature. Ouellet concluded that the Regional Municipality of Waterloo was reluctant to reject development proposals outright, even if an environmental study found that the development would lead to unacceptable negative impacts. The Region of Waterloo more often resorted to minimizing negative impacts through conditions of development, or by altering the zoning of the ESPA to allow the land use change (Ouellet, 1996). Ouellet suggests that part of this reluctance on the part of the Regional Municipality of Waterloo may have been due to the lack of support that such a refusal would receive at the OMB (Ouellet, 1996). The OMB generally ruled (at least in the mid 1970s) that a municipality must either purchase the land or change the zoning of an area designated as "open space" to allow a private landowner to develop (Estrin et al., 1993).

Nevertheless, the Regional Municipality of Waterloo was one of the first municipalities to establish a policy outlining the procedure followed when an environmental study found that a development would produce an unacceptable negative impact. For example, if an assessment indicated that a proposed land use would have a serious impact on an ESPA, then the municipality could either 1) purchase the land (or find some other agency to purchase it), 2) remove its ESPA designation and allow it to be developed, 3) refuse to approve the land use, or 4) negotiate with the owner to preserve the area as much as possible (Regional Municipality of Waterloo, 1998). A review of regional municipal natural area policies found that this policy was still a "leading edge" environmental policy in 1999 (Best Policies Working Group, 1999).

Ouellet also evaluated the effectiveness of these designations in protecting areas from degradation. She compared aerial photos and conducted field studies; however, she had little baseline information with which to compare her findings. This study found that the activities of landowners, and those of adjacent land users, particularly those springing from residential developments, had degraded 39 of these ESPAs. This finding was based on evidence of vandalism, clearance of vegetation, dumping of waste, removal of native vegetation, unauthorized mountain biking, snowmobiling and cat and dog predation of wildlife. These impacts were particularly prevalent within ESPAs that were dryland, versus wetland, forests (Ouellet, 1996).

4.4 Natural Systems Planning from the 1980s to 2007

The problems that attended rapid expansion of dispersed and technological city forms following the Second World War continued into the 1990s, despite the establishment of regional municipal planning to guide local municipal development and stronger land use planning regulations. As a result, throughout the 1980s, dissatisfaction increased with the Ontario land use planning process. Environmentalists and the public were concerned that the land use planning process did not adequately protect the environment from long-term degradation (Estrin et al., 1993). Many citizens were frustrated in their attempts to participate in the planning process, and developers were concerned about the increasing complexity of the system and long development proposal review times. Review staffs from all levels of government and from other agencies (such as conservation authorities) were also dissatisfied. Their increasing awareness of the complexity of the environmental issues frequently led to longer periods of time spent reviewing these applications, and in many cases they felt that they lacked the staff or resources to adequately assess the long-term cumulative impacts of individual development proposals (Ontario Environment Assessment Advisory Committee, 1989).

4.4.1 Legislative Context

In response to the many complaints regarding the performance of the land use planning process in Ontario throughout the 1980s and early 1990s, the Provincial government made significant changes to the Provincial Policy Statements in 1995. These changes sought to increase Provincial government control over municipal level decision-making through the establishment of provincial planning goals, and by stronger provincial environmental policies and guidelines.

Many scholars identified the lack of priority given to environmental considerations in decision- making as one of the major obstacles to the implementation of more ecologically sustainable land use planning (Campbell, 1995; Estrin et al., 1993; Roger-Machart, 1997; Roseland, 1992). The incorporation of provincial planning goals within the 1995 PPS, and all subsequent revisions, was intended to increase the amount of consideration given to environmental issues over economic and social considerations (Estrin et al., 1993). For example, in terms of natural heritage policies, the goal of the 1996 PPS was to ensure that natural heritage features and functions were protected from incompatible development. In contrast, the goal of the 2005 PPS was to ensure that they will be protected “for the long term,” indicating the provincial government’s growing desire to incorporate principles of sustainable development into their policies.

Natural area preservation and protection policies were significantly strengthened within the 1995 PPS relative to those of the 1990 *Planning Act* and the Province’s first individual policy statements. A comprehensive policy statement replaced these individual statements. It expanded the conditions under which certain natural areas could be preserved or protected from development. Prior to 1995, natural area policies that could prevent development were limited to areas subject to flooding or marshy areas and "significant" wetlands south and east of the shield. With the 1995 comprehensive policy statements, this list was expanded to include "significant portions of habitat of endangered and threatened species," (Ontario Ministry of Municipal Affairs and Housing, 1995) and in the 2005 PPS "significant coastal wetlands" were added (Ontario Ministry of Municipal Affairs and Housing, 2006).

The PPS (1995) also adopted policies, similar to municipal natural area policies, that established regulations regarding development within and adjacent to natural areas that the province deemed significant. The applicable natural areas were expanded from hazard lands to include fish habitat, significant wetlands in the Canadian Shield, significant woodlands and valleylands south and east of the shield, significant wildlife habitat, and areas of significant natural and scientific interest. While significant wetlands, coastal wetlands and ANSIs were defined and identified by the Provincial Government, other significant areas were left to the municipalities to identify, at first by using either provincial or municipal criteria (Ontario Ministry of Municipal Affairs and Housing, 1995), and then only provincial criteria (Ontario Ministry of Municipal Affairs and Housing, 2005).

While encouraging "connectivity" and diversity within and among natural areas were identified as important in natural heritage planning in the PPS (1996), the concept of planning these areas as functioning subsystems within urban ecosystems was still not apparent in the wording of these policies. They were still identified as "features" and "areas."

According to the *Planning Act* (1990), sec. 3.2, municipalities could pass bylaws to prohibit certain uses of the land within significant natural corridors (Ontario Ministry of Municipal Affairs and Housing, 1996). However, no guidelines existed to identify these corridors, and their protection was given only weak support in the accompanying PPS (1996), sec. 2.3.3 (Ontario Ministry of Municipal Affairs and Housing, 1996) and within the PPS (2005) s. 2.1.2 (Ontario Ministry of Municipal Affairs and Housing, 2005). In effect, the provincial government failed to specify that an absence of possible negative impacts must be demonstrated before development or site alteration is permitted in these areas. However, s. 2.2.1e. of the PPS (2005) stated that these corridors, or "linkages", must be maintained where they are important for water quantity and quality (Ontario Ministry of Municipal Affairs and Housing, 2006).

Few policies encouraged the restoration of features and functions, although, in both PPS 1996 and PPS 2005, restoration or improvement of connectivity between natural areas was recommended (Ontario Ministry of Municipal Affairs and Housing, 1996; Ontario Ministry of Municipal Affairs and Housing, 2006). Even with respect to ensuring water quality and quantity, there was no requirement to restore or improve connections between hydrological and natural features and areas, only to maintain those in existence (Ontario Ministry of Municipal Affairs and Housing, 2006). This is significant with respect to achieving ecosystem-based planning in Southern Ontario municipalities, since many are already developed. Opportunities for protecting natural features and areas, as well as ensuring water quality and quantity, lie primarily in restoring existing, and more often than not, degraded, natural areas as functioning systems, rather than in preserving and protecting new "significant features and areas."

Similar to those established within the municipalities, these policies required some form of assessment (but not necessarily a formal environmental impact study) to identify the anticipated impacts and outline mitigating measures to demonstrate "no negative impacts on the natural features or their ecological functions." Apart from that provided for fish habitat, the definition of "negative impacts" remains vague, despite attempts between 1995 and 2005 to clarify its meaning in the policy. For example, in 2005, negative impacts are defined as "degradation that threatens the health and integrity of the natural features or ecological functions for which the area is identified". However, the terms, "health" and "integrity" are not defined. In addition, only impacts on the features and functions by which the area was identified are considered "negative impacts" (Ontario Ministry of Municipal Affairs and Housing, 2006).

The PPS 1996 introduced, for the first time, provincial policies to regulate adjacent land use impacts, specifying that development, or any alternation of the site, could only be implemented if it could be shown that it would have "no negative impact on the features or the ecological functions for which the area is identified" (Ontario Ministry of Municipal Affairs and Housing, 1996). Again, an attempt was made to strengthen this policy. In 2005, the policy required that the ecological functions of adjacent land be identified in order to determine the possibility of a negative impact (Ontario Ministry of Municipal Affairs and Housing, 2006).

Between 1995 and 2005, the Provincial Government bolstered the extent to which municipal governments (and the OMB) had to comply with these policies in their decision-making. In 1996, they had only to "have regard to" these policies, which might be interpreted to mean that they had to be considered, but not necessarily adhered to (Ontario Ministry of Municipal Affairs and Housing, 1996). However, Wilkinson and Eagles (2001) found that the OMB routinely ruled that municipalities had to "be consistent with" provincial policies, despite the "have regard to" wording (Wilkinson & Eagles, 2001). In any case, in 2003 the wording was changed to "shall be consistent with" (Ontario Ministry of Municipal Affairs and Housing, 2003).

Of particular importance in the development of ecological planning of natural heritage systems were the 2005 revisions to water policies. In s. 2.2, the provincial government specified that water quality and quantity "shall be protected, improved or restored by maintaining linkages and related functions" between surface and ground water hydrological features and functions and natural heritage features and areas (Ontario Ministry of Municipal Affairs and Housing, 2006). This revision marked the first provincial policy directed toward establishing functional natural area systems, rather than just "natural features and areas."

In the PPS 2005, policies also began to integrate the functions of natural areas with adjacent area site design and community education programs. Again, this is seen in the water policies. Section 2.2.1 f. and g states that planning authorities have to meet provincial water quality and quantity goals through the promotion of the "efficient and sustainable use of water resources, and by ensuring storm water management practices minimize storm water volumes and water pollution levels" (Ontario Ministry of Municipal Affairs and Housing, 2006).

4.4.2 Natural Systems Planning Theory

4.4.2.1 Substantive Theory

Urban planning literature addressing environmental issues greatly expanded along with the number of fields contributing to its development. Theory and methods from the fields of ecosystem management, conservation biology, and landscape ecology in particular, were integrated with planning theory and methods (Berger, 1987; Steiner & Osterman, 1988; Golley & Berlot, 1991; Ahern, 1995; Forman, 1995).

Advances in urban ecology theory introduced new concepts to further the understanding of the functioning of the technological city and its hidden social, environmental and economic impacts. For example, concepts such as the urban "ecological footprint," described the significant negative impacts on hinter and more distant regions that result from technological versus sustainable city forms (Rees & Wackernagel, 1994).

In addition, theories from landscape ecology began to be integrated with planning. The hierarchy theory (O'Neill et al., 1986) became an important theoretical foundation for landscape planning. It refers to how biological systems that have separate functional elements, linked at two or more scales, operate (Forman, 1995, p.9). According to this theory, a suburban landscape may be conceived as drainage basins, which, in turn, are made up of forest and housing landscape elements, that are made up of smaller scaled elements. Each element in the hierarchy functions as a separate, but interacting, unit with its own constraints and degree of stability (Forman, 1995). Flows of elements (such as air, water, heat, chemicals, animals and humans) move both vertically and horizontally, through and across this landscape, linking all these elements together (Forman, 1995). Therefore, to understand how landscape elements function, this theory implies that a planner must understand not only how they are linked together at any one scale, but also how they are linked to encompassing elements at the landscape level, and to component elements at finer scales (Forman, 1995).

A related theoretical foundation is the space-time principal. It asserts that forms and functions at broad spatial scales, such as the landscape scale, are more stable or persistent in both time and space than those occurring at finer scales, which are more spatially varied and change more quickly (Forman, 2005). For planning this meant that to achieve sustainable suburban form it is particularly important to plan at coarse spatial scales because it is form at these scales that primarily determine ecological functions at finer scales, and over the long term.

Planning began to incorporate terms from the ecological sciences that reflected the focus of planning on the ecosystem, rather than just the environment, and the new importance attributed to spatial scale. The more generic term 'environmental planning' began to be replaced by terms such as 'landscape planning, 'watershed planning,' 'ecosystem-based planning,' and 'ecological planning," through the 1980s onward (Johnson, 1982; Steiner, Young, and Zube, 1987; and others).

Planners began to promote natural area networks within cities. They were similar in concept to the core, stepping stone, corridor and buffer model promoted for the nature reserve systems of less developed landscapes. While the concept of linked natural systems was not new in urban and suburban landscapes (See section 4.2.2), landscape ecology theory, and the precedent created by backcountry natural reserve systems, provided, in part, the necessary theoretical basis to popularize the concept. However, these systems were promoted for reasons beyond their ability to support native species. They provided valuable recreational opportunities, connected urban and rural landscapes, and served important ecological functions such as hydrological functions (Searns, 1995; Taylor, Paine, & FitzGibbon, 1995; Walmsley, 1995). In Europe, the emphasis was on their role in support of key ecological processes of importance to human health and well-being, such as water and waste management, recreation or transit functions (Turner, 1998; Tjallingii, 1995). These systems were planned alongside other engineered infrastructure systems designed as “built ecology” to meet ecological performance criteria. Because their functions were considered fundamental to human health, they received a broader basis of popular support than those designed to meet solely the needs of wildlife (Tjallingii 1995). In the Netherlands, they were first designed at the national level (Ministeerie LNV, 1990), followed at the provincial level (Provincie Utrecht, 1993) and municipal level (Meeus, Borst, & Kuipers, 1989). They have also been developed within other countries including Germany (IBA Emscherpark, 1992) and England (Turner, 1992).

4.4.2.2 Procedural Theory

Ecosystem-based planning began to be promoted as an alternative to conventional land use planning. According to Gibson *et al.* (1997) the ecosystem approach to planning, “begins with an ecologically-bounded area, stresses the integration of social, economic, and environmental factors, and seeks to involve all the relevant interests and power holders in identifying desirable futures, evaluating alternative pathways and implementing preferred solutions” (Gibson, Alexander, & Tomalty, 1997). Tomalty et al. (1994) identified the principles upon which ecosystem planning is based in Canada. These principles arose from the work of the Crosbie commission with respect to the future of the Greater Toronto Waterfront (Royal commission on the future of the Toronto waterfront, 1992) and other applications of ecosystem-based planning within the urban communities of Southern Ontario and other Canadian regions (Tomalty et al., 1994). Table 4.1 summarizes the main principles and how they are distinguished from those supporting conventional land use planning:

An appreciation for the importance of biotic and abiotic flows, transport and movement across the landscape for determining ecosystem function at all spatial scales (Forman & Hersperger, 1997; Harris, Hoctor, & Gergel, 1996; Turner, 1987) led to a "chorological" approach to planning (Ahern, 1999). This approach describes the dynamic spatial processes and horizontal flows across a planning unit. The idea is to identify and incorporate the ecological flows that support positive natural and cultural processes into a plan, such as groundwater, animal dispersal, cycling, or electricity transmission. On the other hand, the negative ecological flows are also identified and avoided, such as those that lead to excessive erosion, barriers to animal dispersal, or residential encroachment activities. The Chorological approach requires the proactive planning (including conservation, restoration and re-assembling) of natural area systems to support native biodiversity within a landscape rather than the reactive planning (conservation) of individual natural areas (Ahern, 1999). Planners and designers begin to argue that a reliance on McHarg's topological approach leads to a static conceptualization of the landscape because of its vertical approach to describing its forms and features. Landscape planners begin to promote using both chorological and topographical methods in planning (Ahern, 1999).

Table 4.1 Principles of ecosystem planning versus conventional planning

Ecosystem Planning	Conventional Planning
1) Planning units based on natural boundaries	1) Planning units based on political boundaries
2) Built forms/systems designed in response to ecological forms/ systems	2) Human-engineered forms/ linear systems replace ecological forms/ cyclical systems
3) Consequences of planning are considered at multiple spatial and temporal scales are frequently assumed uncertain and potentially damaging.	3) Consequences of planning are considered at the site scale and during the period in which land development occurs and are assumed to be certain and benign
4) Integrated, inter-jurisdictional planning	4) Segregated, jurisdictional planning
5) Broad based stakeholder decision-making	5) Decision-making dominated by technical or planning experts
6) Plans are adapted over time toward the achievement of planning goals, after repetitive monitoring is used to determine the extent to which they have been achieved	6) Plans are developed once. Little monitoring or assessment of planning effectiveness
7) Planning based on relationships between social, demographic, economic and ecological information at multiple spatial and time scales and information gathering is as ongoing.	7) Planning based on social, demographic and economic information available at time of plan creation. An assessment of whether socio-economic goals can be met by current ecological capacity rarely made, nor how meeting these goals affect ecological functions.
8) Development alternatives are chosen that are not only deemed the least potentially damaging, but heal the negative impacts of previous conventional planning and work toward future community sustainability.	8) Existing development forms are accepted. Minimal mitigation of potential development impacts assumed to be adequate; where inadequate it is assumed that they are offset by positive social and economic impacts of development
9) Economic, social and environmental goals are seen as integrated. Achievement of environmental goals can only be accomplished through the achievement of social and economic goals.	9) Economic, social and environmental goals are seen as competing. Achievement of environmental interests must be defended against those primarily seeking economic or social interests.
10) Implementation of planning goals achieved through exercising legislative authority, the application of financial resources and through broad community support from the affected community.	10) Implementation of planning goals achieved by exercising the necessary legislative authority, and through the application of necessary financial resources

(Tomalty et al., 1994)

4.4.3 Natural Systems Planning Practice

Environmental planning in this period went beyond preserving natural area remnants advocated in the "features and constraint" stage to incorporate dynamic ecological processes and systems into the urban landscape (Dorney 1987). Planning began to seek the integration of built systems into the pre-existing ecosystem, rather than the other way around (Tyler 2000). The complex interactions of humans and dynamic biophysical processes began to be considered in planning. Natural areas were not only viewed as constraints, hazards and important features, but also as performing vital ecological functions in support of human health and well-being. Planners, and most importantly society in general, began to believe that protecting the environment was important because of the vital services it provides to human communities (Cox, 1996), not only from an ecological, but also a social and economic perspective (Newby, 1990).

The number of natural areas preserved increased relative to that preserved in previous years; however, many natural areas continued to be destroyed through agricultural and urban expansion. This occurred despite objections from residents, commenting agencies and planning departments (Ontario Environment Assessment Advisory Committee, 1989; Ontario Environment Assessment Advisory Committee, 1990). However, concern extended beyond the loss or degradation of individual natural areas to concern about the loss of entire natural systems and ecosystems. The cumulative spatial and temporal impacts of urban development over space and time were not being addressed through the piecemeal assessment and mitigation of individual development impacts. Areas of concern widened to include not only loss of aesthetics, recreational and wildlife values but also loss of key ecological functions of vital importance to human health and well-being.

The development of provincial natural heritage policies effectively established a minimum standard of preservation and protection of natural areas. By 1999, a survey of regional municipal plans found that most, if not all, regional municipalities with official plans had environmental policies (Best Policies Working Group, 1999). Most of these policies met the standards for natural heritage protection set out in the Provincial Policy Statement of 1996. These policies focused on the preservation and protection of areas of provincial significance through land use planning tools, in addition to acquisition, conservation easements, landowner contact, stewardship and management agreements, education, or monitoring and evaluation.

The PPS required developers to “demonstrate” no negative impact; however, policies were missing that required municipalities to monitor or evaluate whether any negative impacts actually occurred with the development. A survey found that most municipal policies mirrored the requirements of the PPS and focused on the preservation and regulation of development within specific natural areas, rather than those related to the regulation of adjacent land use impacts, alternative methods of preservation and protection (such as private or public stewardship), or monitoring and evaluation of natural areas to ensure “no negative impact” of development or adjacent land use (Best Policies Working Group, 1999).

Despite the limitations of the PPS (1996) for the preservation and protection of natural areas and functions, one study found that some regional municipalities had policies that met only the minimum standards set out in the PPS 1996 (Best Policies Working Group, 1999). These standards required the preservation of a limited number of natural area types and allowed development within and adjacent to other types as long as no negative impact on the features and functions (for which they were designated) could be demonstrated. While linkages between areas were encouraged, they were not required.

This study also found that municipal land use planning policies that exceeded the minimum PPS (1996) requirements included those that: 1) established regional and local natural area designations, regulations and development controls, 2) required the preservation, enhancement or restoration of “linkages” between natural areas, 3) regulated land uses in terms of their possible future or cumulative impacts (such as one development leading to further future development), 4) established adjacent land use protection policy standards, such as buffers, as minimum mitigation measures to protect natural areas from construction and adjacent land use impacts, 5) required an EIS, criteria for conducting an EIS, or the review of the EIS by an environmental review committee, 6) established a tree cutting bylaw, and 7) established site plan guidelines to reduce adjacent land use effects. These latter guidelines included: encouraging the use of native species, discouraging invasive exotic species, storm water management practices specifying natural infiltration techniques, changes in density, adoption of alternative development standards, or reconfiguration of land uses (Best Policies Working Group, 1999).

Specific controls on development were not described within these official plans, as many of these controls were established during the development review process on a site-by-site basis.

The Best Policies Working Group study of 1999 also indicated that many municipalities were attempting to preserve and protect natural areas using a variety of tools other than land use planning. Some municipalities had policies that promoted municipal acquisition and private donation and land exchanges. Others promoted stewardship through the negotiation of conservation easements, private stewardship or management agreements, land use agreements between private property owners and the municipality; and the encouragement of local municipalities, agencies and private landowners to restore degraded habitat. Few policies dealt with encouraging public education and stewardship.

Only a few municipalities had monitoring programs in place to evaluate the effectiveness of natural area protection policies. These programs generally used coarse spatial scale indicators such as the amount and type of regional forest cover or surface water quality. It was not specified exactly how these indicators would be used to determine policy effectiveness (Best Policies Working Group, 1999).

Some regional municipalities began to establish regional or watershed-scaled goals to guide their policies, such as retaining native species (Regional Municipality of Waterloo, 1998) and increasing the percentage of regional forest cover (County of Oxford, 1996). In addition, some local municipalities began to incorporate broad-based stakeholder decision-making into planning. For example, the City of Waterloo engaged in a comprehensive process to plan the upper Laurel Creek Watershed. The City's consultation process involved the public, the development industry, environmental groups, neighbouring municipalities, the Regional Municipality of Waterloo and the Province. This process was very successful in incorporating "ecological buffers" as a land use category. They were identified for their hydrogeological functions in support of adjacent stream corridors (Trushinski, 1995).

While some municipalities were still preserving and protecting natural areas as individual identities, others attempted to gather the disparate elements of these areas together and plan them as systems (Best Policies Working Group, 1999). Most of these systems in suburban landscapes consisted of relatively small patches, corridors and minimal buffers embedded within a conventionally planned suburban matrix. Despite the promise of these 'systems' for performing multiple functions including recreation, conduit and wildlife habitat, and hydrological functions, little research, or Ontario government monitoring (Policies Working Group study, 1999), was conducted to test empirically the effectiveness of these systems for performing these many functions (Tyler, 2000; Roseland, 1997; Briffet, 2002). Some scholars argued that while the theory had advanced to provide a conceptual basis for an ecosystem approach to planning natural area systems, there were few examples of their successful implementation (Tyler, 2000; Roseland, 1997). Others argued that the implementation of natural heritage systems such as those prescribed in the Ontario Ministry of Natural Resources' *Natural Heritage Reference Manual* (1999), or of minimal width buffer policies, did not support over time the pre-development features and functions of natural areas within urban landscapes (Dougan, 2003).

In recognition of this lack of supporting evidence, the surrounding matrix of natural systems began to be protected from suburban development in areas that performed particularly important ecological functions. For example, in Southern Ontario large areas of the agricultural matrix surrounding remnant natural areas within the Oak Ridges Moraine (ORM) were protected largely to support the area's hydrological functions (Ontario Ministry of Municipal Affairs and Housing, 2002). Other Ontario regional and some municipal governments also began to promote, or plan the protection of natural systems and their surrounding supportive land uses (Planning & Engineering Initiatives Ltd., 2002; C. Gosselin, Region of Waterloo, personal communication, September 28, 2007).

4.5 Summary

This chapter reviewed literature related to the theory and practice of Ontario municipal land use planning for the preservation and protection of suburban natural areas and systems in the period from 1945 to 2007.

The evolution of suburban natural area planning in Ontario progressed through a series of stages. Prior to the 1970s, ecology began to be promoted as a philosophical basis for managing and planning human activities. However, in practice, most involved in suburban land development viewed cities as artificial socio-economic, rather than biological systems. Land development was largely a process of replacing natural with human engineered systems. Ontario municipal planning focused on providing the human engineered infrastructure to support rapid post-war urban development. Local municipalities were mostly responsible for planning and such planning often occurred on a site-by-site basis. Municipal policies preserved natural areas largely because of their predisposition to flooding, erosion, or because they were uneconomical to develop, although a few preserved for aesthetic reasons. Their regulation was seen as a way to protect future homeowners, and public infrastructure; from the negative effects of these natural processes should the land be developed. Planning for adjacent land use effects tended to focus on an assurance that human land uses did not conflict and that natural systems did not have a negative impact on human land uses or systems.

During the 1960s to the 1980s, the Conservation movement prompted a greater respect for natural ecosystems, and an awareness of the negative impacts of human land uses, first in the resource regions and then in urban areas and led to planning that sought a fairer balance between social, environmental and economic considerations. Theories from systems ecology, environmental management and island biogeography began to influence land use planning. Some began to conceptualize cities as urban ecosystems. Many ecological studies were conducted to identify the many plants and animals within cities. The planning of natural areas began to be influenced by island biogeography theory that revealed the importance of natural area configuration, and connectivity on native species diversity.

The rapid loss of natural areas, and environmental degradation in general, resulted in a greater appreciation of the intrinsic as well as some utilitarian values of natural areas, particularly their aesthetic value and recreational roles. This prompted regional governments (followed by municipal) to develop integrated policies to further preserve natural areas. Protection efforts were implemented largely through land use planning tools: although acquisition, easements, stewardship and education were also used to protect some of these areas. Planning for adjacent land use impacts began to develop during this time with many municipalities calling for the assessment of anticipated negative impacts of development prior to plan approval for some natural areas. While some municipalities began to apply some of these findings to urban natural area planning, most urban natural areas continued to be planned as relatively isolated, small, convoluted and static “features” within, or “backdrops” for, urban engineered infrastructure, under the assumption that once preserved from development their values would continue to exist in the pre-development condition. However, little post-construction monitoring occurred to determine whether natural area policies were effective in protecting the natural area values from the negative impacts of construction or the new adjacent land uses.

The problems that attended the rapid expansion of dispersed city forms following World War Two continued into the 1990s. Economic concerns increased along side those social and environmental. There was widespread concern that despite increased efforts to preserve and protect natural areas at the municipal level, the planning process was not protecting high growth areas from widespread environmental degradation, particularly with respect to water quality and quantity. The Provincial Government became more active in land use planning by establishing provincial planning goals, legislative authority and providing financial resources to assist the municipalities in converting their urban communities to more sustainable forms.

The natural area policies developed by the regional municipalities in the previous decade were reinforced at the provincial level to provide greater legislative authority to municipal attempts to preserve and protect significant natural areas. However, many environmentalists and citizens had lost faith in the planning system’s ability to protect urbanizing landscapes from the incremental and cumulative environmental degradation. Ecosystem planning was embraced as an alternative to conventional land use planning and there was a renewed interest in spatial forms of cities and their relationships with ecological function. Ecosystem planning is based on ecological boundaries and integrates ecological principles and socio-economic concerns in decision-making. It involves the repetitive evaluation and implementation of preferred plans through the active participation of a wide variety of relevant stakeholders.

In the 1980s, with the adoption of natural reserve design concepts arising out of studies in landscape ecology that stressed the importance of scale, individual natural areas began to be linked together in suburban landscapes. The concept of natural area patches connected to corridors and surrounded by narrow buffers began to be promoted as a model for urban natural system design, and some previously isolated remnants began to be reconnected and restored. These connected areas began to be conceived as dynamic ecological systems, and their biodiversity functions as well as ecosystem services to humans were emphasized as planning goals. However, the landscape ecology studies upon which these concepts were based took place in undeveloped landscapes, and did not account for the effects of surrounding urban and suburban land uses on these natural area remnants. Planners, consultants and others involved with land development began to notice that despite their continued efforts to protect and restore these areas, even with 5 to 30 metre buffers, they become degraded following development from adjacent land use impacts.

Beginning in the late 1990s there is an increasing appreciation for the role of adjacent land uses on natural area function, and natural areas along with larger areas of surrounding countryside are protected in support of key hydrological functions, and to a lesser extent, in support of keystone species. Definition of these functions at coarse scales, such as water functions within the Oak Ridges Moraine, brought an appreciation for the first time of the role of surrounding land uses in maintaining the function of key life support systems within cities.

Urban planning in Ontario has now moved from the third to the fourth, or ecosystem-based planning, level. The Ontario provincial government, and many regional and local municipalities, developed land use planning policies that reflect some of the principles of ecosystem-based planning. Planning units are being defined according to ecological areas in addition to political boundaries or property ownership, such as watersheds and bioregions. Built forms and systems are increasingly designed in response to ecological forms and systems, rather than the other way around. The consequences of land uses are beginning to be considered at multiple spatial and temporal scales, and development viewed as an opportunity to heal the negative impacts of prior land uses. In addition, broad-based, inter-jurisdictional planning is becoming more common. A frequently missing component of ecosystem-based management, however, is the monitoring and evaluation of natural areas and systems, particularly at the site scale, to determine whether planning and management policies are protecting natural area features and functions through time within suburban landscapes.

The next chapter describes the official and secondary plan policies within the study municipalities for limiting residential encroachment, and protecting natural areas and systems in general.

Chapter 5

Municipal Official and Secondary Plan Policies for Protecting Natural Systems

This chapter presents the results of the content analysis of study municipality official and secondary plans. It summarizes basic, enhanced and pathfinder natural heritage and water policies within the study municipalities in the context of regional and provincial policies. The detailed policy analysis by municipality, provided in Appendix D, is the basis for this summary. Sections 5.1 and 5.2 summarize the goals, objectives and policies of the official and secondary plan policies that relate to natural area and system protection and, more specifically, their protection from undesirable residential encroachment activities. Section 5.3 discusses the results of this analysis in terms of the extent to which the study municipalities have official and secondary plan policies that recognize residential encroachment as a planning issue; and established goals, objectives and policies to limit these activities.

5.1 Goals and Objectives

Goals and objectives contain the rationale for the planning and management of natural systems. All of the study municipalities have a general goal to conserve, protect, and enhance their natural resources, their environment or their ecosystem. They also have objectives to preserve, protect and enhance their "significant" natural areas, and to maintain surface water corridors and/or terrestrial corridors. In addition, all of municipalities refer to their natural areas, together with their other designated undeveloped areas (cemeteries, active parks etc.) as systems, indicating that they are attempting to plan and manage them collectively, rather than individually.

The specific ecological goals for natural systems are unclear. For example, Guelph and Oakville refer to maintaining "ecosystem health" (City of Guelph OP 2004, Pol. 2.3.11; City of Oakville OP 2004, p.7), and Cambridge refer to maintaining the "integrity of its ecosystem" (City of Cambridge OP 2004, Pol. 2.3a). However, none of these municipalities define these terms, or provide objectives or targets that could be used to measure the achievement of their goals.

Nevertheless, all the municipalities mention some of the functions provided by their natural areas or systems. All seek to support some form of biodiversity. However, few are explicit about what biodiversity they seek to support, or at what scale. For example, Guelph seeks to support biodiversity in general (City of Guelph OP 2004, Pol. 7.12e), Waterloo sought genetic biodiversity (City of Waterloo OP 2004, Pol. 1.7.3.10), and Mississauga seeks "biodiversity compatible with indigenous natural systems" (City of Mississauga OP 2006, Pol. 3.12.1.2). Oakville mentions sustaining native plants and wildlife (City of Oakville OP 2004, Pol.8, page 12). Cambridge is the most explicit, with its goal to support "native regional biodiversity", but only "where appropriate" (City of Cambridge OP 2004, Pol. 6.4.3.1). In addition, all of the municipalities recognize, or seek to maintain hydrological or hydrogeological functions. In terms of social functions, all municipalities seek to maintain their recreational functions; however, providing educational, aesthetic, heritage or economic functions (e.g. tourism) are less frequently stated.

All official plans state the objective of protecting their natural areas from the negative impacts of development and, to a lesser extent, site alteration. In these plans, development refers to the construction of buildings and structures requiring approval under the *Planning Act*, the creation of a new lot, or a change in land use (PPS 2005). Site alteration refers to the manipulation of the land itself resulting from such activities as vegetation removal or grading and drainage works use (PPS 2005).

Few official plan objectives relate to protecting natural areas or systems from the negative impacts that occur following development or site alteration. Four of the municipalities indicate that they will protect natural areas from the negative impacts of recreation, although they have few policies that identify the impacts of concern, or how or where they will be mitigated (City of Cambridge OP 2004, Pol. 2.3f; City of Guelph OP 2004, Pol. 6.1b; City of Mississauga OP 2006, Pol. 3.12.2.2m, n; City of Oakville OP 2004, Pol. 8, pp.11, 13). While Oakville indicates that it will protect its natural areas against "day to day human activities," (City of Oakville OP 2004, Pol. 8, p.12) it makes no specific reference to the activities of concern, how they will mitigate them, or where. Mississauga is the only municipality with a management goal to regulate "public encroachment." Although the Mississauga Official Plan does not define the term, it is assumed to refer, at least in part, to edge-resident encroachment (City of Mississauga OP 2006, Pol. 3.12.2.2i).

5.2 Policies

5.2.1 Basic Policies

Basic municipal policies are defined here as municipal policies that meet the requirements of provincial and regional policies. The content analysis indicates that municipal policies fulfill most provincial and regional goals and objectives by ensuring that there is adequate consideration of the anticipated negative impacts of development (by developers) on designated areas (rather than systems), and that specific negative impacts of construction, known to be particularly and immediately damaging, are mitigated. Basic municipal policies are less focused on mitigating the construction impacts that are not immediately evident at the time of development, and on protecting natural areas from the impacts that occur following development. See Table 5.1 for a summary of basic policies by type within the study municipalities.

The basic policies of the study municipalities are of five types:

1. Policies that define what process and criteria the municipality will follow to define and identify natural heritage and hydrology-related areas (rather than aquatic and terrestrial systems);
2. Policies that prohibit the development of structures and/or site alteration within the natural area;
3. Policies that regulate the type of development that occurs (within areas with sensitive hydrological functions);
4. Policies that require developers or land owners to conduct studies that identify potential impacts of their development proposals and how they will be mitigated by altering the pattern of development (where development occurs) and by reducing construction impacts (how development occurs); and,

5. Policies that require studies or plans to determine mitigation measures for specific impacts, such as tree damage or removal, the alteration of hydrological systems, or erosion and siltation.

Table 5.1 Basic municipal policies by type

Basic and enhanced Policies that regulate EIS for locally significant natural areas	**CAM[1]**	**GUE**	**KIT**	**MIS**	**OAK**	**WAT**
1. Natural area/systems identification						
Policies that define type of planning process and criteria municipality will use to define and evaluate natural areas/systems	√	√	√	√	√	√
2. All Development/site alteration prohibitions *(except infrastructure in some areas)*						
Policies that prohibit all development	√	√	√	√	√	√
Conveyance of natural areas considered through parkland dedication	√	√	√			√
Policies that specify conditions under which proposals may be refused	√	√			√	
3. Development type prohibitions						
Restrictions within areas with sensitive hydrological functions	√	√	√	√	√	√
4. EIS/EIR study requirements						
What and when subdivision-scaled comprehensive studies (*EIS, or EIR*) required	√	√	√	√	√	√
5. Specific impact study/plan requirements						
What and when specific studies/plans required (*e.g. tree or storm water management etc.)*	√	√	√	√	√	√

[1]CAM = Cambridge; GUE = Guelph; KIT = Kitchener; MIS = Mississauga; OAK = Oakville and WAT = Waterloo
√ = municipality has a policy meeting the provincial or regional policy requirements; when a cell is empty, this means that the municipality does not have a policy meeting the provincial or regional policy requirement.

The municipalities meet most of the policy requirements within the PPS (2005) for the regulation of land uses within hazardous sites and ANSIs and within regional official plans for land uses within regionally designated areas. There are fewer municipalities with policies for the protection of provincially designated portions of habitat of endangered or threatened species; however, these habitats may not exist, or may not have been identified, within these municipalities. There are no policies for provincially significant woodlands or wildlife habitat because the province has not defined or identified any of these areas. However, these habitats are often identified by the regional or local municipalities.

There is less policy compliance to the PPS (2005) policies regarding water. The study municipalities appear to have identified drinking water supply areas, other groundwater and surface water areas, including surface water corridors and wetlands of all significance. In addition, they have established rigorous storm water management policies to reduce the negative impacts to hydrological regimes in terms of water quantity and quality. However, there are no specific references to maintaining or increasing vegetation or porous surfaces.

The study municipalities appear to be in the process of understanding and establishing policies to protect individual features as interconnected systems. Many of these municipalities may be impeded from implementing these policies by prior development patterns that have replaced or degraded these systems. While all of the municipalities have policies to maintain and restore their main surface water corridors, few policies connect these areas with terrestrial corridors. It is not clear what ecological functions these corridors play within their municipal ecosystems or how their design and protective policies contributes to their functions. In addition, few policies promote the wise use of water, in terms of maintaining water quality and quantity through time.

All of the municipalities are generally in compliance with provincial and regional policies that protect natural areas from the negative impacts of adjacent development. The wide range of definitions applied to adjacent lands indicates a high degree of uncertainty regarding their impacts. There is no mention of the types of negative impacts of concern. This uncertainty results from a general lack of developer or municipal monitoring of development impacts, and the lack of sufficient research regarding urban natural area edge effects.

There is also uncertainty regarding how to define the boundaries of natural areas. Many municipalities continue to define the boundary in terms of a prominent visible characteristic, such as edge vegetation. However, some of the official and secondary plan policies define natural area boundaries to include adjacent areas that either support natural area function, or buffer their functions from adjacent negative impacts. For example, the City of Waterloo defines its perennial streams to include 30 metres of adjacent riparian land from the top of stream bank (City of Waterloo OP 2004, Pol. 6.33.5.5 (10.ii)). This area is not defined as a "buffer" but as part of the stream corridor. Others define valleyland and lakeshore boundaries to include the adjacent land necessary to protect residents against erosion hazards (for example City of Oakville OP, Pol. 4.3.2.1).

The Ontario government appears to be encouraging municipalities to address this issue with its policy requirement for municipalities to evaluate the ecological functions of adjacent land uses (PPS 2005, Pol. 2.1.6). There are no policies in study municipality official and secondary plans that require studies to evaluate the ecological functions of adjacent lands. However, some municipalities have policies designating lands adjacent to natural areas for their important ecological roles in support of natural area systems, and within the urban ecosystem at coarser scales. For example, the secondary plans for Waterloo’s Laurel Creek lands and Cambridge’s North Hespeler, designates areas outside their natural systems as "constraint lands", the same as their natural system lands, but places fewer development restrictions on them according to their lower level of ecological significance (City of Waterloo OP 2004, Pol.6.33.5.5, 12vii; Planning & Engineering Initiatives Ltd., 2002, p. E-4). Waterloo was the first, among the study municipalities, to recognize the importance of these areas in the mid 1990s, through their policies that required low impact design practices for storm water management, wetland creation and housing densities determined, in part, by the needs of the adjacent natural area (City of Waterloo OP 2004, Pol. Pol.6.33.5.5, 12 viii). In terms of the latter policy type, Waterloo has a policy that they "may give preference" to multi-unit residential buildings adjacent to significant natural areas, above low-density single detached subdivisions (City of Waterloo OP 2004, Pol. 3.1.2.8).

All of these municipalities have policies that seek to minimize the impacts of their development on the adjacent natural area through tree protection requirements, and particularly storm water management practices. However, only Cambridge and Mississauga have policies in recognition of the ecological features and functions of these areas in support of core natural area systems. Within their plan for North Hespeler, Cambridge established policies that recognize that some areas within the developed landscape are more important in terms of supporting natural areas than others. Developed areas closer to natural areas are subject to greater regulation than those further away and regulations include not just a consideration of housing density, but also the type of land use and supplementary habitat requirements of the core natural area system. In areas without sufficient riparian or supporting upland habitat, "habitat enhancement areas" are specified. Within other areas ‘complementary’ land uses are specified consisting of "more supportive" urban land uses than single-family residential land uses. Supportive land use characteristics are assumed to include low lot coverage, deep building setbacks, seasonal use, or low frequency single loaded streets. Many of the institutional land uses, such as schools and churches are assumed to have these characteristics (Planning & Engineering Initiatives Ltd., 2002, p. E-2 to E-6). While all the municipalities have policies that favour placing schools adjacent to natural areas, the stated purpose of these policies is to encourage the provision of shared recreational facilities between the schools and the municipality, rather than to provide ecologically supportive adjacent land uses (For example, City of Waterloo OP 2004, Pol. 6.33.5.5 (4.g)).

Mississauga, meanwhile, has policies to protect existing patterns of residential development that play supportive ecological roles (City of Mississauga Official Plan (2003), Pol. 3.12.2.2f). It designates ‘Residential woodlands’ (residential areas with large lots and relatively low lot coverage with mature canopy trees). These areas are recognized for their importance as habitat for "tolerant canopy birds" and for their storm water recharge functions. Mississauga has a policy that re-development or infill development proposals within these areas "should seek to preserve the existing tree canopy" (City of Mississauga Official Plan (2003), Pol. 3.12.2.2j, Sec. 3 – p.26). This policy begins to address the negative impacts on natural areas and systems that may result from the future densification or intensification of existing urban residential areas.

5.2.2 Enhanced Policies

Enhanced policies are those that define, and require, an EIS for locally-significant natural areas, and those that are suggested, but not required, by either the provincial or the regional governments. Relative to basic policies, the enhanced policies of the study municipalities tend to be more proactive, in terms of the municipality participating in, or requiring developers to participate in, specific measures to protect natural areas from development. However, most of these policies still focus on preserving and protecting natural areas from development impacts rather than post development impacts. See Table 5.2 for a summary of enhanced policies by type within the study municipalities.

Most of these policies generally belong to two policy types: 1) policies that require or encouraged the negotiation of specific conditions of development approval within or immediately adjacent to natural areas; and 2) policies that specify how the municipality plans to acquire, restore, manage or monitor natural areas in order to protect them through time. The most common enhanced policies are those that specify:

1. Conditions under which the municipalities will consider purchasing a natural area;
2. Restoration of natural areas, or corridors;
3. Management policies that specified native plants, or restrict the use of non-native invasive species in publicly-owned open space; and,
4. Participation of municipalities within stewardship and education programs mostly focused on private landowners of natural areas.

Table 5.2 Enhanced municipal policies by type

Other Enhanced Policy Types	CAM[1]	GUE	KIT	MIS	OAK	WAT
1. Conditions of Development						
1.1 Restoring areas degraded by past land uses						
Subdivision or site scale				√		
Within an natural area prior to conveyance				√		
1.2 Resident education or stewardship programs	√	√				
1.3 Monitoring of Ecological Systems						
Impacts of development/site alteration	√		√			√
2. Municipal Stewardship Commitments						
2.1 Natural area acquisition policies						
Acquisition of natural areas	√	√	√	√	√	√
2.2 Restoration of negative impacts of past land uses						
Subdivision or site scale (by municipality)	√	√	√	√	√	√
Natural area scale					√	
Systems scale (watershed/subwatershed/landscape)	√					
3. Monitoring of Ecological Systems						
3.1 Impacts of development/site alteration	√	√	√			√
3.2 Impacts of recreation/resident activities	√					
3.3 Impacts of courser scaled urban development/rural land uses (watersheds/subwatersheds)	√	√	√			√
4. Standardized Management Regimes						
4.1 Natives only in municipal lands	√			√	√	
4.2 Discourage the use of exotic invasive plants within lands adjacent to natural areas	√				√	
4.3 Naturalization in natural areas and in other open space types	√	√	√	√	√	√
4.4 Natural area or designation-specific management policies	√					
5. Resident or landowner education or stewardship	√	√			√	
5.1 By Municipality (owners of private natural areas)	√	√	√	√	√	√
5.2 By municipality (residents adjacent to public natural areas)	√	√			√	

[1]CAM = Cambridge; GUE = Guelph; KIT = Kitchener; MIS = Mississauga; OAK = Oakville and WAT = Waterloo
√ = municipality has a policy; when a cell is empty, this means that the municipality does not have a policy of this type

5.2.2.1 Provincially-suggested Policies

Enhanced policies that respond to provincial policy suggestions include:

1. Policies that maintain connectivity between provincially significant natural heritage areas;
2. Policies that restore the features, functions and connectivity of natural heritage areas;
3. Policies that maintain or restore biodiversity within natural heritage areas; and,
4. Policies that monitor the performance of municipal official plan policies according to performance indicators
(PPS 2005, sec. 2.1.2 and 4.11).

1) Maintaining Connectivity Between Natural Heritage Areas

Regional and local municipalities have policies that regulate development within their major and minor river corridors. In addition, remnant hedgerows, roadside tree corridors, utility corridors, and other small patches of remnant terrestrial vegetation are recognized and regulated for their role in natural area connectivity. Their primary functions are the provision of movement corridors and habitat for wildlife and humans, and hydrology. However, in general, these areas are not planned to meet the habitat or connectivity needs for specific wildlife, vegetation species or their communities. An exception to this is the North Hespeler Community Plan, which proposes corridors specifically to support the subwatershed's sensitive hydrological system, and white-tailed deer

(Planning & Engineering Initiatives Ltd., 2002, p. E-2 to E-6). These species are identified as "umbrella" species for this landscape (i.e. meeting the habitat requirements of these species may also meet those of other less sensitive or less area-demanding species within the subwatershed).

2) Restoring and Enhancing Natural Areas and Connectivity

Many of the municipalities have policies that specify the restoration of natural areas from the negative impacts of previous land uses. These policies are applied to both terrestrial and aquatic habitats. Policies with regard to terrestrial habitats largely specify the naturalization of previously managed areas (e.g. utility corridors, or roadside areas). Some municipalities seek to increase the percentage of the municipality covered by trees. All municipalities have policies that specify the restoration of stream corridors (for example, City of Kitchener, 2003, Sec. 5.5, 5.11).

3) Conserving Biodiversity

The PPS (2005) recommends the maintenance or restoration of biodiversity, but does not specify "native" biodiversity, nor the spatial scale at which biodiversity is to be supported (PPS 2005, Pol. 2.1.2). Municipal plans also rarely specify explicit biodiversity goals within their policies. Without a definition of these parameters, these policies are not very meaningful in terms of providing leadership for the planning of natural systems that conserve threatened native biodiversity. For example, many urban areas have high levels of biodiversity because of the large number of exotic species that are cultivated, or naturally spread, within urban landscapes. In addition, biodiversity may be high at the scale of a natural area, but low at the scale of the landscape.

4) Monitoring

The regional governments have policies that specify the regional monitoring of performance indicators at the subwatershed/watershed scale (such as water quality and quantity measurements). Many of the study municipalities appear to be relying on these governments to perform coarser scaled monitoring. However, a few of the study municipalities have policies requiring developers to perform, or participate in, site-scaled monitoring programs (For example, City of Waterloo OP 2004, Pol. 6.33.5.5 (12.viii); City of Guelph OP 2005, Pol. 6.2.4, 6.2.5). Performance indicators for these monitoring programs are established within subwatershed studies that have baseline points of reference from which to monitor change. Most of this monitoring is focused on hydrological parameters, rather than those terrestrial or human. There are no policies for monitoring the impacts of post development resident or recreational activities.

5.2.2.2 Regionally-suggested Policies

The more significant regionally-suggested policies include:

1. Policies that require watershed/subwatershed studies, not only for the planning of hydrology-related policies, but for natural area systems planning in general;

2. Policies that establish criteria, or an independent committee, for assessing development proposals;
3. Policies that establish a course of action should a natural area be threatened with development;
4. Policies that encourage standardized management regimes; and,
5. Policies that encourage the donation, stewardship, or education of primate landowners of natural areas, and residents adjacent to publicly owned natural areas.

1) Planning Through Watershed/Subwatershed Studies

Policies for secondary plans indicate that watershed/subwatershed scaled studies are frequently required prior to, or in conjunction with, a site-scaled EIS. This allows municipalities the opportunity to advance secondary planning policies, or conditions of development, based upon their own technical assessments, rather than relying on developer-prepared EIS that may propose inadequate mitigation measures.

2) Evaluating Development Compatibility through Assessment Criteria

Most of the local municipalities have assessment criteria for the preparation and review of development proposals that require an EIS (the criteria for which is determined by the level of significance applied to the natural area). In addition, within some municipalities, an independent environmental committee, in addition to municipal staff, reviews many of these assessments (For example, City of Waterloo OP 2004, Pol. 2.3.14.6). These committees make recommendations to regional and municipal councils regarding whether proposals should be approved and under what conditions. Their use is a proven method of increasing municipal commitment to environmental values (Hilts & Reid, 1990).

3) A Course of Action Should a Natural Area be Threatened with Development

The Region of Waterloo encouraged its area municipalities to acquire natural areas when developers threaten them (Regional Municipality of Waterloo OP 1998, Pol. 4.2.10c). The Region of Halton also has a policy to encourage its local municipalities to acquire, through purchase or lease, waterfront land (Regional Municipality of Halton OP 2004, policy 136.4). In addition, it encourages its local municipalities to purchase natural areas, and areas adjacent to them, in order to protect them from "incompatible uses" (Regional Municipality of Halton OP 2004, policy 118.7). Most of the study municipalities also have policies to acquire natural areas if developers threaten them. In addition, both Oakville and Mississauga have policies to acquire waterfront properties to allow for public access (City of Oakville OP, Pol. 4.1.3i; City of Mississauga OP 2004, Pol. 2.9.2.1-.3). Nevertheless, the study municipalities generally downplay acquisition policies.

4) Standardized Management Policies for all Natural Areas

There are few management policies contained within any of the official or secondary plans. The Region of Waterloo recommends that its local municipalities use only native and not exotic invasive vegetation within municipal plantings. It also recommends that its area municipalities develop individualized management plans

(Region of Waterloo OP 1998, Pol. 3.3.4, 3.3.5, 4.7.2). The Cities of Cambridge, Mississauga and Oakville have policies to use (where feasible) native plants within public open space, while Cambridge and Oakville have policies to discourage the use of non-natives within and adjacent to natural areas (City of Cambridge OP 2004, Pol. 6.4.3.3, 6.4.3.4; City of Oakville OP 2004, Pol. 4.1.2c, p. 15ol. 4.1.3i; City of Mississauga OP 2004, Pol. 3.12.2.2i). Most of municipalities also have policies that encourage naturalization within parkland, where appropriate. In Cambridge, the subwatershed study for Forbes Creek recommends a maintenance regime for riparian buffers to sustain their hydrological functions; and the siting of trails away from sensitive areas to reduce negative recreation impacts (Planning & Engineering Initiatives Ltd., 2002, E-12, 13, 26).

Mississauga has more management policies than the other municipalities. A Region of Peel Official Plan requires its area municipalities to establish official plan policies for the 'proper management' of their natural areas (Regional Municipality of Peel OP 2005, Pol. 2.3.2.3). This led Mississauga to develop these management policies:

1. The use of native plants and materials;
2. The control of invasive exotic plant species;
3. The regulation of "activities" within natural areas that are "inconsistent with the retention of natural forms, functions and linkages;"
4. The regulation of recreation activities to reduce their negative impacts;
5. The establishment of maintenance regimes that allow natural areas to reach a "natural state;" and,
6. The regulation of "public encroachment"

This was the only official plan that has a policy that specifically relates to residential encroachment, assuming that Mississauga is referring to edge resident encroachment when it referred to "public encroachment" (City of Mississauga OP 2006, Pol. 3.12.2.2).

5) Stewardship and Education among Private Landowners and Residents

The regions promote policies that encourage donation, stewardship (including 'wise management') and education, among private landowners of natural areas, and to a much lesser extent, local residents. However, these policies do not receive much emphasis in a majority of the local municipal official plans. The study municipalities have four types of stewardship policies:

1. Policies that acknowledge the importance of stewardship and make a commitment to 'cooperate' with regional governments in their private landowner stewardship programs;
2. Policies that encourage developers to educate and encourage stewardship among residents;
3. Policies that mention stewardship agreements as a policy option should a privately owned natural area be threatened with development; and,
4. Policies that state the municipality's intent to encourage stewardship and awareness among residents.

5.2.3 Pathfinder Policies

Pathfinder policies are developed through the initiative of the local municipalities. Relative to basic and enhanced policies, pathfinders tend to be proactive in terms of establishing municipal leadership in the preservation and protection of natural area systems. See Table 5.3 for a summary of pathfinder policies by type within the study municipalities. Most of these policies are one of two types:

1. Policies that require or encourage specific mitigation measures to address uncertain, or a broad range of, impacts; and,

2. Policies that specify how the municipality plans to manage natural area impacts in the post development period.

Table 5.3 Pathfinder municipal policies by type

Pathfinder Policy Types	CAM[1]	GUE	KIT	MIS	OAK	WAT
1. Specific mitigation measures						
1.1 Policies that mitigate uncertain impacts that may occur during or post development						
Buffers or minimum buffers required	√	√			√	√
Buffers subject to an EIS			√	√		
Setbacks required, or may be required subject to EIS		√	√		√	√
Supplementary plantings may be required			√		√	
1.2 Policies that regulate how development impacts future management of natural areas						
EIS to demonstrate proposal not conflicting management regimes (locally-significant wetlands)		√	√		√	
Provide space for management activities (*locally-significant wetlands*)						√
1.3 Policies that protect natural areas from future impacts of adjacent residents						
1.3.1 Options for Mitigating/reducing anticipated impacts						
Fencing	√	√	√		√	√
Landscaping					√	
Controlled pedestrian access	√					√
Roads					√	
Signage					√	√
Resident Education	√					
By-laws	√					
1.3.2 Management of impacts after they occur						
Commitment to regulate residential encroachment				√		
1.4 Policies that address cumulative impacts of development						
EIS to consider impacts of future demand for development		√	√		√	
2. Municipal Stewardship Commitments						
2.1 Natural Area Management Policies						
2.1.1 Standardized Regimes						
Passive Management or naturalization		√			√	
Use of native materials				√		
Buffers of Specific designations (hydrological areas)						
Naturalization (to forest)		√	√			
Meadow or early shrub stage	√					
2.2 Policies that protect natural areas from recreation impacts						
Prohibiting access in some areas	√		√	√		
Using access points and trail location	√	√	√	√	√	√
Regulating negative impacts of trail construction		√				√

[1]CAM = Cambridge; GUE = Guelph; KIT = Kitchener; MIS = Mississauga; OAK = Oakville and WAT = Waterloo
√ = municipality has a policy; when a cell is empty, this means that the municipality does not have a policy of this type

1) Measures to Limit Specific Impacts of Development and of Adjacent Land Use

All the municipalities have policies that require developers to take specific measures to limit general impacts. Policies that specify buffers or building setbacks in association with river corridors are most common. There are frequently many reasons given for setback policies. For example, policies indicate that setbacks are required to: 1) protect residents from unstable or erosive slopes; 2) protect edge vegetation from construction impacts; and, 3) maintain natural area views. However, municipalities give few reasons to support buffer policies. Buffer functions are frequently assumed site specific and, for some natural area designations, municipalities require developers to consider buffers, or define their characteristics, in an EIS (Environmental impact assessment), EIR (Environmental Implementation Report), or a buffer study. However, five of the municipalities have policies that require specific or minimum buffer widths for stream corridors that range between 7.5 and 30 metres (City of Cambridge OP 2004, Pol. 6.3.3; City of Kitchener OP 2005, Pol. 7.8.1.2; City of Guelph OP 2005, Pol. 6.9.1, 6.9.5; City of Oakville OP 2006, Pol. 4.3.2.1d; City of Waterloo OP 2004, Pol. 6.35.5.5). These widths appear to reflect those commonly recommended in guidelines provided by the province (such as those within the Ministry of Natural Resources (Ontario Ministry of Natural Resources, 1999), or by some Conservation Authorities, rather than specific watershed or subwatershed studies. These authorities commonly specify buffer widths of 7.5 metres to protect edge vegetation from construction impacts, and buffers of between 15 to 30 metres to protect the hydrological functions of streams and wetlands (Planning & Engineering Initiatives Ltd., 2002).

2) Limiting Impacts of Development on Future Natural Area Management

Official plan and secondary plan policies require developers to consider the negative impacts of adjacent development on the future management of some natural areas, or specify policies to limit these future impacts. Within Guelph, Kitchener and Oakville proponents have to demonstrate within an EIS that their proposal for land adjacent to a locally significant wetland will not "conflict" with the way the wetlands are managed (City of Guelph OP 2005, Pol. 6.4.3; City of Kitchener OP 2005, Pol. 7.5.2 (2.iii); City of Oakville OP 2006, Pol. 4.3.2.3 c.iv). The province initially introduced this policy for provincially significant wetlands in its Provincial Wetland policy statement (Province of Ontario, 1992). Waterloo requires developers to ensure adequate land has been conveyed with a parkland dedication adjacent to an open watercourse to allow for its subsequent management (City of Waterloo OP 2004, Pol. 2.3.9). In addition, the North Hespeler subwatershed plan states that its open space system was planned to minimize the need for its future management (Planning & Engineering Initiatives Ltd., 2002, p. E-26).

3) Limiting Cumulative Impacts of Development

Some municipalities have policies that look beyond the impacts of an individual development to address future impacts of subsequent developments. Three of the municipalities, Guelph, Kitchener and Oakville require proponents to consider cumulative impacts of adjacent land use development on locally significant wetlands (City of Guelph OP 2005, Pol. 6.4.3; City of Kitchener OP 2005, Pol. 7.5.2 (2.iii); City of Oakville OP 2006, Pol.

4.3.2.3 c.iv). The provincial government first introduced this policy for the regulation of development adjacent to provincially significant wetlands within the Provincial wetland policy (Province of Ontario, 1992).

4) Limiting Impacts of Recreation

Most municipalities have policies that state that natural areas, or their buffers, will accommodate passive forms of recreation where compatible. Specific policies to limit recreation impacts tend to focus on reducing the impacts of recreation facility construction, and placing trails and access points away from sensitive areas (For example, City of Waterloo Op 2004, Pol. 6.33.5.5, 4) iii d.). However, few policies state the impacts of concern on either the natural area, or buffer functions.

5) Limiting Impacts of Adjacent Residents

Few of the municipalities have specific policies within their official or secondary plans for avoiding the occurrence of adjacent resident activities, and none has policies for resolving them after they have occurred. Oakville's Official Plan is the only one to have a boundary demarcation policy. Oakville's policy requires some form of boundary demarcation (landscaping, signage, fencing, and/or a public road) between shoreline residences and the adjacent natural area abutting Lake Ontario. The type of demarcation is to be established in conjunction with "nearby residents," and its function is to provide a "physical and legal separation" between the two land uses, rather than to mitigate residential encroachment (City of Oakville OP 2004, Pol. Part D, i, b.). Waterloo's Official Plan states an intention to develop a policy to prevent or reduce post development activity impacts on adjacent natural areas within the Laurel Creek Planning Area. The stated intent of the policy is to "control human access" to Laurel Creek's buffer areas via some means, such as fencing or signage (City of Waterloo Official Plan, Pol. 6.33.5.5, 10 iii, p. 248). However, this policy does not refer specifically to adjacent residential land uses.

The Management Plan for Kitchener's Doon South Secondary Plan recommends a fence with signs between riparian buffers adjacent to wetlands, ESPAs, significant woodlots and all adjacent land use types (Doon south community greenspace management plan 2003, Sec. 8(1)). However, there is no policy of this type in the secondary plan for Doon south. The Forbes Creek Subwatershed Study recommends two scales of policy for addressing adjacent land use impacts of residential subdivisions. Firstly, it recommends supportive adjacent land uses that will serve as a form of buffer, or transition, between subdivisions, and sensitive natural areas. Secondly, at the scale of the boundary, between residential areas and adjacent natural areas, the plan recommends fencing and resident education regarding the use of pesticides on lawns, and the proper disposal of pet manure. The plan suggests these policies will address the following adjacent land use impacts: "direct residential encroachment, chemical use, light noise, pets and human presence." It is particularly concerned about their degrading impacts on interior habitats within core natural areas (Planning & Engineering Initiatives Ltd., 2002, p. E-12).

5.3 Discussion

The content analysis indicates that the study municipalities generally do not recognize residential encroachment, or post development impacts, as significant issues at the official and secondary plan policy levels. Few official plan goals relate to protecting natural areas from residential encroachment activities, or from any of the impacts that follow development; and none of the municipalities have objectives that could serve as measurable indicators of goal achievement. Few of the municipalities have specific policies for either reducing the incidence of encroachment activities, and none have policies for resolving them after they had occurred. Although the municipalities rarely mention the actual residential impacts of concern, some indicate that they intend to develop policies to protect their more sensitive natural areas from unspecified adjacent land use impacts. This indicates that there is an awareness of the natural area degradation resulting from adjacent land use activities; however, this concern has not yet translated into identifying the source of the degradation and establishing a course of action to address it. Municipal policy options focus largely on fine-scaled courses of action, such as the establishment of property line demarcation, such as fences, rather than on courser scale solutions that might involve significant changes in subdivision configuration or establishing alternative land uses adjacent to these sensitive areas. This appears to reflect an assumption among the municipalities that fine-scaled boundary mechanisms, such as fences, can effectively mitigate these activities and their impacts on natural areas. The official and secondary plans do not mention any strategies explicitly for reducing encroachment, or adjacent activity impacts. However, the policy options being considered, such as boundary demarcation, and public roads suggest that the municipalities are considering a site scaled containment strategy that seeks to concentrate resident activities within or close to the private property boundary. Other commonly mentioned policy options, such as signage, and resident education suggests that they favour a strategy of indirectly altering the behaviour of adjacent residents that lead to encroachment activities.

In terms of the planning trends for natural area and systems protection indicated within the literature, this content analysis indicates that the focus of policies is still on the protection of natural areas, rather than natural systems. Accordingly, policies focus on ensuring that developers consider the negative impacts of their land use pattern change and construction methods, under the assumption that if certain measures minimize site scaled impacts, within and immediately adjacent to the natural area, the natural area’s pre-development features and functions will continue to exist. The general lack of policies that protect natural areas from resident activities, and land uses following subdivision release, and policies that actively manage natural areas to ensure that municipalities sustain the features and functions through time, reflects this assumption. There is a general lack of municipal monitoring policies to provide the proof that natural systems become degraded following development, and therefore require policies to protect them is the post development period.

Nevertheless, the focus is shifting away from the protection of isolated natural areas, toward the protection of natural areas as key ecological subsystems (or "infrastructure") within coarser scaled urban ecosystems. This analysis confirms that the municipalities studied are beginning to practice ecosystem-based planning. Although there remains a general lack of ecological objectives for the planning and management of natural areas in terms of their functions at different spatial scales, the independent components of these natural systems are becoming spatially connected. This is occurring through policies that preserve linear shaped natural areas, or corridors, and that value and restore other areas in the landscape that are potentially significant as components in the natural area system. These include policies that restore areas that were degraded from previous land uses, and other areas of "open space" to more natural states.

The planning of natural systems is also expanding spatially outward from a focus on the natural area patch or corridor, and its immediate adjacent land use edge, to embrace more remote adjacent land uses and further toward planning all the lands within the watershed as natural systems. This shift is occurring through the watershed/subwatershed planning process that has encouraged municipal planners to take a more active planning role at coarser scales.

Landscape ecology theory suggests that ecological planning should occur at a minimum of three scales in order to design ecological systems that adequately support multiple scale form and function in the landscape (Dramstad, Olson and Forman 1996). The policies reviewed in this content analysis indicate that planners are moving toward multiple scale planning. Planning of natural systems is occurring at the subdivision scale through the preparation of EIS by developers, at the Watershed and subwatershed scales, through the preparation of plans by municipalities, and Oakville is now conducting natural area-scaled ecological studies that indicate a third scale of planning and management is beginning to occur. However, in many cases, one scale of planning is being replaced by another. For example, within some of the study municipalities, subwatershed plans take the place of plans that result from an EIS at the scale of the subdivision. The municipal preparation of watershed, subwatershed and natural area plans allow more municipal control over the planning of natural area systems. They provide municipalities with the knowledge, supported by evidence, required to plan proactively these systems in advance of development. Ensuring that developers prepare subdivision-scaled EIS according to certain criteria, without watershed and subwatershed municipal studies of these areas, places municipal planners in a passive position, particularly when municipalities or developers are not conducting monitoring. At the same time, a reliance on watershed or subwatershed planning to determine subdivision-scaled policies does not allow protective policies to respond to natural area or edge specific conditions that ideally should contribute to the planning of protective policies. Oakville's third scale of planning may fill this gap.

Despite this shift in the spatial scale of natural area planning, a corresponding shift in the temporal scale of planning has yet to occur. The study municipalities have very few mechanisms, in terms of official and secondary plan policies, for protecting natural areas and systems from negative impacts that occur following the development period. This includes either direct impacts (edge resident activities, or recreation) or indirect impacts (noise, light, microclimate, water and chemical flows, pet predation, etc.). Watershed, subwatershed, natural area studies and environmental impact studies focus on regulating land use in the protection of natural areas through to the end of the development period. Yet, many of these municipalities are close to, or are, fully developed, and will have little remaining opportunity to apply these protective policies. At the same time, many of these, and other municipalities throughout Southern Ontario, are in the process of redeveloping their existing urban land uses making them more intensive, which may result in increased coverage of residential areas with structures, and an accompanying increase in the numbers of residents and recreationists. Such an outcome is likely to result in increases in both direct and indirect impacts on adjacent natural areas. In addition, it may result in the loss, or degradation of supporting ecological functions within adjacent residential neighbourhoods, such as Mississauga's "residential woodlands," as infill development expands the area covered by buildings and parking lots, and the large canopy trees can no longer grow, or have significantly reduced life spans.

The following chapter provides an in-depth view of how municipal staff within the study municipalities view residential encroachment activities and their understanding and implementation of their residential encroachment goals, objectives, strategies, and policies.

Chapter 6

Municipal Perceptions of Encroachment Policies and their Implementation

This chapter presents the results of the interviews with development, environmental and parks planners, forest managers, bylaw officers and municipal real estate officials. Analysis of the interviews revealed nine themes: 1) definitions, 2) concerns, 3) prevalence, 4) significance, 5) goals, 6) strategies, 7) policies, 8) implementation, and 9) barriers to implementation. Five sections present these themes. Section 6.1 describes how interviewees as a group perceive residential encroachment. It summarizes how they define encroachment, their concerns, and how prevalent and significant they feel encroachment is within their municipal natural areas. Section 6.2 describes the goals and strategies of the interviewees and their municipalities. Section 6.3 describes the policies, their implementation, and barriers to implementation within each study municipality. Section 6.4 discusses the results of this analysis in terms of the extent to which the study municipalities have: 1) recognized the existence of residential encroachment as a problem, 2) established goals, strategies and policies for its mitigation; and 3) implemented these policies. In addition, it identifies barriers to policy implementation.

6.1 Perceptions of Residential Encroachment

6.1.1 Residential Encroachment Defined

Most interviewees define residential encroachment as the unauthorized use of public land by residents, “Encroachment is any kind of use of our property that hasn’t been authorized or approved” (PP1). However, a majority of interviewees exclude at least some resident activities, or their impacts, when it comes to addressing residential encroachment. For example, when asked about residents dumping waste in the forest edge, one interviewee replied, “that’s not encroachment though; they’re just dumping their own personal items into parkland” (FM1). Many indicated that they exclude activities that do not leave highly visible traces, such as pool water disposal, or chemical use. Others said the resident has to be consciously encroaching, while for still others the resident has to experience a personal gain. However, some interviewees consider these distinctions irrelevant, arguing that encroachment consists of any unauthorized activity, “any type of negative activity carried out by residents, whether they know about it or not, from the subtle effects of feeding or attracting animals to extreme activities, such as building structures or pools in the forest” (FM3).

Interviewees have different spatial definitions of residential encroachment (Figure 6.1a). Many said that residential encroachment included impacts from activities occurring within the forest edge, as well as those from activities occurring within immediately adjacent residential properties. Others said that impacts resulting from edge-resident activities within their property boundaries should not be included. They argued that residents must be physically within the forest edge to encroach. A smaller number of interviewees argued that residential encroachment should include all impacts of an adjacent residential land use, whether they arrive from unauthorized activities within the forest, within adjacent residential yards, or from areas more remote:

> But there's a lot of different types of encroachment, dumping and, um, the indirect ones, the functional ones being more things around noise and sound, light and pets and that kind of thing, things that sort of extend the impact even if humans don't go into the spaces themselves, their impacts do. (PC1)

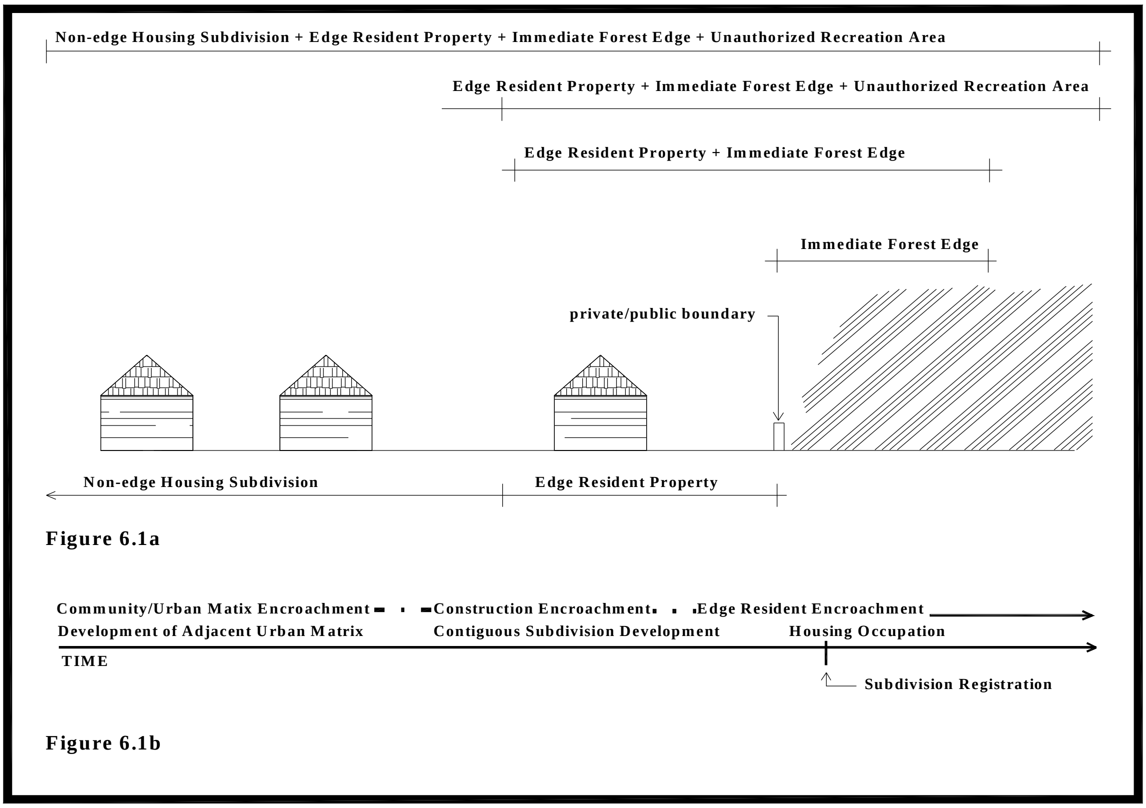


Figure 6.1a and b. Spatial and temporal definitions of residential encroachment

Interviewees also hold different temporal definitions of residential encroachment (Figure 6.1b). Interviewees who were planners indicated that the residential encroachment process begins prior to residents moving into their homes. Some said that the construction process generated materials that residents subsequently use in their encroachment activities, such as in the construction of tree forts. Others said that builders often crossed the limit of development removing part of the forest edge, and that builders commonly grade and sod these area in an effort to repair their encroachments. These construction-related encroachment areas may subsequently become part of the resident's yard, or an unintentional invitation to encroach. Grading certificates may also be approved without verifying that the graded area meets the agreed upon limit of development.

> We've got tons of those too where it's like the person's gone out to do a grading certificate sign off and ah, in that case that's not a city person, the consulting engineer, and they might say that it's fine and then all of a sudden we get out there 2 years after the fact; it's been signed off and someone's complaining about another issue and we're going, 'Oh my God, you know you've got 50 extra feet!' (PP5).

6.1.2 Concerns

Interviewees raised a wide variety of ecological and social concerns regarding residential encroachment. Those troubled by ecological impacts stated they were concerned about the loss of, or damage to, forest vegetation, particularly the understory, "We're getting encroachments of a large variety – removal of vegetation, compaction of soil, degradation of the woodlot understory – that's my biggest concern" (FM5). The introduction of exotic species is also a concern. Interviewees indicated that residents contribute to their introduction through yard extension activities and the dumping of waste:

> We had euonymus going for hundreds of square metres up to a foot thick, 30 feet up the trees – nothing could compete. We believe that it was actually introduced by people dropping their cuttings. Even people who believe that they are doing the right thing – dumping green waste into the forest (FM4).

Many are concerned that encroachment activities, particularly yard extensions, will lead to an incremental and cumulative loss of forest area, both for wildlife and human recreation. They said their municipality had protected these areas for the benefit of all people in their communities; and that it was unfair that some residents took pieces of it for their own use, or degraded it, "Someone is using the property for their benefit to the exclusion of the general populace" (FM2). Bylaw and property manager officials are particularly concerned about the possibility of long-time encroachers acquiring public land for free through successful adverse possession claims, "In parks particularly, you know, if somebody comes out with 10 or 20 years of exclusive use of a bit of our park, they could claim adverse possession" (PM2).

Forest managers and bylaw enforcement officers also expressed concern about reduced public safety or increased municipal liability, should an encroachment harm another member of the community, "We need to deal with the ones that are hazardous, causing an unsafe condition first" (PM2).Encroachment that involves unsafe stairs and decks and other structures like tree houses are priorities for mitigation, "We've actually found some old decks that if you stepped on them, you would fall through into the ravine! They had to be mitigated immediately" (FM4).

Despite their concerns, some interviewees do not think residents, or the community, are concerned about residential encroachment. Some said they did not think many residents appreciated the ecology of natural areas, or were aware of the negative impacts of encroachment activities:

> It seems like for residents it's a feel good-thing, that people see trees, you know they don't understand the vegetation community. People mean well, but I just don't think they have a lot of connection between their individual activities and what that means (DP3).

Forest managers and planners in both Kitchener and Cambridge argued that awareness of the encroachment issue was low because residential edges are often hidden from community view, "In a lot of cases in our natural areas, we don't have trails near the property edge, so people may not notice" (PP1). Furthermore, there were arguments that since a majority of edge residents are encroaching, few are likely to complain about it to their municipalities:

> When Kitchener looked at its encroachments, we found that over 80% of people were encroaching, so it's sort of like everybody's doing it so the number of people that have concerns about it are somewhat limited (FM3).

There were also concerns raised about the impacts of encroachment on interviewees' ability to do their jobs. Some interviewees argued that it is their job to steward the forest on behalf of the public and feel less able to do so because of encroachment activities:

> You know, we go through the process of trying to protect and enhance these natural areas and a lot of it, even engineered open space areas, are design built to regenerate over time. So, we put in these requirements for a specific reason and we don't want these encroachments to happen, and invariably it has been a struggle (DP4).

One development planner argued that it undermines her ability to enforce her municipal zoning bylaws. She said that residents have come to her city hall to apply for a re-zoning of the land behind their properties so they could encroach legally. She commented that when she denies a re-zoning request, residents often get angry because they say all their neighbours are encroaching and the City is doing nothing about it:

> You know, if you've got somebody coming in, we quite often here ask for valley watercourses to be dedicated below top of bank or below the flood line hazard. Well, if you've got somebody with their pool sitting there, this neighbour's coming in for rezoning or wants to do something, and they look and point downstream and say, 'well they're not in compliance.' It makes it very hard to then keep consistently applying the rules through development applications (DP3).

She also maintained that encroachment undermines her ability to negotiate protective mechanisms with developers for new developments. She indicated that some developers are aware of the high level of encroachment. She said that some have decided that it is pointless to concede land to her municipality to protect these areas when the municipality cannot protect it from residential encroachment, "It sort of breaks down our ability to negotiate and protect these areas" (DP3).

Some forest and parks operations managers also complained about the amount of time they dedicate to dealing with encroachments rather than addressing important silvicultural concerns. They complained about having to repair municipal fences and remove gates, gardens and waste. Some argued that if they do not manage encroachment impacts the forests looks degraded, uncared for, and may attract further degradation, "It's like vandalism. It begets vandalism. And we've got indigents going in there and living in there because they see that it's in a degraded condition" (FM2).

6.1.3 Prevalence

There is a wide variety of opinions among interviewees concerning the prevalence of encroachment in municipal forest edges. Many of the interviewees in Kitchener, Mississauga said Guelph believe a large proportion of their edge residents are encroaching, "It is at epidemic proportions across Ontario" (FM2). This belief in Kitchener and Mississauga may stem from the results of encroachment surveys conducted in these municipalities in 1996 and

1999, respectively. The surveys indicated a significant percentage of edge residents were encroaching (FM3 and FM4). However, many of the interviewees in Cambridge and Waterloo indicated that they do not know if it is prevalent. Some said that they are not sure because they have not conducted surveys, "I don't know the extent of the encroachment throughout the city" (PP1). Others said they suspect only a minority are encroaching:

> They are common, but they are not, I think I can say that they're not rampant. If one were to look at say twenty lots, you'd probably see about a third of those lots where you have somebody trying to kind of alter conditions (EP4).

Interviewees in Oakville stated that they thought encroachment is not prevalent in Oakville. Oakville conducted an encroachment survey in the early 1980s and, similar to Kitchener and Mississauga, found that a majority of residents were encroaching (FM5). Interviewees said that they subsequently implemented a fencing policy, and that it has been effective in addressing the encroachment issue, "I think that in the last 20 years through the policies that we put in place, that the encroachment issue is not an issue" (PP4).

In Cambridge, Guelph and Waterloo interviewees feel that there are more residential encroachments now than before and that this is why their municipalities are beginning to address the problem, "I think encroachment is increasing. I think the general public has less regard for public land and what that means and the respect for that and they are pushing the bounds in some cases" (PP5). Others admitted their municipality had ignored encroachment, but are now ready to deal with it, "You know the city's been in existence for 175 or 178 years, or something like that, and we've turned a blind eye in some respects" (PM2). Interviewees in the Forestry department in Mississauga said that in the past their staff wanted to deal with the problem, but lacked the necessary tools. In addition, they stated that past foresters and parks managers failed to appreciate the impacts of encroachment:

> People, who have been with the city a long time, have been trying to deal with these issues, but they say that they didn't have the 'teeth' or the backup by which to deal with it. The spearhead came from the foresters, recognizing what an ecological impact these things were having (FM4).

A few of those interviewed said that while their municipality is ready to address the issue, they doubt that residents are ready to support their municipality's efforts, "I think that the general public is maybe not keeping up with those values" (PP5).

Interviewees in Guelph and Waterloo said that encroachment is common in all open spaces, whether a natural area, an active park, or a storm water management facility, "It is a common occurrence in terms of it is happening in all types of green spaces and across municipalities" (BE4). However, there is some feeling that it is particularly prevalent within forests, particularly those remote from public use, "Typically where we have encroachment occurring is in the less used sort of natural areas" (PP1). One forest manager suggested that encroachment might be more common in neighbourhoods characterized by a high proportion of young families:

> I would say it varies by the demographic profile of the community. For example, in terms of Iroquois Shore Woods, many of them are retirees, like they don't have the physical capabilities, they're not gardening as much and, they're encroachment activity might have been fifteen, twenty years ago when they first moved in, but now they're not. But the newer communities, the

> newer woodlots, that generally attract the younger residents, yes, probably because they can't control themselves, they're out there doing little, what they consider, improvement projects and plantings, and touching up, so, yes, in those areas which are probably close to the northwest part of Oakville (FM5).

6.1.4 Significance

A majority of those interviewed indicated that they were unsure whether encroachment was ecologically or socially-significant relative to other impacts associated with adjacent land use development, such as construction or recreation-related impacts. However, many surmised that construction and recreation-related impacts are more significant.

Many who assumed that construction impacts are most significant pointed to their ecological significance, particularly those resulting in the alteration of hydrological regimes, or the removal of the forest side canopy. They argued that these impacts were readily apparent within three to five years following construction,

> I think the engineering effects have a far more significant impact on the ecology of the woodlot because they get right to the fundamentals and affect, I won't say on a watershed basis, that's an exaggeration, but on a broader basis. For example, diverting the overland water flow into a piped storm water system changes the whole water table in the entire woodlot. That will have a more dramatic impact and longer felt even than you know 50% of the lots going in and pruning back the overhanging limbs (FM5).

On the other hand, there was some feeling that planning and engineering advances over the last several decades have lessened the impacts of construction and recreation-related impacts might be more significant:

> Water management infiltration galleries, getting groundwater back in the ground to maintain wetlands and so on, I think we're getting a handle on that. And, I think that probably they would have formerly been the worst impacts on remnant natural areas, but I think we're improving. I think now it is the unintended impacts from recreational uses. Like mountain biking can involve some pretty substantial construction projects and they're hidden from public view by and large. They often use organic soil areas that are wet, streams and so on. So it's not just trampling of vegetation. We're getting into fisheries and amphibian impacts (EP3).

There were arguments that recreation-related impacts are more significant because their impacts extend further into the forest edge, "encroachments sort of nibble at the edges and, yeah they can be bad, but I think generally, the most important values of a natural area tend to be located closer to the interior" (EP3).

A few of the interviewees expressed concern that construction, residential encroachment and recreation impacts may intensify if the housing and infrastructure in existing and newly developing areas expands through the municipal implementation of the Ontario government's "Smart growth" planning policies:

> We tend to box our plants in spaces that are too small to sustain them, so it doesn't matter if you have all the conditions and even some innovative engineering applied within a subdivision. I think it's going to put a lot more pressure on the remnant woodlots that are being planned outside the protected greenbelt zones' (FM5).

However, a planner consultant who has prepared many EIS for developers argued that all these site-scaled impacts are insignificant relative to those occurring with courser scaled urban development:

> What we recognize in landscape ecology is that there is a matrix condition where certain parts of the landscape are basically controlling dynamics and functions in the landscape. When you go from, say, agricultural to residential matrix there's a dramatic change. Expecting us to be able to protect, you know, go in and inventory before development and say, 'yeah there's forest interior birds and a range of other sensitive features,' when we know full well that the conversion of the matrix is going to basically extricate those species – they're going to have to leave or die, and there's a real misconception on the part of the municipal managers that in fact they're actually protecting the feature - because what they're protecting is a museum piece. The inhabitants have left. (PC1).

6.2 Encroachment Goals and Strategies

6.2.1 Encroachment Goals

Approximately 60% of interviewees said they thought that their municipal goal is to eliminate encroachment; however, they said the goal is unwritten, and many were not sure of their municipal goal. Some interviewees stated that their unwritten departmental goal is to minimize encroachment because they do not believe it possible to eliminate residential encroachment:

> We don't have a goal I could even cite that would say that, you know, we have a zero tolerance policy or something like that. I think that it's inferred, but it's, in practice, it's not practical. So, our goal, our non-enunciated goal, is to deal with, to minimize encroachments (FM5).

Only one interviewee indicated that his department has a written goal. The goal of the forestry department within Kitchener is, "to address and reduce the problem of encroachment through education and enforcement" (Schmitt, 1995). However, one Kitchener interviewee commented that he saw no point in having this as a goal since there is not any way of achieving it until residents are better educated:

> You know, I think setting goals is a bit ridiculous if you don't even, because I think the social issues have to be addressed first. Like, we have all these policies and that now, we say, 'no encroachments', we say, you know, it's the same thing when we say, 'no, dogs must be leashed.' Well, most people don't do it, so there has to be more public education (FM3).

The remaining 40% of interviewees admitted that they are unsure of either their municipal or department goal. Some said that they do not have a goal because residential encroachment has not been identified as a significant issue:

> You know, I guess there's never really been anything brought forward that, that says, you know, they are absolutely horrible. They're going to ruin everything that we have (PP2).

However, many of the development planners, bylaw officers and property managers argued that addressing residential encroachment is not their responsibility:

> Part of the EIS is supposed to be the impact on the natural heritage feature from the land use proposed. When we talk about impacts it's really how many of the trees are going to be lost. Is an appropriate buffer being established? Is the storm water being dealt with properly? The thing to remember about an EIS document is that we're looking at it from what do we force the developer to do? That's why you get into the whole construction thing. What you're talking about (*protecting natural areas from encroachment*) is after the fact, how do we maintain it? (DP2).

6.2.2 Encroachment Strategies

Interviewees indicated that they do not implement their policies strategically. For example, they had few thoughts as to whether they should reduce the intensity or areal extent of these activities; whether they should be addressed at property boundaries or at coarser scales; or at what point in time they should be addressed.

Nevertheless, implicit municipal encroachment strategies were revealed by asking interviewees whether their department or their municipality sought to reduce the number of times encroachment occurred, or to alter the way it occurred, when it occurred or where it occurred within the forest edge, or the municipality. A large majority of subjects indicated a desire to reduce the number of times encroachment occurs, and expressed concern that encroachment might be encouraged by authorizing it under certain conditions, "If you're going to take on when, or how much, it's almost like you saying it's acceptable to do it" (FM4). However, the environmental planners from Waterloo and Cambridge indicated that they sought to control where encroachment occurs through buffers.

> Cause I have no control or influence over, operationally, how the city manages the plan, so my solution from my end would be to set the development back. You know, if there's thirty metres between the end of their backyard and the significant natural area – I'm hoping that's enough (EP1).

Subjects were asked whether their departments, or their municipality, seek to address all encroachments, or only those most significant. A majority felt their municipalities are focused on all encroachments, "I think the intent is just to mitigate any alterations at all" (DP4). Despite this intent, many bylaw enforcement, property managers, forestry and park staff indicated that they more frequently address safety and liability-related encroachments. Furthermore, many environmental planners and forestry managers indicated encroachments within ecologically significant natural areas should be a priority because protecting these areas is the focus of official plan policies. Still others saw a need to focus their efforts because their departments or municipalities lack the resources, or the municipal support, to address all encroachments.

6.3 Encroachment Policies and their Implementation

Study municipalities have developed policies to resolve encroachments that centre on bylaw enforcement; and policies to prevent encroachment that centre on boundary demarcation and resident education.

6.3.1 Policies to Resolve Encroachments

Most of the municipalities have had bylaws prohibiting some encroachment activities for many years. However, many interviewees indicted their municipality only developed effective bylaws, and procedures for resolving existing encroachments, in the last 5 to 10 years. Interviewees in Guelph said that their previous bylaws did not clearly communicate to residents that the municipality prohibited encroachments:

> What we wanted to do was send out word that you are not to do this. And, so, by establishing the encroachment by-law it says that you shall not do any of these things on the City's property without authorization (PM2).

Cambridge and Guelph did not have bylaws that dealt with certain encroachment activities, particularly yard extension types of encroachment. In addition, interviewees within many of the municipalities stated they could not use their previous bylaws to force residents to remove encroachments, pay for their removal or the restoration of the forest. For example, prior to 2004, Mississauga relied on a parks bylaw that stated that if residents performed certain unauthorized activities, parks operation staff, or a bylaw officer, could ask them to remove the structure, or cease the activity. If the City decided to prosecute the resident under the bylaw, the resident, if convicted, could face a fine or "other penalty" (City of Mississauga Parks By-law 186-05). Some Directors of bylaw enforcement, including Mississauga's, argued that they could not enforce their bylaws because the wording did not give them the authority:

> I said that I would enforce it, but the wording of the parks by-law didn't give us the authority, or strong enough authority, to do anything about the situation they described. So, really, from an enforcement perspective, we didn't feel that we had anything to enforce. It was just a provision that said, 'you know, you really shouldn't partake in such and such activity in the public space.' There were no teeth to it and no process (BE3).

In response to these issues, Cambridge, Kitchener and Waterloo decided to develop corporate policies to supplement their existing bylaws. Oakville, on the other hand, amended their bylaws to make them more effective, and Guelph and Mississauga decided to create new bylaws dedicated to resolving encroachments. All of these policies or bylaws indicate residential encroachment can only occur under municipal authorization; otherwise, residents are required to remove their encroachments. Most also establish a course of action for dealing with encroachments under different circumstances. None of the policies include residential encroachment goals, objectives or strategies. In this respect, they are similar to the by-laws. They provide a tool staff can use to resolve encroachments, but make no municipal commitment to address encroachment or its effects.

All of the corporate policies lack definitions of encroachment, and they address only yard extension related encroachments. For example, the policy of the City of Kitchener only states examples of encroachment activities they prohibit. These include fences, gardens and structures. The definition of encroachment within the City of Cambridge's policy can only be surmised from the author of the policy. She said that residential encroachment refers to structures, gardens/lawn extensions, fences, and/or sports equipment that extend from the private boundary into the public property. Neither of these municipalities has a policy that addresses encroachment such as the dumping of waste, recreation-related or indirect encroachments, such as water and chemical runoff. Interviewees in these municipalities indicated they prohibited some of these forms of encroachment under their bylaws.

While interviewees in Oakville indicated they update their Parks bylaw to prohibit new encroachment activities that arise through time, the bylaws of Mississauga and Guelph establish legal definitions of encroachment:

> Encroachment means any type of vegetation, structure, building, man-made object or item of personal property of a person which exists wholly upon, or extends from that person's premises onto, City-owned lands and shall include any aerial, surface, or subsurface encroachments and shall also include, but is not limited to, any activity that results in a removal, addition, alteration, or material change to the City-owned lands (City of Guelph By-law (2005)-17789, p. 2)

Interviewees within all six municipalities indicate they have multiple courses of action for resolving encroachments depending on the circumstances. The procedure may involve following one or many actions, including: 1) asking residents to remove the encroachment; 2) asking residents to restore the forest edge; 3) removing the encroachment; 4) charging the resident for the cost of removal and/or restoration; 5) fining the resident; 6) authorizing the encroachment through an encroachment agreement; or 7) selling the encroachment land to the resident. Asking residents to remove their encroachment and the uncompensated municipal removal of the encroachment were common elements within these policies and bylaws. Municipal removal of the encroachment is particularly common when staff consider the encroachment minor (such as when it did not involve a significant structure), and cannot determine, or prove, which resident had caused it.

While all policies or bylaws allow residents to apply to their municipalities to have their encroachments authorized; only two of the municipalities, Guelph, and Mississauga, have a written list of criterions under which an encroachment will not be authorized (Table 6.1). Guelph has their criteria written into their encroachment bylaw, while Mississauga developed theirs as an inter-departmental guideline. P. Lyons said that Mississauga's approach was preferred because it avoided lengthy council debate (P. Lyons, City of Mississauga, personal communication, September 15, 2005). Interviewees in both municipalities indicated they needed specific criterions to limit the number, and haphazard approval, of authorized encroachments in their natural areas.

Table 6.1: Criteria that guide the authorization of encroachment within natural areas

Criterion	Guelph	Mississauga
Interferes with city's current/ future purpose in holding the land	*	*
Contravenes existing contracts with other parties		*
Creates unsafe condition/endangers public/adjacent property/owners	*	*
Increases city's exposure to liability	*	*
Contrary to City bylaws, policies or resolutions or Provincial/Federal environmental policies	*	*
Interferes with forest management according to designation	*	*
Interrupts natural/engineered flow of water		*
Interferes with public utility or city installation	*	*
Conservation Authorities do not authorize encroachment or other level of government interested in area		*
Applicant unable to demonstrate need for the encroachment	*	

The procedures necessary to deal with a significant encroachment can consume the time of many staff members, including forestry, parks staff, bylaw enforcement and property management officers, lawyers, surveyors and council members. In addition, prosecuting a resident can be very expensive, particularly if the case ends in a courtroom. It can also be every expensive for residents. For example, last August 2006, an Oakville resident decided to clear 650 municipal trees within the forest edge behind her property line. She was going to use the land as an active recreation area. Oakville charged her a $1,500 fine plus $8,500 to restore the forest vegetation. She entered a plea of guilty and paid the fine without going to court (P. Bouillon, City of Oakville, personal communication, February 14, 2007). Bouillon said the municipal costs of preparing this case were approximately $1,500 excluding overhead; however, if the case had gone to court, the costs would have been much higher.

Interviewees within all of the municipalities indicated they implemented their encroachment resolution policies infrequently. Many were frustrated they had been able to resolve only a small proportion of their suspected encroachments. They indicated they primarily resolved encroachments in response to resident complaints:

> We're reactive, not proactive. We don't go out and look for encroachments. If our managers see them or a neighbour complains, we have to react and go through the process. (FM1).

Within most of the municipalities, forestry managers indicated their forest edge monitoring policies were mostly practices, or procedures. Staff within all the municipalities said they infrequently monitored the forest edge where it directly abutted residential yards. They focus their monitoring on removing potentially hazardous encroachments, "There'd be more garbage pick up, the dismantling of tree forts, normally this stuff is reactive" (FM4). However, interviewees in Oakville indicated that where there are pathways running between the private property line and the forest border, regular monitoring occurs because staff is able to access this area with vehicles.

Only interviewees in Mississauga said they proactively try to locate and resolve encroachments. However, those interviewed indicated that since 2004, when they enacted their encroachment bylaw, the process has been very slow and difficult. Forestry staff commented they have had many conflicts with both residents and councilors, and have been successful in implementing their policies in only a few natural areas, "We're finding petitions, a lot of residents and politicians being dissatisfied, councilor calls - a lot of talking" (FM4). This may partly be due to their strategy of implementing their fencing policy at the same time as they resolve their encroachments. The fencing policy is meant to ensure that encroachments do not reoccur; however, many residents do not support its implementation.

The principal barriers to implementation are lack of sufficient tools, resources, and commitment from council and/or staff. The City of Cambridge lacks a bylaw prohibiting yard extension forms of encroachment, such as buildings, pools, fences or garden extensions. Yet, interviewees said these forms of encroachment are most significant. Without this tool, Cambridge is in a weak position to enforce the removal of an encroachment, or to ensure that residents cover municipal removal and restoration costs. This is reflected in their encroachment policy that focuses on property management solutions (encroachment agreements and land sales), rather than on forcing residents to remove their encroachments. Their policy indicates that council will authorize encroachments through land leases when the encroachment is deemed too costly or difficult to remove and where the municipality does not need the land. Furthermore, one interviewee indicated she would recommend selling encroached upon land to council, rather than signing a lease agreement, even though selling land is not an option within the Cambridge policy, "Our next attempt is to sell it. If we, if we felt that we could do without the land, we would sell it before entering into an encroachment agreement." (PM1).

Interviewees within all the municipalities said they often lack the means to prove that residents take part in encroachment activities unless there is clear physical evidence directly linking the encroachment with resident properties. For example, yard extension activities are easier to prove because they visually extend from resident yards, but with activities such as dumping or the removal of forest vegetation, a resident can claim they were not responsible for the encroachment. Interviewees indicated that policies that remedy these encroachments are limited to resident warnings, and staff removal:

> The challenge with by-law enforcement is that just because you find an unacceptable activity behind someone's property, or even if you find a structure, you still can't necessarily prove who did it, unless you actually physically see them doing it. Removing it tends to be at our cost, unless we're in a position that we can actually find clear evidence to charge. Then we could recover costs, and it gets very difficult (FM3).

Interviewees in all municipalities also said they do not have the means to resolve many indirect forms of encroachment, such as the drainage of swimming pools, or the invasion of exotic garden plants:

> The drainage of a pool, it could be killing microorganisms and things like that, that are important in a wetland system, but the only way re really enforce things are based on physical conditions. We simply don't have a way to evaluate the impacts (EP4).

Lack of resources was a major impediment, particularly for forestry staff, "We do not have the staff, and I'm sure you'll find this out in other municipalities, to be proactive and go out and actually walk the lot lines of all our parks" (FM1). The forest managers in most of the municipalities suggested their departmental budgets are insufficient to manage these impacts because of a lack of supporting management policies. They argued that many existing forest management procedures and practices are based on the belief that forests are better off evolving naturally with little management:

> There is a big argument being made, not just for significant natural areas, but others, that there has to be greater consideration given to the cost of maintaining them, the park infrastructure, rather than planning occurring in isolation. It's a huge management nightmare! (FM3)

By-law enforcement and property management staff also indicated they lacked the required resources to implement their policies or bylaws more frequently, particularly when enforcement requires taking residents to court. Furthermore, some bylaw enforcement interviewees said the courts might be more likely to find a municipality negligent if a resident gets hurt on an encroachment when council has directed staff to implement, proactively, their policies or bylaws:

> They will say, council directed you to do this, but you did it this way. Usually, if we're found out to be at fault, then that is going to lead to a harder judgment. The single biggest factor determining whether we are going to be reactive or proactive is resources. And, it doesn't matter which by-law we're talking about (PP5).

Insufficient council and staff commitment were also impediments to policy implementation. Interviewees in Guelph, Mississauga and Oakville suggested their councils were either not upholding their policies or bylaws, or were instrumental in slowing down enforcement, or determining where their policies or bylaws would be enforced. For example, in Guelph, council recently sold a piece of land to an encroaching resident, despite staff recommendations to enforce the removal of the encroachment, and a bylaw that did not indicate that selling municipal land was part of the procedure for resolving encroachments. One interviewee said that this council decision may undermine staff efforts to implement their policy and creates a precedent that may lead to similar council decisions in the future (PM2). Similarly, an interviewee in Mississauga suggested it is difficult to enforce their bylaw more frequently because of councilor complaints. They indicated they were forced to make decisions regarding where they remedied encroachments based on politics rather than on the significance of the encroachment:

> Someone complained so it came on the radar of our senior management, so they have taken them up. But, we spent a lot of time and money with ones that do not represent the most significant encroachment areas of the city (FM4).

Nevertheless, interviewees in Oakville said that a strong council commitment was instrumental to enforcing and upholding their Parks bylaw and their fencing policy in natural areas adjacent to established subdivisions in the early 1980s:

> Successive councils of the day through the 80s and 90s, to their credit, they must have, I'll take a wild guess, I bet it isn't too far off, 50 public debates where the nimby syndrome was beaten back (FM5).

Despite concern on the part of forestry staff regarding encroachment, many indicated they lacked the commitment to address it, even if they had the resources. They argued they are not certain whether encroachment is a significant issue within natural areas, particularly relative to silvicultural issues. They said they are just beginning to prepare management plans that will establish management goals for individual natural areas and they need to establish management priorities, according to these goals, before making a commitment to addressing the encroachment issue:

> I think those issues have to be dealt with as a package and as a management plan. I don't, I think that if you go into these areas just dealing with encroachments, it's, personally, I think you're wasting your time because it, in some natural areas, encroachment may not be the most serious issue (FM3).

6.3.2 Policies to Prevent Encroachment

The most commonly established corporate policies for preventing encroachment are those involving boundary demarcations, and to a lesser extent, resident education. These latter policies primarily involve the installation of signs at park entries that prohibit encroachment activities (primarily dumping) and first resident education procedures. Most of the municipalities established these policies in the last 10 years, with the exception of Oakville that established their boundary demarcation policy in 1983.

6.3.2.1 Boundary Demarcation Policies

All municipalities have boundary demarcation policies for newly developing subdivisions. Two-thirds of the municipalities (Kitchener, Guelph, Mississauga and Oakville) have established these policies as corporate policies. However, Waterloo's policy is an interdepartmental procedure, and Cambridge's policy is a departmental practice. Oakville, Mississauga and Cambridge have a policy of a 1.2 to 1.5 metre black vinyl, chain link fence without a gate for residences abutting most natural areas. Guelph and Waterloo combine a "living fence" with a municipal boundary marker. Their living fences consist of a three metre wide planted border with boundary posts installed every 30 metres. According to the Guelph policy, the municipality can also specify a chain link fence if they feel it is necessary to protect the feature (City of Guelph Corporate Policy 8D1, 1996). Kitchener has a treatment consisting of a 1.5-metre high post at 15-metre intervals. They also attach a sign to the post in significant natural areas, indicating the name of the municipality, the natural area's conservation status and their encroachment prohibitions (City of Kitchener Tree Management Policy, 2001). All the municipalities require developers to establish residential boundary demarcation treatments on municipal land so that they have control over the long-term management of the boundary.

Only the environmental planners within two of the municipalities, Cambridge and Waterloo, said they negotiate official and secondary plan buffer policies, in some areas, to address residential encroachment. Both environmental planners said establishing a buffer is their primary policy for protecting sensitive natural areas from encroachment, i.e. they did not combine them with their boundary demarcation policies to protect these natural areas from encroachment. For example, when I asked one interviewee in Waterloo whether Waterloo had an encroachment policy he said:

> Yeah, I would say so, in the sense that we have a policy on buffers. Now, do we have a policy on mitigating encroachment onto buffers, you know, that's debatable. We certainly have an approach that we deal through our practices, and we have some things that we try to apply through the design stage to mitigate it, but I'm not aware that we have a specific approach for policy (EP4).

Both environmental planners said they negotiated buffer width based on the environmental significance of the natural area. Their official plan buffer policies call for similar buffer widths for stream corridors. Both require a 30 and 15 metre buffer for cold and warm water streams, respectively (City of Cambridge OP, Pol. 6.1.4.7 and 6.1.4.8; City of Waterloo OP). In addition, Waterloo's Official Plan calls for 15-metre buffer for high quality vegetation adjacent to or linking ESPAs and locally significant vegetation greater than four ha in area. While interviewees in other municipalities, including Guelph, Kitchener and Oakville, indicated they were aware of their buffer policies, they primarily established buffers to limit the impacts of development, particularly its impacts on forest edge vegetation.

Interviewees within all municipalities said they have no difficulty negotiating their boundary demarcation policies with developers within natural areas adjacent to newly developing subdivisions; however, the municipalities appear to vary in their ability to negotiate and implement buffers. For example, one interviewee said that for their most significant natural areas (mostly wetlands and stream corridors), their municipality is typically able to negotiate buffers of between 9 and 30 metres, while for those less significant, they negotiate buffers of between 5 and 15 metres. In addition, he said that they negotiate buffers for terrestrial woodlands of between 7 and 100 metres (EP4). However, in another municipality, an interviewee said that their municipality has never implemented their official plan buffer policy. She attributed this to a lack of council commitment, "I have been very unsuccessful. Council does not buy into the idea of buffers at all" (EP1).

Few municipalities have corporate boundary demarcation policies for natural areas adjacent to established subdivisions. Only Oakville and Mississauga apply the same corporate policy (a fence) to natural areas adjacent to both newly developing and established subdivisions. However, Kitchener has a departmental procedure and Cambridge and Waterloo have departmental practices of establishing municipal posts within some natural areas adjacent to established subdivisions.

All interviewees indicated that they infrequently implement these boundary demarcation policies within natural areas adjacent to established subdivisions. For example, while Oakville implemented their fencing policy within these areas when they first established their policy in the early 1980s, interviewees indicated that some of these natural areas did not get fenced at that time. However, they said they do not intend to implement their fencing policy within these areas now. Most interviewees indicated the primary barrier to implementation was resident resistance to a new boundary demarcation treatment:

> We are looking at implementing boundary markers within our existing parks, but it's, when we start doing that, it's going to be a real contentious issue. It will be, and I know other municipalities have started doing that and they hit a brick wall when it comes to dealing with people. So that's the other thing is that even though you want to pursue these things, it can backfire on you too (FM3).

One interviewee said that Oakville could improve the long-term implementation of their fencing policy by establishing an educational program that increased support for fences among residents. He argued that without support, residents within newly developing areas will continue to challenge the policy and this might lead to a change to a less effective policy:

> We could beef up our outreach program so that we're not always reacting, cause I'm sure next month there'll be a plan of subdivision ad you have the same argument over and over again. They'll say they don't want it. They want uninhibited access to the woodlot. And we'll have to go through the same thing again (FM5).

This policy erosion has already occurred with respect to lakefront properties in Oakville. Some of the residents successfully challenged the corporate fencing policy and the Oakville Official Plan now allows the residents within these areas to negotiate their own boundary demarcation (City of Oakville Official Plan 2004, Sec. 4.1.3i (b)). Oakville installed boundary demarcation posts within some of these areas, but one Oakville interviewee said significant encroachments have occurred, “In those areas we’re getting encroachments of a large kind, a large variety – removal of vegetation, compaction of soil, and degradation of the woodlot understory” (FM5).

Interviewees within municipalities with fencing policies indicated they were more or less satisfied with the effectiveness of their policies for limiting encroachment, "I don't know if we're happy, but I respect that we've had this fencing policy for almost three decades and it's a good conservation tool" (FM5). However, some interviewees in both Guelph and Waterloo are less satisfied with their living fence and post boundary demarcation policies:

> The reality is that chain link fences are more effective at preventing yard waste encroachment. So, um, some of the things I resorted to eventually. I got on board with the chain link fences in some areas. They’re just more effective and made more sense; otherwise people just consider it their own and move into it (EP2).

One interviewee commented that the City of Guelph has to maintain the living fence after it has been planted and that it takes a long time to grow into a physical barrier to encroachment. She said her municipality lacks the resources to maintain the planted borders and they often become full of plants that residents consider “weeds.” As a result, she indicated that some residents alter or remove the living fence (EP2). One Guelph interviewee said that he has resolved encroachments involving the removal of living fences. Once a resident removes or damages a living fence, or some of the plants die, he said that residents complain to the City and it is impossible to prove that the residents caused the damage. Furthermore, the City has to pay for the replacement of the living fence because they are located on city land (PM2).

Despite the dissatisfaction expressed by interviewees with softer boundary treatments, such as living fences or municipal posts, some said that they are better than fences because they make aesthetically pleasing transitions between the private garden and the forest edge, and residents prefer them to harder boundary treatments, such as fences. They also argue that these types of treatments are beneficial, or less harmful than fences, to wildlife and forest border vegetation. The installation of posts does not require the removal of forest border trees; and living fences can contribute to wildlife habitat, and may reduce microclimatic edge effects (EP4).

6.3.2.2 Resident Education Policies

Most of the municipalities have procedures and practices for educating residents about the impacts of their encroachment activities on the natural area. However, it was generally felt that edge-residents needed to be better educated in the forms and functions of natural area ecosystems, and the impacts of their activities, for municipalities to reduce residential encroachment levels over the long-term.

Within newly developing subdivisions, procedures include installing signs at park entry points. In terms of encroachment, these signs are frequently limited to prohibiting dumping under the authority of a bylaw. Although all the municipalities have installed such signs within many of their natural areas, interviewees were uncertain whether they are effective. Many felt they failed to reduce dumping activities.

Developers or builders within all the municipalities are required to distribute, and sometimes develop, brochures aimed at educating new homebuyers. Some municipalities re-distribute these brochures once the homeowners move into their homes; however, none of the interviewees knew whether residents receive or read the literature, or whether it was effective in altering encroachment behaviour:

> My view on education is that really in a lot of cases it's a wasted effort because you're going to get people regardless of what they know, behave in the way they want and then they're seemingly the worst offenders when it comes to encroachment (EP4).

Many of the municipalities focus their practices for educating encroaching residents within established subdivisions. Forestry and parks operations staff said they sometimes hand-deliver shorter, more focused, fact sheets about encroachment, or speak to residents about their encroachments face to face. They generally feel this method of education is more effective in convincing residents to remove their encroachments than mailing out general, or encroachment-specific, educational materials. However, most interviewees said that this more focused method is more time consuming and they infrequently implement it. Waterloo is the only municipality to have a corporate proactive education policy. However, interviewees indicated they do not implement their policy proactively, but only in response to existing encroachment:

> I think that's where we would ultimately like to go - a social marketing program where we identify where the barriers are, find out why the heck this stuff's happening and what we can do to make it not happen (BE4).

Most interviewees said the primary barrier to implementing their education policies is lack of sufficient resources, but suggested this, in turn, may be due to insufficient staff and council commitment, "I have absolutely no budget to work with. Nobody has made encroachments a priority, and I think that it's difficult for management with their background to look at encroachment in terms of the interdisciplinary thing that it is" (BE4).

6.4 Discussion

The results of the interviews indicate all interviewees are aware of the problem of residential encroachment. Employees within environmental and parks planning, forestry, and parks operations are particularly concerned. They are concerned encroachment activities displace forest vegetation, reduce forest area and contribute to the spread of undesirable invasive exotic species. Some of these interviewees, in addition to bylaw officers, and real estate managers, are also concerned about public safety issues and increased municipal liability. These latter groups are particularly concerned about the loss of parkland through successful resident adverse possession claims. A majority of these municipalities has developed most of their land, and the vast majority of their natural areas already have established adjacent subdivisions. However, many interviewees indicated they only developed or refined their policy tools to both prevent and resolve encroachments in the last 10 years. If residential encroachment is as prevalent as many interviewees suspect, then many of the residents of these subdivisions may have longstanding encroachments. According to many of the bylaw officers and real estate managers interviewed, some of these residents are likely to be successful if they claim adverse possession of this land under the *Land Registry Act.*

While staff and councils are becoming increasingly aware of residential encroachment, they do not consider it significant relative to development and recreation impacts, or other planning and management issues. They are uncertain about the types of encroachment occurring and whether their effects are ecologically or socially significant. Although they see the direct impacts of edge resident encroachment within their forest edges, many are also aware of the indirect impacts of wider residential community encroachment on the forest, but lack the tools or the resources to address them.

This study and the content analysis clearly indicates that municipalities primarily protect natural areas through land use planning policies prior to development, rather than forest management policies post development. However, a majority of interviewees indicated that preventing and remediating encroachment activities post development is extremely difficult and resource intensive. These results clearly point to the importance of planning in the protection of natural areas post development, yet many of the development planners interviewed argued that addressing encroachment through planning was not a significant part of their job. They indicated that they focused on protecting natural areas from the impacts of development, or construction. They said their job was to review the protection recommendations outlined in an EIS in light of official and secondary plan protection policies. Yet, this study and the content analysis indicate that goals, objectives and policies related to addressing residential encroachment (or any post-development impact) are missing from official and secondary plans.

The lack of attention to the post development protection of natural areas is also evident in forest management. Many of the forest managers interviewed said that the lack of active management within their natural areas have left many degraded. They indicated their management policies consisted of departmental procedures and practices, rather than corporate, official and secondary plan policies. Within the vast majority of municipal natural areas, management activities are restricted to maintaining recreational facilities and responding to the hazard-related concerns of residents. Proactive management infrequently occurs. Many of the forestry and park operations interviewees said they are concerned about the effects of this lack of management on silvicultural aspects of some of their forests. They argued that because they did not manage them properly, their current silvicultural problems are more significant than they would have been had they been managed. This lack of management may not be due to neglect, but to a widely held view that active forest management is unhealthy for these ecosystems - that they are better off being left to develop '"naturally." Forest managers and ecologists commented that this attitude is evident among many residents living adjacent to forests who frequently object to the removal and trimming of forest trees adjacent to their property boundaries. Some managers said that they impede their efforts to manage these forests properly, and that they sometimes avoid managing the edge as intensively as they would like to avoid conflicts with residents. They also suggested that this attitude is also common among their colleagues, including planners, who may feel they are protecting natural areas for the long term solely by preventing their development into housing, and by limiting construction impacts.

In light of this, they point out that encroachment impacts are just one of many of their concerns. They argued that they need to assess the significance of these activities relative to their social and ecological values. However, while the forest managers and ecologists within some of the municipalities indicated they had developed management plans that specified these values and goals for two to three of their natural areas, other municipalities, such as Cambridge, were missing qualified staff to develop these plans.

Interviewees indicated that goals, objectives and strategies for addressing encroachment were generally lacking. While a majority indicated that the implicit municipal goal within their encroachment policies, or bylaws, was to eliminate encroachment activities, many suggested their unwritten departmental or personal goal was to minimize them, because they did not believe their municipal goal was achievable.

Those questioned also allowed that most of the municipalities follow an implicit strategy that seeks to limit the frequency of edge-resident encroachment activities. To implement this strategy they have established policies that create physical and psychological barriers to these activities at the boundary, and regulate them through the enforcement of bylaws, or policies that address encroachment resolution. Few interviewees considered the alternative strategies outlined in Chapter three for altering the way encroachment occurred, or when and where it occurred, at different spatial or temporal scales. Most argued that following such strategies might indicate to residents that municipalities permit residential encroachment activities. Nevertheless, there were those who claimed they consciously sought to address encroachment by controlling where it occurred through the implementation of buffers between the natural areas and the residential edge. In addition, Waterloo's Partners in Parks program implements a strategy that regulates how encroachment occurs, although the intent of the program is not to address encroachment, but to beautify parks. Nevertheless, participating residents are allowed to conduct activities that would normally be considered encroachment, under certain controlled circumstances. However, the goals of this program could potentially conflict with those of policies seeking to limit encroachment. Desirable interaction between residents and their municipal forests need to be defined in order to ensure that they are consistent with forest management goals.

The interview results indicate the study municipalities have developed many policies to both prevent and resolve residential encroachment, largely within the last ten years. However, municipalities have not combined them into an integrated approach to addressing residential encroachment over space and time. According to the boundary theory, the properties of the boundary between two different ecosystems strongly influence edge effects. The results of this study indicate that municipalities focus their policies on establishing both physical and regulatory filters to protect forest edges from edge resident encroachment activities at the scale of the forest and residential border. Physical filters in the boundary post development may be composed of boundary elements established to address encroachment, such as boundary demarcation treatments and buffers. They might also be composed of other boundary elements established to meet other objectives, such as pathways and active recreation areas to meet recreational objectives, or storm water management ponds to meet hydrological functions. Together, municipalities could spatially integrate these elements to provide multiple filters to residential encroachment activities at the scale of the forest and residential border. Yet, the results indicate that the study municipalities only establish these elements as separate boundary treatments. For example, in terms of edge encroachment boundary policies, boundary demarcation treatments are not consciously developed in concert with buffers to address encroachment, but rather to address the impacts of construction. In addition, forest managers and ecologists indicate that, in general, all natural areas are protected from encroachment equally. Nevertheless, post development integrated boundary treatments have been developed, albeit unconsciously, between some natural areas and adjacent residential subdivisions. Figure 6.2 provides an example of a Waterloo integrated boundary treatment for cold-water streams. The treatment includes boundary demarcation and a buffer, as well as grass strips and path to meet a myriad of protection and recreation-related policy objectives.

Boundary theory also indicates that filters function through time to protect adjacent land use values. Planning interviewees indicated that the impacts of development, such as construction encroachment during subdivision development, could influence residential encroachment. In response to construction encroachment, planners have established policies to limit these impacts, such as housing setbacks, yard depths, limits of development, construction fencing or site inspections. These policies establish boundary elements or relationships that contribute to the protective properties of the post development boundary, yet interviewees indicated that these construction-related boundary treatments were not considered in the development of post development protective boundaries.

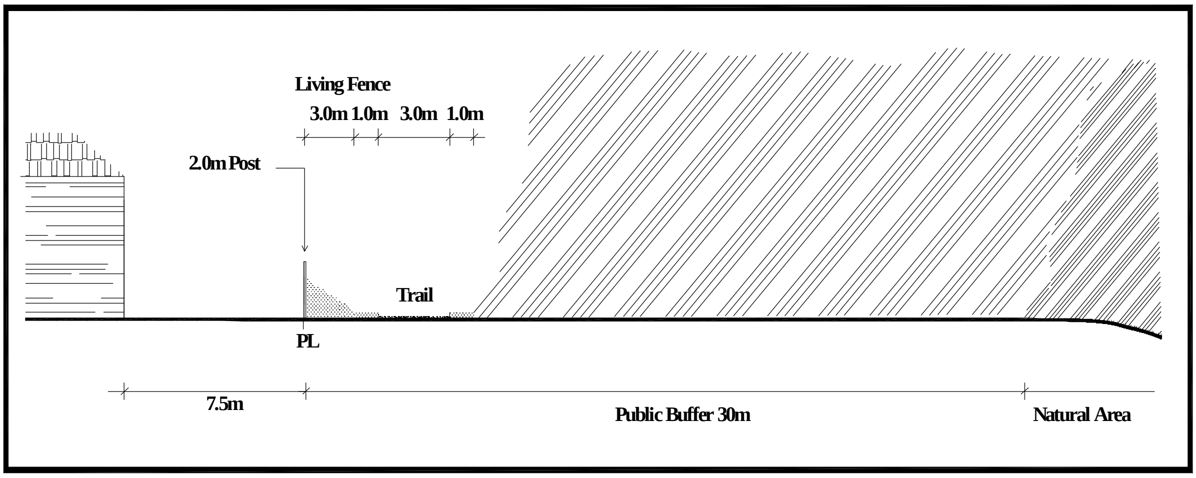


Figure 6.2 City of Waterloo integrated boundary treatment between new subdivisions and cold-water stream corridors

The results of this study indicate that study municipalities infrequently implemented preventative policies, such as physical boundary filters and resident education, in natural areas adjacent to established subdivisions. A principal barrier to implementation is resident resistance to new boundary demarcation treatments, particularly fences. In addition, staff and council commitment to implementing these policies is frequently insufficient, particularly in the face of resident opposition and competing forest management priorities.

Interviewees also indicated their municipalities were infrequently implementing policies to resolve encroachment. Many said they lacked the resources, and in some cases the staff and council commitment, to implement these policies more frequently. Others said their policies, bylaws and implementation procedures had only recently been developed, and they were still refining them. As a result, many interviewees said they suspected only a small proportion of the existing encroachments had been resolved. In addition, many commented their policies could not be implemented to address indirect forms of encroachment, such as the flow of resident wastewater or herbicides and pesticides into the forest edge.

These results indicate that the study municipalities have developed subdivisions adjacent to natural areas over the last 50 to 60 years without sufficient policies, and without sufficient implementation of existing policies, to limit encroachment activities. Municipalities have yet to tackle the encroachment that has resulted within these established subdivisions. Policies to prevent them are largely missing, and bylaws to resolve them are implemented infrequently. They also suggest that municipalities may not have the resources to tackle the scale of this problem. Many interviewees commented that residential encroachment is a community-wide problem and that their municipalities could not solve it solely by implementing their existing policies. They argued that community involvement was necessary if a lasting solution was to be found. Spreading awareness and educating residents in the community regarding this issue are important toward this end, yet interviewees said that, in general, their resident education and stewardship policies were informally and haphazardly established and implemented.

The next chapter presents the results from the unobtrusive measurement of resident encroachment behaviour in selected municipal forest edges.

Chapter 7

Edge-Resident Encroachment Activities within Municipal Forests

Chapter 7 presents the results of the unobtrusive measurement of encroachment behaviour within selected forests of the study municipalities. Section 7.1 describes the results of the intensive sampling method. Sections 7.1.1 and 7.1.2 describe the encroachment traces occurring under all, and under different policies and boundary types, respectively. Each of these sections describes the type of encroachment traces occurring, their frequency and intensity, and their distribution in the first 20 metres of the forest edge. Section 7.2 describes the results of the extensive sampling method. Sections 7.2.1and 7.2.2 describe the maximum extent of encroachment for all types of encroachment, and by type and category, occurring under all policies and boundary types; while section 7.2.3 describes those occurring under different policies and boundary types. Both studies measured the distance of the encroachment trace from the property boundary in sites with no grass strips, and from the forest border in sites with grass strips. Both origins are referred to here as the forest border. Section 7.3 discusses the findings, in terms of the effectiveness of alternative boundary demarcation policies and treatments for limiting residential encroachment.

7.1 Types, Frequencies, Intensities, and Distribution of Encroachment Traces in the first 20 metres of the Forest Border

7.1.1 All Policies and Boundary Types

7.1.1.1 Mean Frequencies and Intensities of Encroachment of all Traces

In 99% of intensively sampled sites, 4,422 encroachment traces were recorded. The mean frequency of encroachment traces was 23.4 traces per site. This compares with a mean frequency of native forest components (e.g. native plants, forest floor detritus or bare soil) of 80 traces per site, and a mean frequency of exotic vegetation of 25 traces per site. Native, exotic and encroachment trace types each covered an average of 26 to 50% of their quadrats. The mean intensity of encroachment traces per site (a qualitative indicator of encroachment levels calculated by summing the mean frequencies of encroachment traces by the mean cover scale category for each site and dividing by the number of sites) was 103. This compares with 102 and 306 per site for exotic vegetation and native forest traces, respectively.

7.1.1.2 Frequencies and Intensities of Traces by Type and Category

Twenty-nine types of traces were recorded. Definitions of the different types are provided in Appendix B. Table 7.1 lists the total number of traces by type classified according to assumed encroachment motive: waste disposal, yard extension, forest-recreation, response to forest encroachment, and garden vegetation expansion. Traces classified as ‘response to forest encroachment’ are encroachments in response to the encroachment of the forest into a residential property. For example, the removal of forest border vegetation that hangs over a boundary fence into a residential yard. 'Garden vegetation expansion ' traces are exotic plants that arrive from adjacent residential yards.

Table 7 .1 Number of encroachment traces recorded within all study sites by type and category

Waste Disposal	**# of Traces**	**Yard Extension**	**# of Traces**	**Forest Recreation**	**# of Traces**	**Forest Encroachment**	**# of Traces**	**Garden Vegetation Expansion**
Organic debris	1176	Lawn Extensions	852	Unauthorized Pathways	263	Forest Floor Removal	137	**142**
Consumer waste	716	Garden Extensions	304	Forts	10	Hacked Tree	8	
Construction Waste	216	Firewood	12	Furniture (in forest)	5	Totals	**145**	
Granular Material	192	Building (including fences)	12	Fire Pit	1			
Human-placed Rock	141	Balls	11	Totals	**279**			
Leaf piles	65	Swimming Pool	6					
Junk	61	Sport Court	2					
Grass Clippings	36	Totals	**1199**					
Ash and Charcoal	15							
Compost Bin	11							
Compost	8							
Christmas Tree	7							
Pool Pipe	7							
Dog feces	4							
Visible Chemicals	2							
Totals	**2657**							

Waste disposal and yard extension were the most commonly recorded encroachment types and the most intensive; they accounted for approximately 59% and 27% of total number of encroachment traces recorded, respectively (Table 7.2).

Table 7.2 Frequency, intensity and percentage cover of trace categories per site

Trace Category	**% of Encroachment Traces**	**% of Sites with Trace Category**	**Mean Frequency of Traces/ Site**	**Mean Intensity[1] of Traces/Site**
Waste Disposal	59	99	14	51
Yard Extension	27	44	6.2	35
Forest Recreation	6	44	1.5	8.2
Response to Forest Encroachment	3	12	.8	4.1
Garden Vegetation Expansion	3	24	.7	3.0

[1]Mean intensity of traces = total number of encroachment traces x their cover categories / number of sites

Fifteen types of waste disposal traces were recorded in 99% of study sites. Traces from this category made up approximately 60% of the encroachment traces recorded (Table 7.2). Types referred to as ‘other organic debris (e.g. branches, discarded plants)’, ‘miscellaneous consumer waste’ (e.g. packaging materials), ‘construction waste’ and ‘granular material’ (soil, gravel etc.) accounted for approximately 86% of all waste disposal traces (Table 7.3). Waste disposal trace types covered a mean of 26 to 50% of their quadrats. Figure 7.1 is an example of typical yard-related wastes sampled in a Cambridge forest edge.

Table 7.3 Waste disposal traces for all policies and boundary types

Waste Disposal Trace Types	% of Waste Disposal Traces	% Sites with Traces	Total # of Traces	Mean Frequency of Traces/Site	Mean Intensity[1] of Traces/Site	Mean % Cover	% of Encroachment Traces
Organic Debris	44.3	91	1176	7	32	5 (51 to 75%)	27
Misc. Consumer Waste	26.9	78	716	5	10	2 (1 to 5%)	16
Construction Waste	8.1	44	216	2	7	3 (6 to 25%)	5
Granular Material	7.2	34	192	3	12	4 (26 – 50%)	4
Human-placed Rock	5.3	31	141	2	7	3 (6 to 25%)	3
Leaf Piles	2.4	12	65	3	13	5 (51 to 75%)	2
Junk	2.3	18	61	2	5	3 (6 to 25%)	1
Grass Clippings	1.4	11	36	2	6	4 (26 – 50%)	<1
Ash /Charcoal	.6	6	15	1	4	3 (6 to 25%)	<1
Compost Bin	.4	4	11	1	7	5 (51 to 75%)	<1
Compost	.3	4	8	1	3	3 (6 to 25%)	<1
Christmas Tree	.3	5	7	1	4	5 (51 to 75%)	<1
Pool Pipe	.3	2	7	1	6	3 (6 to 25%)	<1
Dog Feces	.2	2	4	1	2	2 (1 to 5%)	<1
Visible Chemicals	.1	5	2	1	4	2 (1 to 5%)	<1
Total Category	100	99	2657	14	52	4 (26 – 50%)	60

[1]Mean intensity of traces = total number of encroachment traces x their cover categories / number of sites

Figure 7.1 Dumping of organic debris at 42 Pezzade Street, Winston Blvd. Woodlot, Cambridge
(Source: W. McWilliam Digital Photograph, June 27, 2005)

Encroachment traces related to yard extension activities were recorded in 44% of all study sites. They composed 27% of all encroachment traces recorded. Lawn extensions (areas of mown grass) and garden extensions (e.g. flower beds, patios etc.), together, accounted for approximately 96% of these traces (Table 7.4).

Although yard extension traces occurred less frequently than waste disposal-related traces, they tended to cover a greater proportion of their quadrats, occupying a mean of 76 to 100%. Building encroachments (including fences) were sampled infrequently; however, they may have been under-sampled. Only 38% of the study sites had a municipal fence, post or survey stake to indicate the legal property line. Locations of property lines were assumed in alignment with neighbouring fences; however, these fences may not have been located on legal property lines. In addition, sites with doubtful property boundary locations were not selected for sampling. Figure 7.2 is an example of garden extension traces sampled within a municipal forest edge in Kitchener.

Table 7.4-Yard extension traces for all policies and boundary types

Yard Extension Trace Types	% of Yard Extension Traces	% sites with Traces	Total # of Traces	Mean freq. of traces/site	Mean Intensity of traces/site	Mean % cover	% of Encroachment Traces
Lawn Extensions	71.1	31	852	14	85	6 (76 to 100%)	19
Garden Extensions	25.4	24	304	7	35	5 (51 to 75%)	7
Firewood	1.0	4	12	2	7	5 (51 to 75%)	<1
Buildings (including fence)	1.0	2	12	3	11	4 (26 – 50%)	<1
Balls	.9	4	11	2	4	2 (1 to 5%)	<1
Swimming Pools	.5	<1	6	6	36	6 (76 to 100%)	<1
Sport Court (trampolines etc.)	.2	<1	2	2	6	3 (6 to 25%)	<1
Total	**100**	**77 (44)**	**1199**	**16**	**88**	**6 (76 to 100%)**	**27**

[1]Mean intensity of traces = total number of encroachment traces x their cover categories / number of sites

Figure 7.2 Garden extension encroachment at 102 Stoke Crescent, Monarch Woods, Kitchener
(Source: W. McWilliam Digital Photograph August 27, 2004)

Forest recreation traces were recorded in just over 40% of sites. Almost 95% of these traces were unauthorized pathways. Although this encroachment category had a relatively low frequency of traces per site relative to yard extension and waste disposal categories (making up only 6% of all encroachment traces), they covered a large percentage (76 to 100%) of their quadrats (Table 7.5). Figure 7.3 is an example of a typical children's fort sampled in a Kitchener forest edge.

Table 7.5: Forest recreation related traces for all policies and boundary types

Forest Recreation Trace Types	% of Forest Recreation Traces	% sites with Traces	Total # of Traces	Mean frequency of traces/site	Mean Intensity[1] of traces/site	Mean % cover	% of Encroachment Traces
Unauthorized Pathways	94.3	39	263	4	20	6 (76 to 100%)	6
Forts	3.6	2	10	3	17	5 (51 to 75%)	<1
Furniture (in forest setting)	1.8	3	6	1	5	6 (76 to 100%)	<1
Fire Pit	.4	<1	1	1	4	4 (26 – 50%)	<1
Totals	**100**	**44**	**279**	**4**	**20**	**6 (76 to 100%)**	**6**

[1]Mean intensity of traces = total number of encroachment traces x their cover categories / number of sites

Figure 7.3 Children's fort, a common type of forest recreation encroachment at 77 Sabrina Ave., Tilt's Bush, Kitchener
(Source: W. McWilliam Digital Photograph October 21, 2005)

Traces in response to forest encroachment were recorded in 10% of all sites sampled. The removal of forest vegetation constituted 95% of those recorded. The mean percentage cover of the traces was high at 51% to 75% of their quadrats (Table 7.6). Figure 7.4 is an example of traces sampled that resulted from a resident's reaction to forest encroachment in Mississauga. The resident has removed the forest vegetation along the outside of his fence.

Table 7.6 Reaction to forest encroachment traces for all policies and boundary types

Reaction to Forest Encroachment	% of Reaction to Forest Encroachment Traces	% sites with Traces	Total # of Traces	Mean frequency of traces/site	Mean Intensity[1] of traces/site	Mean % cover	% of Encroachment Traces
Forest Floor Removal	94.5	10	137	7	41	6 (76 to 100%)	3
Hacked Tree	5.5	3	8	2	6	3 (6 to 25%)	<1
Total	**100**	**12**	**145**	**6**	**35**	**5 (51 to 75%)**	**3**

[1]Mean intensity of traces = total number of encroachment traces x their cover categories / number of sites

Figure 7.4 Reaction to forest encroachment at 4234 Wakefield Crescent, Creditview Park, Mississauga
(Source: W. McWilliam Digital Photograph, October 25, 2005)

Garden vegetation expansion traces were recorded in 24% of the study sites. They had mean frequency per site of three traces, each covering a mean of 26 to 50% of their quadrats. This trace category accounted for 3% of the encroachment traces recorded. Observations of their patterns, and conversations with residents, indicated that some residents planted them in the forest edge to improve the forest's aesthetic appearance, or to screen or protect their yards from the forest, or its inhabitants. Observations of growing patterns also indicated that they sometimes arrived inadvertently through vegetative reproduction across residential boundaries, and through resident waste disposal encroachment within the municipal forest edge. Figure 7.5 is an example of garden vegetation expansion traces. The pattern of growth indicated that a resident planted this vegetation in the forest edge.

Figure 7.5 Garden plants in the forest edge at 12 Idlewood Avenue, Idlewood Park, Kitchener
(Source: W. McWilliam Digital Photograph, August 3, 2004)

7.1.1.3 Distribution of Mean Intensity of all Encroachment Traces in the first 20 metres of Study Forest Borders

The distribution of the intensity of encroachment demonstrated a significant bias to the forest border (Kruskal-Wallis x^2 = 319.349, 10*df*, P = .000). Ninety-five percent of the recorded traces were within 18 metres. Mean intensity was highest at the forest border, decreased steeply until approximately 8 metres, and then more gradually to low intensity levels beyond 20 metres (Figure 7.6).

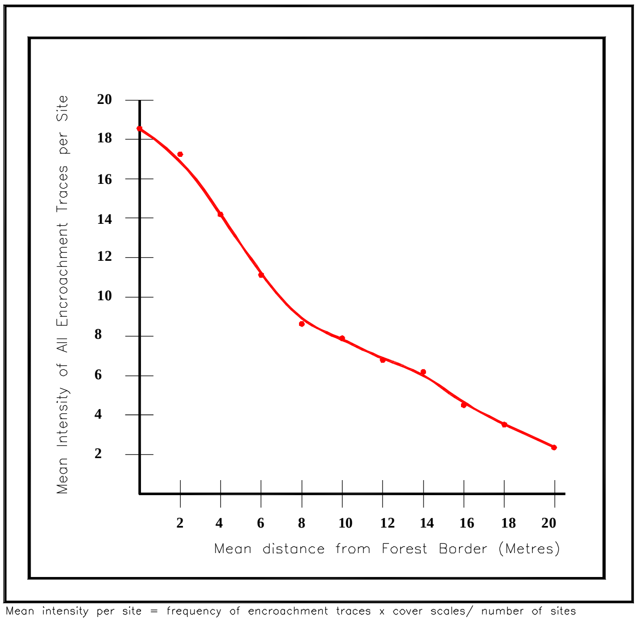
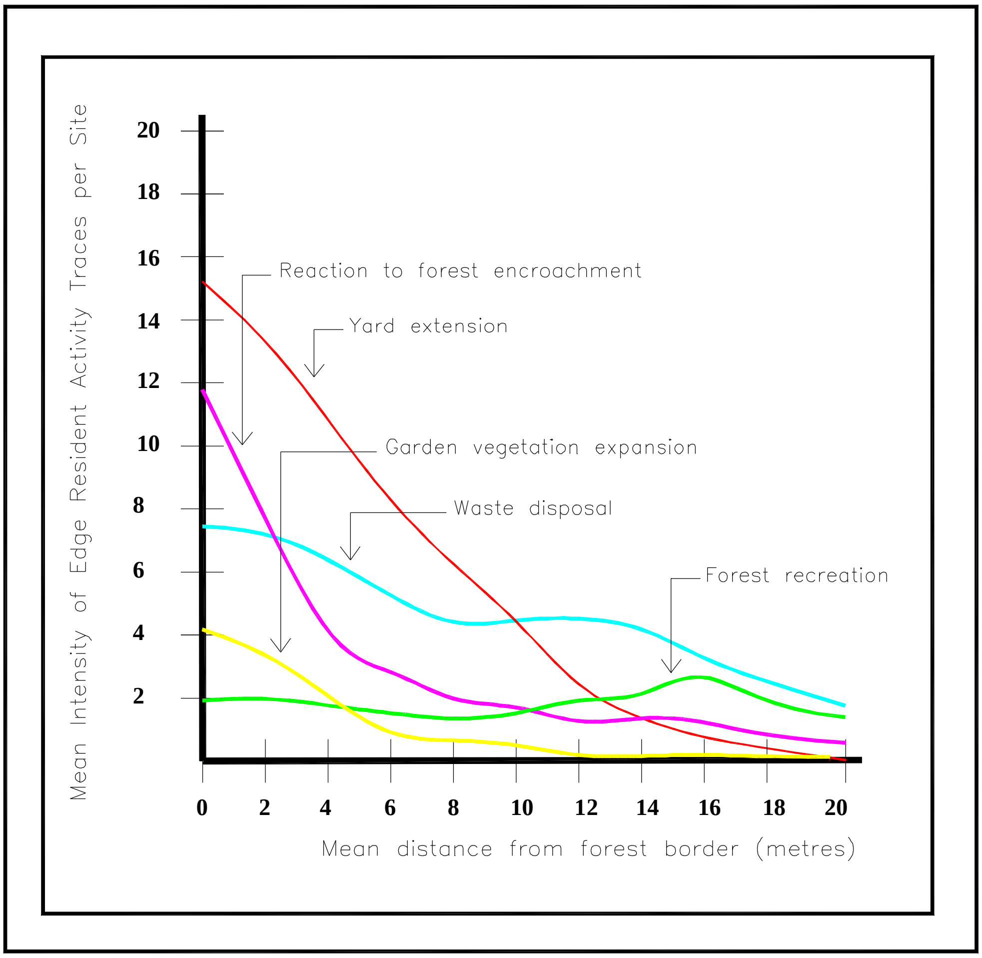


Figure 7.6 Mean intensity of encroachment with respect to distance from the forest border

7.1.1.4 Distribution of Mean Intensity of Encroachment in the First 20 Metres from the Forest Border by Trace Category

The distribution of the intensity of waste disposal, yard extension, garden vegetation expansion, and reaction to forest encroachment trace categories demonstrated a significant bias to the forest border (Kruskal-Wallis x^2 = 110.308, 10*df*, P = .000; x^2 = 332.019, 10*df*, P = .000; x^2 = 142.996, 10*df*, P = .000; x^2 = 62.000, 10*df*, P = .000, respectively). There was no significant bias to the property boundary for forest recreation traces (Kruskal-Wallis x^2 = 9.155, 10*df*, P = .517). Yard extension, followed by reaction to forest encroachment traces tended to be the most intensive closest to the boundary, but decreased steeply within shorter distances of the forest border than the traces of other categories of encroachment (Figure 7.7).



Mean intensity per site = frequency of encroachment traces x cover scales/number of sites

Figure 7.7 Mean intensity of encroachment traces per site with respect to distance from the forest border by encroachment category

Yard extension traces have the highest mean intensity per site of any trace category. It is highest at the forest border and then descends sharply, but steadily, within approximately 12 metres into the forest edge. Beyond this point, it continues to decline until approximately 20 metres, where it ceases. Figure 7.8 is an example of this yard extension pattern sampled in an Oakville study site where the resident installed an illegal gate in the municipal fence.

Figure 7.8 Typical yard extension trace pattern at 182 Chalmers Street, Villagewood Park, Oakville
(Source W. McWilliam, Digital Photograph, October 31, 2005)

The mean intensity per site of traces in reaction to forest encroachment mimics the yard extension distribution pattern. However, it starts at a lower mean intensity, and drops off more sharply closer to the forest border at approximately four metres (Figure 7.5). Garden vegetation expansion traces tend to be concentrated in the first six metres. Figure 7.9 is an example of typical garden vegetation expansion traces, in a Mississauga forest, that have spread through vegetative reproduction.

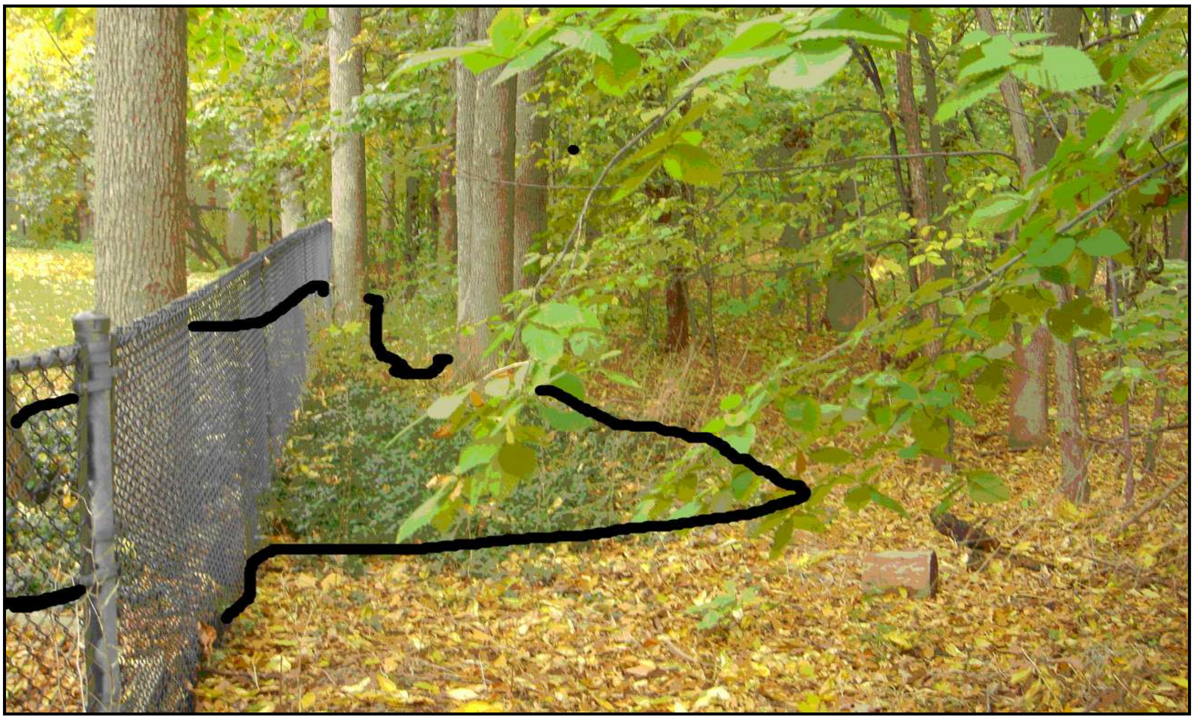


Figure 7.9 Typical pattern of garden plant extension traces that have spread vegetatively from the private property at 4080 Deer Run Court, Deer Run Park, Mississauga
(Source: W. McWilliam Digital Photograph, October 27, 2005)

Mean intensities of forest recreation related traces in forest edges are not significantly biased to the forest border (Kruskal-Wallis, $P > .05$).This is reflected in Figure 7.7. Unauthorized pathways frequently originated at forest borders and extended deep into the forest edge, while children's forts and fire pits also tended to be located at greater distances.

The sampling of waste disposal traces revealed a 'two-humped' pattern of distribution in the forest edge. Waste disposal traces tended to decrease in intensity with distance from the forest border, although less steeply than the traces of the other encroachment categories. The 'two humped' pattern illustrated in Figure 7.7 may reflect the two distinctive dumping patterns observed with different boundary treatments. For example, with a fenced boundary, waste tended to be heaved over the fence, landing close to the boundary (the first hump) (Figure 7.1). However, when there was no boundary demarcation, or when a gate was placed in the fence, residents tended to 'hide' the waste from view further into the forest edge, frequently on the other side of a yard extension area. This may represent the second 'hump' in Figure 7.7. Figure 7.10 is an example of a Kitchener fence with gate site sampled with this latter dumping pattern. The dumping occurred in and adjacent to the composting bins concealed by forest vegetation in the right side of the photograph.

Figure 7.10 Dumping pattern commonly associated with Fence and gate boundary types at 627 Manchester Road, Forfar Park, Kitchener
(Source: W. McWilliam, Digital Photograph, July 14, 2005)

7.1.2 Different Boundary Policies and Types

7.1.2.1 Mean Frequencies and Intensities of all Traces and Categories of Traces

Study sites under the two different policies, and under all other boundary types had encroachment traces. Table 7.7 summarizes the mean intensity and mean frequency (in brackets) per site for each encroachment category by boundary type. A zero in a chart cell means that no encroachment traces were sampled for that boundary type.

Table 7.7 Mean intensity and mean frequency of encroachment by trace category and boundary type

Trace Categories	No boundary demarcation	Municipal Boundary Post	Grass strip	Grass strip, path	Fence with gate	Fence, gate, grass strip	Fence, gate, grass strip and path	Fence	Fence and grass strip	Fence, grass strip and path
Waste Disposal	51 (13)	42 (9)	45 (12)	20 (6)	51 (13)	73 (21)	59 (17)	61 (17))	8 (3)	25 (7)
Yard Extension	111 (19)	13 (3)	0	57 (9)	35 (6)	23 (41)	0	10 (2))	0	0
Forest Recreation	7 (1)	4 (.7)	3.0 (.5)	6 (1)	14 (3)	7 (1)	7.5 (1.3)	2 (.4)	0	19 (3)
Reaction to Forest Encroachment	3 (.5)	0	0	0	5 (.8)	14 (3)	0	6 (1)	0	0
Garden Vegetation Expansion	4 (.8)	.5 (.1)	0	0	6 (2)	0	.3 (.1)	3.1 (.8)	0	.4 (.2)
All Traces	177 (35)	59 (12)	48 (13)	83 (17)	110 (24)	117 (29)	66 (19)	90 (23)	8 (3)	44 (10)

A Kolomogorov-Smirnov two sample test demonstrated that sites subject to a municipal encroachment policy had a significantly lower mean frequency and mean intensity of encroachment than sites not subject to a policy (Kolomogorov-Smirnov Z = 1.792, P = .003; Z = 2.048, P = .000, respectively). Similarly, a Kruskal-Wallis test showed a significant difference in the mean frequency and mean intensity of encroachment between all boundary types (including policies) (Kruskal-Wallis X = 63.146, 9*df*, P= .000; X = 72.032, 9*df*, P= .000, respectively).

To determine which policies and boundary treatments had a significantly different frequency and intensity of encroachment; Kolomogorov-Smirnov two-sample tests were conducted. Appendix E, Tables E.1 to E.8 report the test statistics for the differences in mean frequencies and intensities between boundaries for all encroachment categories, and for waste disposal, yard extension and forest recreation categories.

The mean frequency and mean intensity of all types of encroachment for sites with a fence policy were not significantly different from those of sites with no boundary demarcation policy (Kolomogorov-Smirnov Z = .987, P = .285; Z = 1.262, P = .083, respectively). Although these sites had significantly lower mean frequencies and intensities of yard encroachment (Kolomogorov-Smirnov Z = 1.617, P = .011; Z = 1.814, P = .003, respectively); and forest recreation encroachment (Kolomogorov-Smirnov Z = 1.605, P = .012; Z = 1.605, P = .012, respectively), these reductions in encroachment were offset by a significantly higher mean frequency of waste disposal encroachment (Kolomogorov-Smirnov Z = 1.448, P = .030).

Relative to sites with a municipal post policy, sites under a fencing policy had a significantly higher mean frequency of all types of encroachment (Kolomogorov-Smirnov Z = 1.725, P = .005). Again, fence policy sites had significantly lower mean intensities of yard extension encroachment (not frequencies) (Kolomogorov-Smirnov Z = 1.380, P = .044); however, they had a significantly higher mean frequency of waste disposal encroachment (Kolomogorov-Smirnov Z = 1.898, P = .001). There were no significant differences between these policies in terms of forest recreation, reaction to forest encroachment, or garden vegetation expansion trace categories (Kolomogorov-Smirnov P = > .05).

Relative to the other boundary types, fenced sites had a significantly lower mean frequency and mean intensities of encroachment than sites with no boundary demarcation, and lower mean intensities of encroachment than sites with fences and gates (Kolomogorov-Smirnov P = < .05). Placing a gate in a fence significantly increased the mean intensity of encroachment. The percentage of the forest floor covered by encroachment traces increased from 26 to 50% in fenced sites to 51 to 75% in fenced sites with gates. In two of the forests where Oakville had implemented a fencing policy, two of the residents installed illegal gates. There were no statistically significant differences in mean intensity and frequency of encroachment between these two sites and other fenced sites (Kolomogorov-Smirnov, P > .05). Nevertheless, in one of these sites, the mean intensity of total encroachment, and particularly the mean frequency and intensity of yard extension encroachment, increased dramatically relative to those of fenced sites (Figure 7.8).

Despite these gains, fences still had significantly higher mean frequencies of encroachment than sites with fences, gates, grass strips and paths; and sites with fences with grass strips (with or without paths) (Kolomogorov-Smirnov, P <.05). These higher mean frequencies were largely due to significantly higher mean frequencies of waste disposal encroachment between fences and these other boundary types (Kolomogorov-Smirnov, P <.05). Fences were not, on average, effective in reducing the intensity and, particularly, the frequency of waste disposal encroachment. The heights of the fences may have been too low to discourage residents from dumping over the fence. The mean height of study site fences was 1.5 metres measured from the municipal forest side of the fence. The Oakville fencing policy requires a 1.2-metre fence, and those implemented in Mississauga and Guelph required 1.5-metre fences. The height of the fence on the resident's side, however, was often appreciably less than these heights since many residents installed raised flowerbeds, patios and pool decks that raised the grade of their yards above that of the adjacent forest edge. However, no correlation was found between fence heights (ranging from 91 to 163 cm) and the mean frequency and intensity of waste disposal encroachment (Spearman, P>.05). The sampling of higher fences is required to determine whether an increased height would reduce waste disposal encroachment, and to identify the effective height. Kolomogorov two sample tests indicated that there were no significant differences between the mean frequencies and mean intensities of sites with municipal versus resident-installed fences (Kolomogorov-Smirnov, Z = .452, P = .987; Z = .759, P = .611, respectively). Some caveats apply to these results. Waste disposal encroachment traces in fenced sites may have been over-sampled relative to those in sites with other boundary treatments. In fenced sites waste tended to be thrown over the fence into a pile, or spread out, along the fence line, whereas that of sites with other boundary types tended to consist of one or two concentrated heaps deeper into the forest edge. Under the sampling design that always began sampling at the boundary, traces dumped along the fence line may have had a higher probability of being sampled than traces dumped in one or two piles at random distances into the forest edge.

Sites with municipal boundary posts had significantly lower mean frequencies and intensities of encroachment than sites with no municipal boundary demarcation policy (Kolomogorov-Smirnov Z = 1.830, P = .002; Z = 1.611, P = .011, respectively). However, there were no significant differences between the mean frequencies and intensities of any of the categories of encroachment (Kolomogorov-Smirnov, P >.05). A municipal post policy also resulted in significantly lower mean frequencies of encroachment traces than a fence policy (Kolomogorov-Smirnov, P <.05). This resulted from a significantly lower mean frequencies of waste disposal (Kolomogorov-Smirnov, P <.05), despite a significantly higher mean intensity of yard extension encroachment (Kolomogorov-Smirnov, P <.05).

Relative to the other boundary treatments, sites with municipal posts had significantly lower mean frequencies and intensities of encroachment than sites with no, or minimal boundary demarcation; and sites with fences with gates (Kolomogorov-Smirnov, P <.05). In terms of differences in categories of encroachment, they had significantly lower mean frequencies and intensities of yard encroachment than these sites.

The differences in encroachment levels between these sites was surprising given the municipal posts were not highly visible to residents and, similar to no boundary demarcation and fence with gate sites, enabled residents to access, easily, the forest edge. The low levels may be due to site-specific factors, since only 12 sites were sampled, and most were located in one municipality. Within many of these sites, the adjacent houses were built without removing the forest vegetation from resident yards. Some residents retained the forest floor vegetation in these areas. Shade within residential yards, created by overhanging forest canopy trees, may have deterred residents from establishing lawns. Some of these sites appeared to exemplify the adoption by residents of the forest's aesthetic appearance. These residents appeared to have allowed the forest to ‘encroach’ into yards, rather than extending their yard's aesthetic into the forest edge (Figure 7.11).

Figure 7.11 Low frequency and intensity of encroachment within a municipal boundary marker (lower right corner of photo) site at 357 Northlake Dr., Sparrow Park, Waterloo
(Source: W. McWilliam, Digital Photograph, July 12, 2005)

Nevertheless, similar to fenced sites, those with municipal post policies still had significantly higher mean intensities of encroachment than sites with fences, and grass strips (Kolomogorov-Smirnov, Z = 1.420, P = .035). In terms of the categories of encroachment, sites with posts had significantly higher mean intensity and frequency of yard extension than sites with fences, gates, grass strips and paths (Kolomogorov-Smirnov, Z = 1.721, P = 0.005; Z = 1.721, P = 0.005, respectively), and sites with fences, grass strips and paths (Kolomogorov-Smirnov, Z = 1.665, P = 0.008, Z = 1.665, P = 0.008).

In general, the results of the Kolomogorov-Smirnov two sample tests between boundary types indicated that boundary types that allowed edge residents ready access to the forest edge, had higher frequencies and intensities of encroachment, particularly yard extension encroachment than boundary types that deterred access. Sites with no boundary demarcation and, to a lesser extent, fenced sites with gates, had significantly higher frequencies and intensities of encroachment than most other boundary types. On the other hand, sites that deterred access through fences, grass strips, and possibly paths, had significantly lower mean frequencies and intensities of total encroachment. In terms of the categories of encroachment, these boundary types tended to have significantly lower mean frequencies and intensities of yard extension encroachment, and in the case of sites with grass strips, lower mean frequencies and intensities of waste disposal encroachment than sites without these boundary elements (Kolomogorov-Smirnov, P < .05). Combined together, fences, grass strips and paths provide a more effective barrier to encroachment than fences, grass strips, or grass strips and paths, by themselves. However, the contributions of grass strips and pathways, relative to each other, and fences, for reducing total encroachment, or different categories of encroachment, are unknown. An insufficient number of sites with these individual boundary types were available for sampling.

In terms of the effect of boundary type on reducing forest recreation encroachment, the results were ambiguous. Fenced sites with gates had a significantly higher mean frequency and intensity of forest recreation encroachment than fenced sites and fenced sites with gates, grass strips and paths (Kolmogorov-Smirnov, $P < .05$). Most of the forest recreation traces (94%) were unauthorized pathway traces. In the field, it was observed that all fences with gates had unauthorized pathways leading from the resident's yard into the forest edge, while fenced sites did not have these pathways. However, many informal pathways were noted entering forest borders where there were grass strips, even when adjacent residences were fenced. Sites with fences and grass strips and paths had a significantly higher mean intensity of forest recreation encroachment than sites with no, or minimal boundary demarcation; fences, gates, grass strips and paths; and fences (Kolmogorov-Smirnov, $P < .05$). These ambiguous results may be due to the sampling of unauthorized pathways not created by immediately adjacent residents, but rather neighbouring residents, or recreationists. Unauthorized pathways were commonly observed throughout many of the forests sampled regardless of the boundary type. Where the pathway entered the forest border following a grass strips, it was difficult to determine which resident had created the pathway.

Higher frequencies and intensities of traces in reaction to forest encroachment were recorded in fenced sites (with or without gates) than sites with grass strips (with or without pathways). A grass strip may separate the residential property from the forest border, thereby removing the encroaching forest vegetation from the property boundary. However, there were no statistically significant differences between any of the boundary types (Kolmogorov-Smirnov Z, $P > 0.05$). Furthermore, there was no significant difference in the mean frequency and intensity of forest encroachment traces between sites with grass strips and those without grass strips (Kolmogorov-Smirnov $Z = .763$, $P = 0.606$).

Sites with fences and gates followed by integration and fenced sites had the highest mean frequencies and intensities of garden plant traces. However, only significantly higher mean frequencies and mean intensities of garden plant traces were found between fenced sites with gates and 1) fenced sites, gates and grass strips (Kolmogorov-Smirnov $Z = 1.710$, $P = .006$; $Z = 1.710$, $p = .006$, respectively). Fenced sites with gates also had a significantly higher mean intensity of encroachment than fenced sites with gates, grass strips and paths (Kolmogorov-Smirnov $Z = 1.563$, $P = .015$). The grass strip may be a barrier to the expansion of garden plants into the forest edge via vegetative reproduction. Sites with grass strips had a significantly lower mean frequency and mean intensity of garden plant invasions than sites without grass strips (Kolmogorov-Smirnov $Z = 1,717$, $P = .006$; $Z = 1.893$, $P = .002$, respectively). Fences were not an effective barrier to this type of encroachment. Sites with fences (without gates) were not significantly different in terms of mean frequency or mean intensity of garden plant invasions than sites without fences, or those with gates (Kolmogorov-Smirnov $Z = .439$, $P = .991$; $Z = .487$, $P = .972$, respectively).

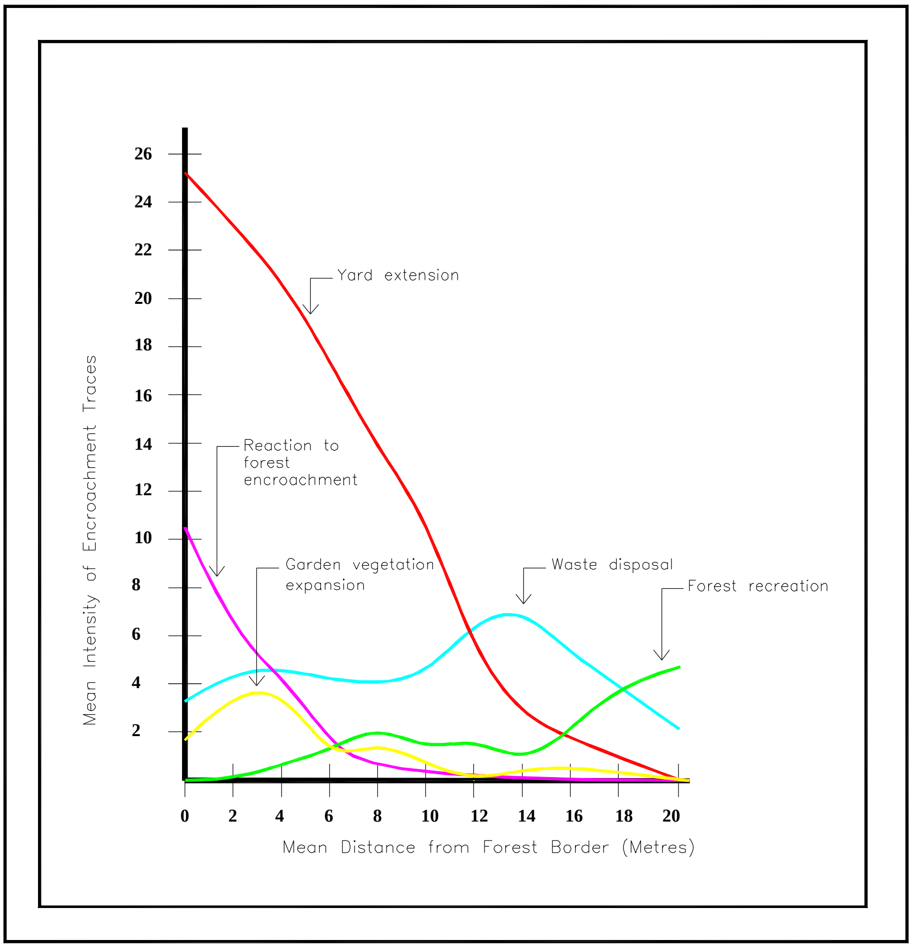
7.1.2.2 Distribution of Mean Intensity of Encroachment in first 20 metres of Study Forest Edges For all Trace types by Policy and Boundary Type

The distribution of the mean intensity of total encroachment traces demonstrated a significant bias to the forest border in sites with: 1) no, or minimal boundary demarcation sites (Kruskal-Wallis x^2 = 120.242, 10*df*, P = .000), 2) fences and gates (Kruskal-Wallis x^2 = 117.885, 10*df*, P = .000) and 3) fences (Kruskal-Wallis x^2 = 146.4, 10*df*, P = .000). Their mean intensities of encroachment were higher closer to the forest border and decreased with distance into the forest edge. However, those of fenced sites (regardless of boundary ownership) were distributed closer to the forest border than were those of the other boundary types. While 50 % of the traces were located within eight metres of the forest border in sites with no boundary demarcation, and in sites with fences and gates, they were located within six metres of the forest borders of sites with fences. Similarly, 95% of traces in sites were located within 18 to 20 metres of the borders of sites with no boundary demarcation and fenced sites with gates, and within 16 metres of borders of fenced sites. There were no significant effects of distance from the forest borders on the mean intensities of encroachment within sites with the other boundary types.

7.1.2.3 Distribution of Mean Intensity of Encroachment in Study Forest Edges For different traces categories by Policy and Boundary Type

There was a significant effect of distance on the mean intensities of some categories of encroachment depending on the type of boundary demarcation. These effects will be described for sites with; 1) no, or minimal boundary demarcation; 2) fences with gates; 3) fences, and 4) fences, grass strips and paths.

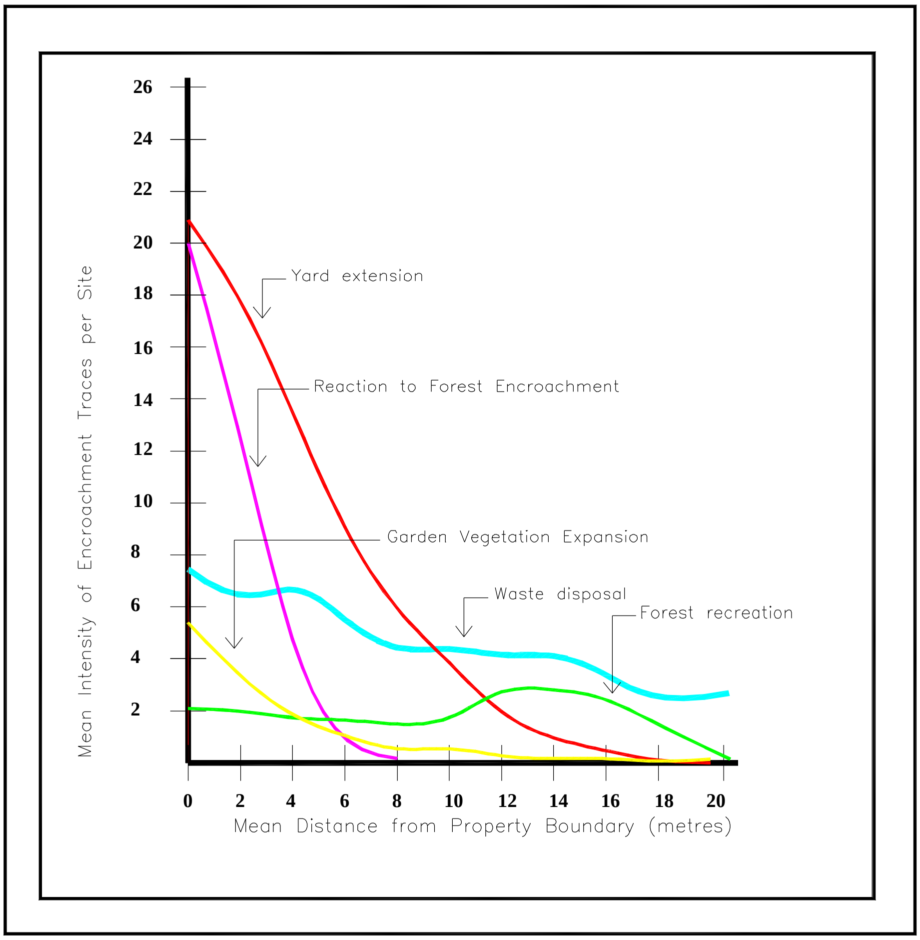
The distance from the property boundary had a significant impact on the mean intensity of yard extension traces in sites with no, or minimal, boundary demarcation (Kruskal-Wallis x^2 = 29.93, 10*df*, P = .001. The mean intensity of yard extension encroachment was higher at the property boundary than sites with any other boundary type. It peaked at the border, and gradually decreased until approximately 12 metres into the forest edge. The patterns of distribution of the other categories of encroachment are provided in Figure 7.12, although the effects of distance from the property boundary did not have a statistically significant impact on their mean intensities.



Mean intensity per site = frequency of encroachment traces x coveer scales/number of sites

Figure 7.12 Mean intensities of encroachment categories with respect to distance from the forest border within sites with no, or minimal boundary demarcation

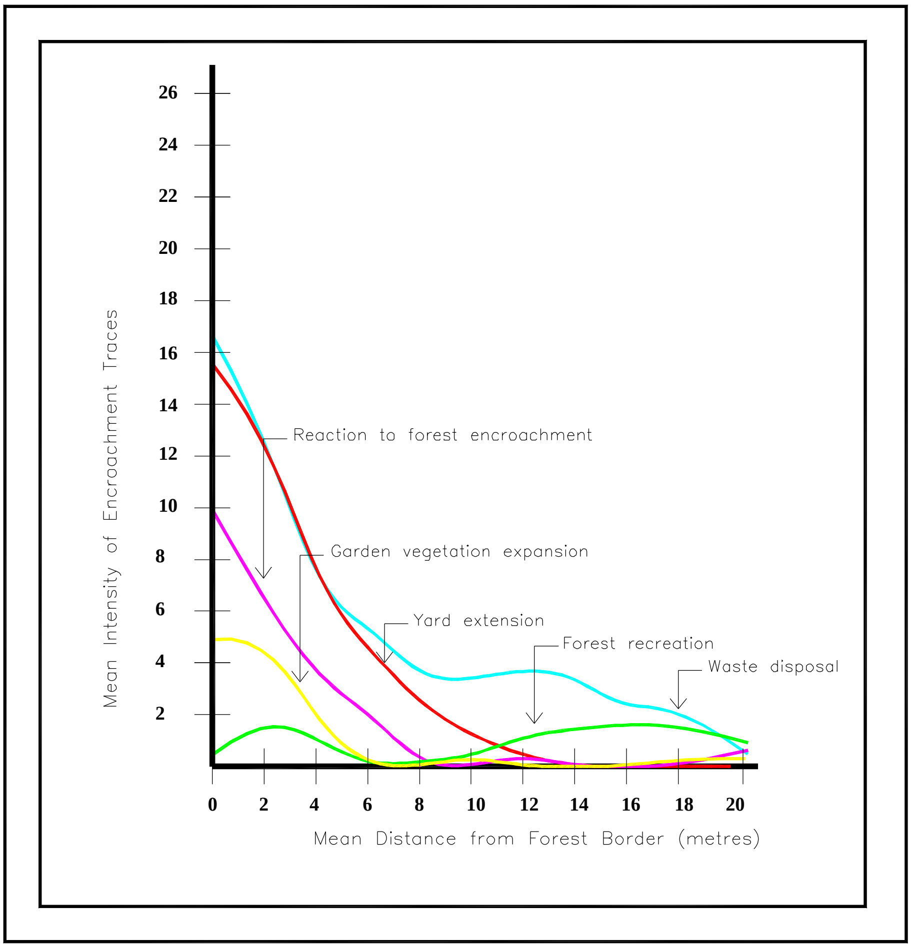
The distance from the property boundary had a significant impact on the mean intensity of yard extension traces in fenced sites with gates (Kruskal-Wallis x^2 = 18.957, 8*df*, P = .015). The mean intensity of yard extension encroachment traces recorded was high at the boundary relative to those of sites with most other boundary types (except those with no boundary demarcation; grass strips and paths; and fences, gates and grass strips). Similar to sites with no, or minimal, boundary demarcation, the intensity decreased steeply with distance from the boundary, but did not extend as far into the forest edge as sites with no boundary demarcation Figure 7.13.



Mean intensity per site = frequency of encroachment traces x cover scale/ number of sites

Figure 7.13 Mean intensities of encroachment trace categories with respect to distance from the forest border within sites with fences and gates

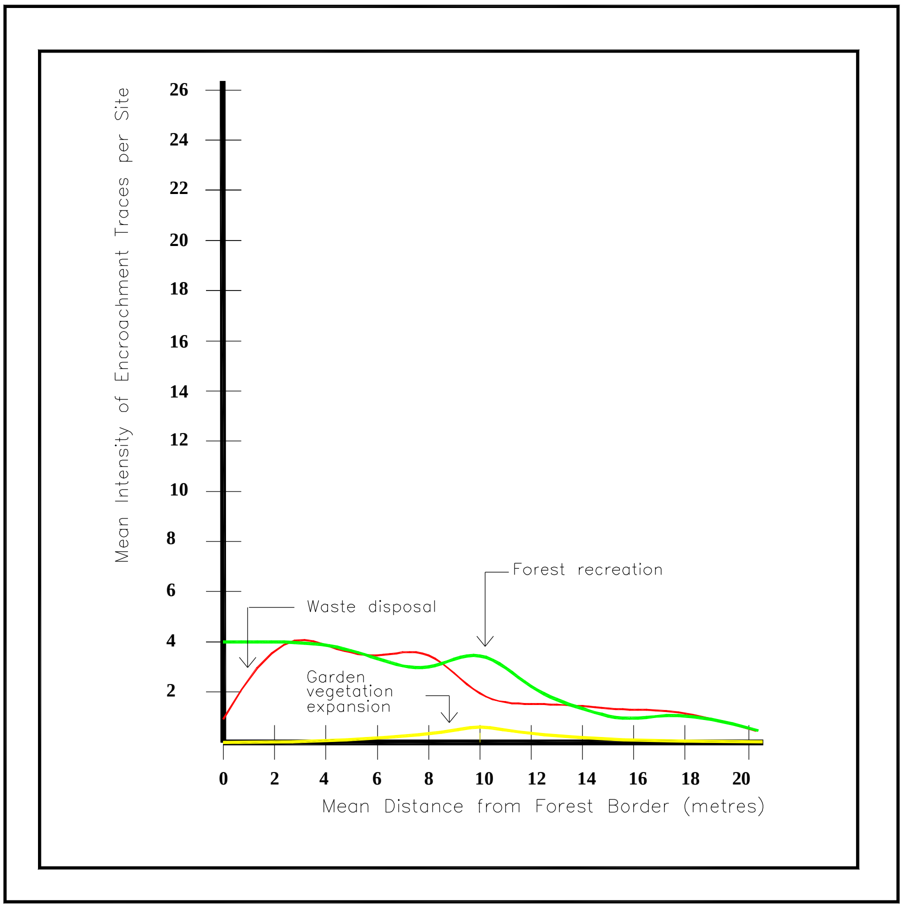
The distance from the property boundary also had a significant impact on the mean intensity of waste disposal encroachment in fenced sites with gates (Kruskal-Wallis x^2 = 20.662, 10*df*, P = .024) and in sites with fences (Kruskal-Wallis x^2 = 19.687, 10*df*, P = .032). Higher mean intensities of waste disposal traces were recorded at the border in fenced sites with gates, and particularly in fenced sites, relative to sites with no, or minimal boundary demarcation (Figures 7.13 and 7.14). Fenced sites tended to have high mean frequencies and intensities of dumping along the property boundary that dropped off sharply to levels similar to fenced sites with gates and sites with no, or minimal, boundary demarcation. Although fenced sites with gates had slightly higher mean intensities of encroachment at the boundary than sites with no, or minimal boundary demarcation, both boundary types appeared to share similar patterns of mean intensity of waste disposal with respect to distance from the edge. The patterns of distribution of the other categories of encroachment for fenced sites, and fenced sites with gates, are provided in Figures 7.14 and 7.13, respectively, although the effects of distance from the property boundary did not have a statistically significant impact on the mean intensities of these categories of encroachment.



Mean intensity = frequency of encroachment traces x cover scales/number of sites

Figure 7.14 Mean intensities of encroachment trace categories with respect to distance from the forest border within sites with fences

Although the distribution of the mean intensity of total encroachment traces did not demonstrate a significant bias to the forest edge within sites with fences, grass strips and paths (Kruskal-Wallis; $P > .05$), it did show a significant bias in terms of the mean intensity of waste disposal traces (Kruskal-Wallis $x^2 = 19.687$, 10*df*, $P = .032$). Mean intensities of waste disposal traces were lower at the forest border than most other boundary types, and tended to diminish to low levels closer to the forest border (Figure 7.15). The patterns of distribution of the other categories of encroachment traces present, forest recreation and garden plant extensions, are provided in Figure 7.15, although the effects of distance from the property boundary did not have a statistically significant impact on their mean intensities.



Mean intensity per site = frequency of encroachment traces x cover scales/ number of sites

Figure 7.15 Mean intensities of encroachment traces with respect to distance from the forest border within sites with fences, grass strips and paths

7.2 Maximum Distance of Encroachment

7.2.1 All Policies and Boundary Types

7.2.1.1 Maximum Distance of Encroachment of all Encroachment Traces

Ninety-five percent of extensively sampled sites had encroachment traces. The maximum furthest extent of encroachment was 49 metres from the forest border. Ninety-five percent of the furthest encroachment traces were within 34.4 metres; and the mean maximum distance was 16.4 metres (Figure 7.16). A null hypothesis of uniform distribution was tested with a Kolomogorov-Smirnov one-sample test. The distribution of the maximum distance of encroachment was significantly biased to the forest border. (Kolomogorov-Smirnov Z = 6.441, P = .000).

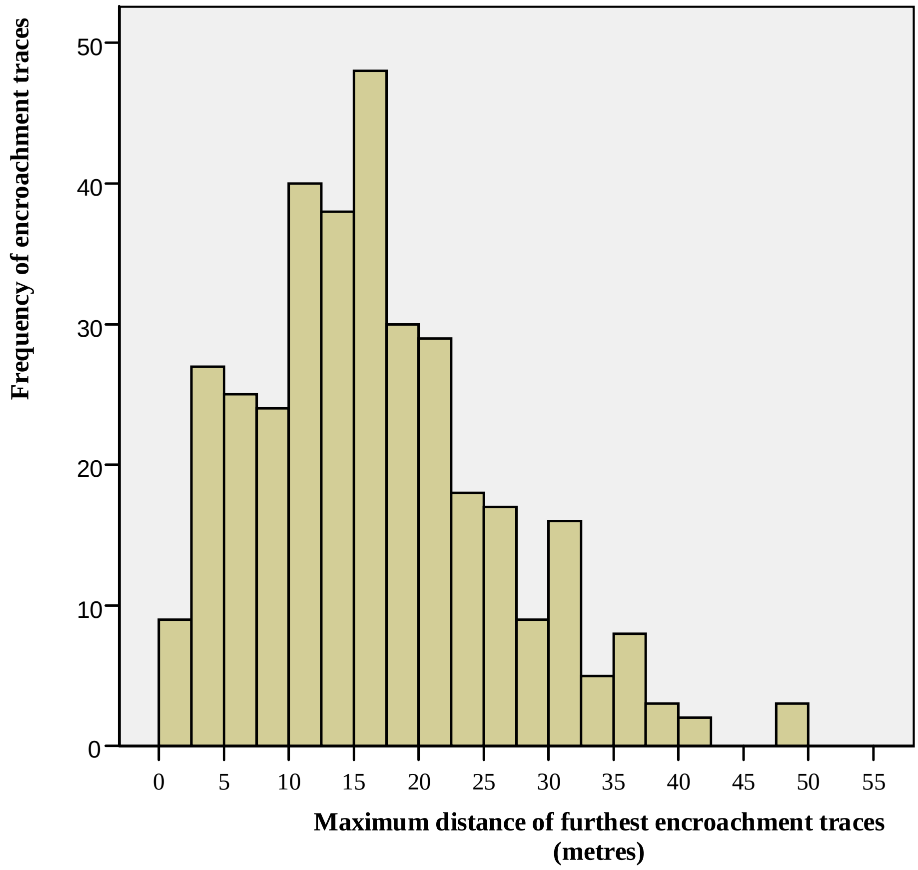


Figure 7.16 Mean maximum distance of encroachment traces from the property boundary for all boundary types

7.2.1.2 Maximum Distance of Encroachment by Type and Category

Twenty different types of traces were recorded furthest from the forest border. Traces from the waste disposal category accounted for approximately 92% of these traces. Waste disposal category traces had a mean maximum extent of encroachment of 17 metres, and a maximum extent of 49 metres. Other organic debris (e.g. branches or discarded plants), construction waste, and miscellaneous consumer waste contributed 78% of these traces, and had mean maximum extents of between 15 and 16 metres, depending on the type.

Forest recreation category traces had a mean maximum extent of encroachment of 24 metres, and a maximum extent of 49 metres from the forest border. Children's forts were most commonly furthest from the forest border, with a mean maximum distance of 24 metres, and a maximum distance of encroachment of 49 metres.

Traces from yard extension, garden vegetation expansion, and reaction to forest encroachment categories were infrequently found furthest from the forest border. In addition, they were found closer to the forest border than traces from waste disposal or forest recreation categories. Their mean maximum extents were 14, 14 and 2 metres; and their maximum extents of encroachment were 31, 32 and 2 metres, respectively (Table 7.8).

Table 7.8 Mean frequency and maximum extent (metres) of encroachment from the forest border by encroachment type and category

Encroachment Types	Encroachment Category	# Traces	Mean Distance	Max. Distance
Ash/Charcoal	Waste Disposal	1	25	25
Fort	Forest Recreation	13	24	49
Christmas Tree	Waste Disposal	11	25	33
Compost Bin	Waste Disposal	1	19	19
Fire Pit	Forest Recreation	1	20	20
Grass Clippings	Waste Disposal	3	19	27
Leaf Pile	Waste Disposal	2	18	24
Granular Material	Waste Disposal	21	18	37
Ball	Yard Extension	3	18	31
Junk	Waste Disposal	18	17	39
Miscellaneous Consumer Waste	Waste Disposal	50	16	29
Sport Court	Yard Extension	1	16	16
Other Organic Debris	Waste Disposal	223	16	49
Compost	Waste Disposal	2	15	19
Construction Rubble	Waste Disposal	70	15	49
Garden Plants	Garden vegetation Expansion	5	14	32
Pool Pipe	Waste Disposal	1	11	11
Lawn Extension	Yard Extension	3	10	11
Human Placed Rock	Waste Disposal	3	8	11
Forest Floor Removal	Reaction to Forest Encroachment	2	2	1
All Types		433[1]	17	49

[1] The extensive study measured 358 sites; however, I recorded 433 traces furthest from the /forest border because within many sites there were two or more trace types at the same distance furthest from the border.

7.2.2 Different Boundary Policies and Types

A Kolomogorov-Smirnov two sample test demonstrated that there was no significant difference between the mean maximum extent of encroachment between sites with boundary demarcation policies and those with no policies (Kolomogorov-Smirnov, Z = .961, P = .314). While sites under a fence policy had significantly lower mean maximum extent of encroachment than sites under no policy (Kolomogorov-Smirnov, Z = 1.986, P = .001) there were no significant differences between sites with a municipal post policy and no boundary demarcation policy (Kolomogorov-Smirnov, Z = .773, P = .589), or between sites with a municipal post policy and a fencing policy (Kolomogorov-Smirnov, Z = 1.115, P = .166).

A Kruskal-Wallis test also showed a statistically significant difference in the mean maximum distance of encroachment between boundary types (Kruskal-Wallis X = 62.661, 7*df*, P = .000). Table 7.9 summarizes the mean maximum encroachment distance in metres from the forest border of residential encroachment under the different boundary policies and types.

Table 7.9 Mean maximum distance (metres) of encroachment traces from forest border by boundary type

Boundary Type	No boundary demarcation	Municipal Post	Fence, gate	Fence, grass strip, path	Fence	Fence, gate, grass strip, path	Grass strip, path	Fence, gate, grass strip	Total
# Study sites	77	17	96	11	121	24	8	5	358
# Sites with traces	75	17	94	9	115	19	6	5	340
# Sites without traces	0	0	0	2	6	5	2	0	15
Mean maximum distance	**21**	**20**	**19**	**14**	**13**	**12**	**10**	**9**	**16**
Maximum distance	49	49	41	25	39	49	17	13	49

Kolomogorov-Smirnov two-sample tests were conducted to determine which boundary treatments had a significantly different mean maximum extent. Appendix E, Table E.9 reports the Kolomogorov-Smirnov test statistics for the differences in mean maximum extent between policies and boundary types. The tests showed that, in general, the softer boundary treatments, having minimal barriers to forest edge entry, tended to have significantly higher maximum extents of encroachment than sites with more significant barriers, including sites with fences. There was no significant difference between the mean maximum extent of sites with fencing policy relative to sites with resident installed fences (Kolomogorov-Smirnov, $Z = .639$, $P = .805$). Sites with no, or minimal, boundary demarcation, and those with fences and gates, had significantly more extensive encroachments than most other boundary treatments (Kolomogorov-Smirnov, $P < .05$). In addition, sites with municipal boundary markers had significantly more extensive encroachments than sites with fences, gates and grass strips (Kolomogorov-Smirnov, $P < .05$).

7.3 Discussion

Site visits confirmed that most of the study municipalities had implemented their current boundary demarcation policies in the last 5 to 10 years. As a result, a municipal boundary demarcation policy was not protecting a majority of their forests with existing adjacent housing. Site visits and discussions with the interviewees also revealed that other policies for limiting encroachment activities were either missing, or infrequently implemented, within many study municipality forests. Encroachment bylaw enforcement had occurred in only 6% of the sites. Interviewees indicated that municipal monitoring for encroachment within forest edges occurred frequently where there were grass strips, and particularly where there were paths, but infrequently where residences directly abutted forest edges. Only 40% of sites had signs prohibiting an encroachment activity, most prohibiting the dumping of waste. In addition, interviewees revealed that resident education regarding encroachment activities infrequently occurred.

The results of both intensive and extensive sampling of forest edges indicated that edge resident activities generate edge effects, or 'encroachment-generated edges,' within urban forest fragments of Southern Ontario. Both the intensity of encroachment in the first 20 metres, and the maximum furthest extent of encroachment were significantly biased to the forest border (Kruskall-Wallis, $P<.05$; and Kolomogorov-Smirnov, $P < .05$, respectively). Encroachment traces were particularly intense (both highly prevalent and covering a large proportion of the sample area) in the first 8 metres from the forest border; however, they were frequently present after 20 metres. They extended a mean maximum distance into the forest edge of approximately 16 metres. The maximum distance from the forest border in which encroachment traces were identified was 49 metres, with 95% of the furthest encroachment traces occurring within approximately 34 metres. These results are supported by those of Matlack's study of the spatial distribution of human impacts in suburban forest edges. He found the distribution of human impacts associated with edge resident activities, such as lawn maintenance, showed a significant bias to the forest edge (Kolmogorov-Smirnov, $P<.05$); and that the majority of the activity traces within forests with adjacent suburban housing occurred within 30 metres of forest edges (Matlack, 1993).

These edge effects were highly prevalent within study forests. Encroachment traces were recorded in 99% of intensively sampled sites and 95% of extensively sampled sites. Traces also occurred at relatively high frequencies per site and covered significant proportions of their forest floors. In the intensive study, 4.422 encroachment traces were recorded, with a mean frequency per study site of 80 traces, each covering a mean of 25 to 50 percent of their quadrats.

The results of the intensive study indicated encroachment activities, and the behaviours that motivate them, are complex. Twenty-nine different types of encroachment traces were recorded, that appeared to be driven by five resident motives: 1) waste disposal, 2) yard extension, 3) garden plant extensions and 4) reactions to forest encroachment into residential yards, and 5) forest recreation. This suggests that municipal policies that seek to limit these activities must also be complex in order to address the different encroachment types, and the behaviours that motivate them.

All categories, except for forest recreation traces, demonstrated a significant bias to the forest border (Kruskal-Wallis, $P <.05$). Waste disposal traces were most common, occurring in 99% of intensive study sites. While this encroachment category did not cover as great a percentage of their sample areas (26 to 50%) as some of the other types, such as yard extensions, they occurred with greater frequency, and on average, further from the forest edge (at mean distances of 17 metres). They were the most evenly distributed within the forest edge relative to the other encroachment categories; however tended to be concentrated in the first 12 metres of the forest border. Field observations indicated that they smothered significant areas of forest understory vegetation.

Yard extension traces were recorded in 44 % of intensively studied sites. They occurred at a lower mean frequency per site than waste disposal traces; however, they covered a mean of 76 to 100% of their sample areas, Similar to waste disposal traces, they tended to be most intensive in the first 12 metres of the forest border, but did not extend as far into the forest edge. They had a mean maximum extent of 10 metres from the forest border. These results indicate that a significant amount of municipally owned land in many of the study municipalities is no longer forested, and is currently under private use.

Garden plant extension traces were recorded in approximately 25% of the sites, but at a relatively low mean frequency of three traces per site covering a mean of 26 to 50% of their quadrats. They made up only 3% of the encroachment traces recorded. However, this trace category still occurred at significant mean distances from the forest border, 14 metres. In some sites, particularly those with older adjacent housing, these traces occurred at high frequencies and intensities, covering large areas of the forest edge, up to maximum distances of 32 metres from the forest border. These results suggest that currently grown garden plants tend to spread relatively slowly into adjacent forest edges; however, given time some are capable of extending significant distances. Research in the control of exotic vegetation species within natural areas indicates that many of these plants are very costly and difficult to control once they become established over large areas (Hobbs et al., 1995). This indicates that municipalities should address garden vegetation expansions now, while these plants are still concentrated close to the residential border and can still be associated with individual properties.

Traces in reaction to forest encroachment were recorded in 12% of the study sites, and made up only 3% of encroachment traces recorded. The most frequently recorded type was the removal of the forest vegetation. They had a low mean frequency per site, but covered a relatively high percentage of the samples per trace (51 to 75%). They tended to concentrate in the first four metres, and were rarely the encroachment trace found furthest from the forest border. This trace category may have been under or over sampled. In some sites, particularly where the boundary type allowed access to the forest edge, it was difficult to distinguish this category of trace from garden extension traces. Research is required to confirm the existence of this category of encroachment, i.e. to determine whether residents respond to forest encroachment, and whether it provokes residential encroachment in the forest edge.

Forest recreation traces were recorded in 44% of the study sites. Although they had a low frequency per site, they covered 76 to 100% of the sampled area where they occurred. Unauthorized pathways were the most frequently recorded traces of this category, occurring in approximately 40 % of the study sites. Although they were not sampled in the extensive study, they were frequently observed to be the most extensive encroachment type. Many extended from residential borders deep into the forest edge where they met with the authorized pathway system, and still other unauthorized pathways. In addition to the impacts on the forest ecosystem that result from the creation of the trails; research indicates that increasing human access, through the provision of trails and roads, tends to significantly increase other types of encroachment within the accessed areas (Matlack, 1993). The results of Matlack's study, in addition to this research indicate that reducing edge resident access to the forest edge, and its recreation system, significantly reduces the intensity and extent of edge resident encroachment activities.

None of the policies or boundary types was effective in eliminating encroachment traces. Buffers between 10 and 20 metres would be required to segregate the mean maximum extents of encroachment activities from sensitive forest values, depending on the policy or boundary treatment.

However, sites with boundary policies had significantly lower mean frequencies and intensities of encroachment than sites without policies (Kolomogorov-Smirnov, $P < .05$). Although those with fencing policies did not have significantly lower mean frequencies and intensities of total encroachment than sites with no policy, or sites under a municipal post policy, they did have a significantly lower mean intensity of yard extension encroachment, and mean maximum extent of encroachment. In addition, traces in fenced sites tended to be distributed closer to the property boundary. However, these reductions were offset in these sites by significantly higher mean frequencies of waste disposal encroachment relative to both no policy and municipal post policy sites. While municipal post policy sites had significantly lower total mean frequencies and intensities of encroachment than sites with no policy, and a significantly lower total mean frequency of encroachment than sites under a fence policy, there were no significant reductions in any encroachment category, or in their mean maximum extent of encroachment, relative to no policy sites.

In terms of the relative effectiveness between the different boundary types, sites with no, or minimal, boundary demarcation, and sites with fences and gates, had higher mean frequencies and intensities of total encroachment, waste disposal and yard extension, and mean maximum extent of encroachment than most of the other boundary types. Conversely, sites with fences and grass strips (with or without pathways) tended to have lower levels. The encroachment levels of sites subject to fencing and municipal post policies tended to lie between these two extremes. These findings suggest that levels of residential encroachment respond to the degree to which edge residents are able to access the forest edge, and that fences (without gates), grass strips, and possibly paths, act as barriers to yard extension and, to a lesser extent, waste disposal types of encroachment.

Fences tended to significantly reduce the levels of yard extension encroachment. However, when residents eroded this barrier function through the installation of gates, yard extension encroachments significantly increased. If municipalities wish to maintain this function through time, fences require regular monitoring to ensure that residents do not install gates. Fences were, however, less effective in reducing waste disposal encroachment. While, some of relatively high mean frequency of encroachment may be due to over sampling of waste disposal traces, the sampled fences (ranging from 91 cm to 1.63 metres in height) may be too low to deter edge residents from dumping large amounts of waste into the forest edge. Grass strips, on the other hand, appeared to be barriers that are more effective in this regard, particularly when coupled with fences. Combined together, fences, grass strips and paths provided a more effective barrier to both types of encroachment. However, the contributions of grass strips and pathways, separately, or in relation to fences, for reducing total encroachment, or a category of encroachment are unknown.

The effects of the policies and other boundary types on forest recreation, reaction to forest encroachment and garden vegetation expansion categories of encroachment were less clear. Sites with fences and gates tended to have significantly higher levels of forest recreation encroachment than fenced sites, suggesting that gates increase access to the forest edge and therefore recreation encroachment. However, sites with fences, grass strips and paths also had significantly higher levels. Unauthorized pathways were the most common type of forest recreation encroachment, and were apparent not only in forest edges, but throughout many of the forests sampled. The ambiguous results may be due to the sampling of pathways created by other residents or recreationists. While, traces in reaction to forest encroachment tended to be less frequent and intense in sites with grass strips than those without, there were no statistically significant differences between boundary types for this category of encroachment. In terms of garden plant extension traces, there was some evidence to suggest that sites with grass strips had lower mean frequencies and intensities. Sites with fences and gates had significantly higher levels than sites with fences, gates, and grass strips (with and without pathways). Fences, however, were not effective barriers to this type of encroachment. Sites with fences did not have significantly different levels of this category of encroachment than sites without fences, or with fences and gates.

The next chapter integrates the results from the content analysis of official and secondary plans, municipal interviews, unobtrusive measurement of encroachment behaviour, and the literature review to determine whether the policies of the study municipalities for addressing residential encroachment are sufficient for protecting suburban forest ecosystems from edge-resident encroachment activities within study municipality forests..

Chapter 8

Evaluation of Municipal Policies for Limiting Edge-Resident Encroachment

Chapter 8 evaluates the municipal policies for limiting edge resident encroachment activities by integrating the results from the literature review, the content analysis of municipal official and secondary plans, the interviews with municipal staff and the sampling of behavioural traces left by edge-residents in the forest edge.

Section 8.1 evaluates the municipal policies from three points of view according to Weale (1992). Weale suggests that policy evaluation should answer two primary questions: 1) are the policies sufficient to meet the scope of the problem; and 2) when implemented, do they meet the policy goals (or their intent), solve or adequately reduce the problem (Weale, 1992). Section 8.1.1 evaluates the policies in terms of whether they are sufficient to meet the problem presented by encroachment. It will evaluate the extent to which policies have been developed and implemented. Section 8.1.2 evaluates the extent to which the implemented policies have been effective in eliminating or reducing edge-resident encroachment activities. Section 8.2 concludes the evaluation of municipal encroachment policies.

8.1 Evaluation

8.1.1 Are Municipal Policies Sufficient to Meet the Scope of the Encroachment Problem?

The results of the content analysis, interviews and forest edge sampling indicate that municipal policies are not currently sufficient to address the encroachment problem, but they are evolving in the right direction. Many of the study municipalities have developed corporately approved policies within the last 5 to 10 years for preventing or minimizing residential encroachment within natural areas adjacent to newly developing subdivisions. Interviews indicated that the study municipalities now regularly implement these policies. In addition, over this same period, many of the municipalities developed or refined their policies or bylaws to improve their effectiveness for resolving existing encroachments. However, the vast majority of municipal natural areas are adjacent to subdivisions that were developed prior to the development of these policies. To prevent encroachment within these areas, many of the municipalities have informally developed departmental procedures or practices, but interviews and the field studies indicated that they have rarely been implemented. Within these natural areas, the municipalities sometimes focused on resolving the encroachments that have occurred over the last 60 years through the enforcement of their improved policies and bylaws. However, the interviews and encroachment trace sampling results indicated that this approach has had limited effectiveness in addressing or preventing encroachments because it is irregularly implemented, and it does not prevent encroachment re-occurrence, either by the same or future residents.

Both the literature review and the content analysis indicated that while many effective provincial, regional and municipal planning policies evolved to protect natural areas from being replaced by housing, and from construction impacts, very few have been developed to protect natural areas from adjacent land uses following development. While the primary goal of provincial, and regional and municipal official and secondary plans was to protect these areas for the long term, few developed policies requiring monitoring following development to ensure that this was occurring, particularly at the scale of the natural area. This indicates that municipal, regional and provincial governments do not yet attribute much significance to the impacts of surrounding land uses on adjacent natural areas and systems, nor to their ecosystem functions in support of these systems. The planning literature supports these findings, indicating that most Ontario municipal policies in 1999 focused on preserving and regulating development within natural areas, with little focus on regulating adjacent land use impacts or monitoring and evaluating natural areas post development (Best Policies Working Group, 1999).

The interviewed planners also indicated that they did not focus on protecting natural areas from post development impacts. While many indicated that they had developed some preventative policies for protecting newly developing natural areas from residential encroachment, most within the last 5 to 10 years, they also indicated that developing these policies was not a significant planning concern. They suggested that developers provided the resources to protect these areas from development-related impacts, but planners could not negotiate mechanisms to protect post development values because developers were not responsible for the impacts that occurred following development:

> Part of the EIS is supposed to be the impact on the natural heritage feature from the land use proposed. When we talk about impacts it's really how many of the trees are going to be lost. Is an appropriate buffer being established? Is the storm water being dealt with properly? The thing to remember about an EIS document is that we're looking at it from what do we force the developer to do? That's why you get into the whole construction thing. What you're talking about (*protecting natural areas from encroachment*) is after the fact, how do we maintain it? (DP2)

None of these interviewees, nor their policies, had goals, objectives or strategies for addressing residential encroachment. For example, while most of the municipalities had a corporately approved boundary demarcation policy; there was no mention in these policies of their purpose for addressing residential encroachment. Nevertheless, the content analysis and the interviews indicated that the planning focus was shifting. Provincial policies were beginning to place greater emphasis on the role played by adjacent lands. Policy 2.1.6 of the PPS (2005) requires the evaluation of the ecological functions of adjacent lands prior to their development and site alteration. In addition, the water policies of this provincial policy statement require that municipalities maintain the linkages and functions between hydrological system components and natural heritage features. They also require that municipal and regional governments promote sustainable water use among residents and best management practices for storm water management design within adjacent lands. The content analysis also indicated that regional and, particularly, municipal governments were increasing their planning focus on adjacent lands and post development impacts. For example, within some municipal official and secondary plans, developers are required to consider recreation and adjacent resident impacts. In addition, areas adjacent to natural areas are beginning to be zoned for complementary land uses that are supportive to natural area ecosystem functions. The Region of Peel now requires its local municipalities to develop policies for the 'proper management' of their natural areas. All of these policies indicate the increased emphasis placed on planning for post-development ecosystem functions.

Unfortunately, most natural areas within a majority of these municipalities were developed prior to the establishment of these emerging protective planning policies. In addition, interviews with forestry and parks operation staff indicated that both protective policies and those designed to resolve existing encroachment, have only been developed in the last 5 to 10 years. While four of the six municipalities indicated that they either had not developed protective policies, or had established them informally as departmental procedures or practices, all the interviewees indicated that their preventative policies were infrequently implemented. Furthermore, while many said their policies and bylaws to resolve existing encroachments were effective, or more effective than they were 5 to 10 years ago, they said these policies and bylaws were also infrequently implemented. Some of the forestry staff, particularly in Kitchener and Mississauga, were concerned that few existing encroachments had been resolved relative to the number existing. These interviewees had conducted encroachment surveys within their forested natural areas within the last 10 years and were aware of the large percentage of edge residents encroaching. The results of the unobtrusive measurement of encroachment traces within the study forest edges of these municipalities provided evidence to support their concerns. It indicated that 70% of the sites sampled were without a boundary demarcation policy, and that despite high intensities and extents of encroachment within many of these sites, the municipalities had approached only 6% of study site residents regarding their encroachments.

Interviewees indicated that for many years, parks operation staff has focused on maintaining the facilities of their parks designed for active recreation. Once the municipalities had acquired forests from developers, parks operation staff generally left them to "evolve naturally," according to the widespread belief that this management approach was most beneficial for the forest. This lack of active forest management was reflected in the results of the content analysis and the interviews that revealed a general lack of official, secondary and corporate policies for managing municipal forests. Within the interviews, it was difficult to determine forest management policies or their status and implementation. Most were procedures or practices and were limited to the removal of waste from receptacles, trail management, and the periodic monitoring for hazards, including those related to encroachments. One of the results of this approach is the large number of encroachments within municipal forests; however other, perhaps more serious, results include magnified silvicultural problems. Some of the foresters argued that planners have shared the belief that natural areas require little management, or have not sufficiently considered their post development management during the planning process. As a result, they said that some acquired natural areas have had very high management requirements, or questionable ecological or social value:

> There is a big argument being made, not just for significant natural areas, but others, that there has to be greater consideration given to the cost of maintaining them, the park infrastructure, rather than planning occurring in isolation. It's a huge management nightmare (FM3).

While some of the foresters said they no longer adhered to this passive management approach for many of their natural areas, and wished to reduce the number of encroachments occurring, few had explicit goals, objectives or strategies for doing so. Similar to the planners, they were uncertain of their municipal goals for addressing encroachment. Many of the foresters or parks operation staff indicated they did not have the resources to manage actively their natural areas, and some were lobbying their municipalities to increase awareness of the need to manage these areas more actively. However, foresters within two of the municipalities commented that they were uncertain whether encroachment was a primary concern within some of their natural areas. They said they were just beginning to identify their social and ecological values, and to define management goals, objectives and strategies. They both commented, however, that their silvicultural issues, such as the overcrowding of trees, and addressing tree diseases, were management priorities, arguing that their ecological effects were greater than the effects of encroachment.

Many of the interviewees indicated that both reducing encroachment through the installation of municipal boundary demarcation treatments, and resolving it through the enforcement of their policies or bylaws were contentious and resource intensive. Others said they avoided managing the residential edge because edge residents objected to, and impeded their attempts to manage these areas, particularly where it meant the removal of trees or undesirable exotic species. Because of these difficulties, most of the interviewees indicated they only resolved encroachments when they had to, i.e. when another resident complained. Most said that when they did install boundary demarcation treatments, they were generally limited to municipal posts because this treatment evoked the least resistance from residents.

Mississauga was the only municipality attempting to implement boundary demarcation policy proactively within its natural areas adjacent to established subdivisions. These policies were supported by the only municipal official plan policy to make a commitment to regulating encroachment. However, forestry department interviewees indicated that it was a very time consuming and resource intensive process, fraught with conflict and politics. Since the passage of their fencing policy in 1999, and their new encroachment bylaw in 2003, Mississauga has been able to resolve encroachments and fence only a small number of their natural areas. More recently, they have been successful in implementing these policies while addressing a silvicultural crisis within some of their natural areas. They found that resident compliance to these policies was easier to obtain when they could link compliance with forest health. This experience indicates that while Mississauga is moving in the right direction (combining the resolution of encroachment with its prevention); insufficient policy focus has been given to involving residents who live adjacent to the edge, and particularly those who do not. Forestry staff within four out of six of the municipalities indicated that educating and encouraging stewardship among residents was of primary importance for minimizing encroachment in the long term; however, official plan and corporate policies were again lacking. While some of the interviewees said that they had departmental procedures or practices in this area, they said they were unsure of their effectiveness and only implemented in response to existing encroachments.

8.1.2 Are Implemented Policies Effective for Eliminating and Minimizing Encroachment?

This section evaluates the degree to which the implemented policies are effective in meeting the intent of municipal encroachment policies. While none of the municipalities, or departments had explicit encroachment goals, the interviewees indicated their implicit municipal goal was to eliminate encroachment. However, many indicated their personal goal, or that of their department, was to minimize encroachment. The following evaluation will consider the degree to which the policies have met both these policy intents. The focus of this evaluation is on the effectiveness of implemented boundary fencing and municipal boundary post policies.

The results of the unobtrusive measurement of encroachment activities indicated that fence policies were not effective in eliminating encroachment activities. Encroachment traces were recorded in 98 % and 99% of intensively and extensively sampled sites, respectively. Waste disposal encroachment was particularly frequent and intensive, especially in the first 4 to 6 metres of the property boundary. The mean maximum extent of encroachment was 13 metres, and the maximum distance of encroachment recorded was 39 metres. To segregate 95% of these impacts from sensitive forest ecosystems, a buffer of 29 metres would still be required, in addition to the fence. Among the commonly negotiated buffer widths mentioned by interviewees for segregating residential encroachment activities, only the buffer width for cold-water streams of 30 metres would be of effective in performing this role.

A fence policy significantly reduced some encroachment levels relative to sites with no boundary demarcation policy. They were effective in significantly reducing the mean frequency and intensity of yard extension traces relative to sites with no policy (Kolomogorov-Smirnov, $Z = 1.617$, $P = .011$; $Z = 1.814$, $P = .003$, respectively).This is important achievement of the policy since many interviewees said that they were most concerned about yard extension encroachments relative to other encroachment categories. However, these reductions in yard extension encroachment may be eroded where lack of sufficient municipal monitoring has allowed residents to maintain illegal gates within municipal fences. A fence policy is also effective in significantly reducing the mean maximum extent of encroachment relative to sites with no policy (Kolomogorov-Smirnov, $Z = 1.898$, $P = .001$). This policy resulted in an approximately 20% reduction in mean maximum extent, from a mean of 16 metres for sites with no policy to a mean of 13 metres for sites with a fence policy. However, a fence policy did not significantly reduce the mean frequency and mean intensity of all encroachment traces relative to sites with no municipal policy (Kolomogorov-Smirnov, $P > .05$). The lower frequencies and intensities of yard encroachment traces were offset by significantly higher levels of waste disposal.

A fence policy was also not effective in minimizing the frequency or intensity of all encroachment traces relative to a municipal post policy. Municipal post policies had significantly lower mean frequencies (not intensities) of encroachment than fence policies (Kolomogorov-Smirnov, $Z = 1.725$, $P = .005$). This was due to a significantly higher mean frequency (not intensity) of waste disposal encroachment within sites under a fencing policy (Kolomogorov-Smirnov, $Z = 1.898$, $P = .001$). Nevertheless, fenced sites had significantly lower mean intensities of yard extension encroachment (Kolomogorov-Smirnov, $Z = 1.380$, $P = .044$). Although municipal post sites tended to have higher mean maximum extents of encroachment than sites with fences, the differences were not significant (Kolomogorov-Smirnov, $P > .05$).These results should be viewed with some caution. Municipal post sites enabled edge residents ready access to the forest edge, as did other boundary types, such as no, or minimal boundary demarcation; and fence with gate. However, sites with these latter boundary types had significantly higher mean frequencies, intensities and extents of encroachment than sites with a fencing policy, and those with many other boundary types. In addition, fenced sites may have been over-sampled in terms of waste disposal traces (See Chapter 7, page 128).

A fence policy was also not effective in minimizing the mean frequency, intensity of encroachment activities occurred relative to the other boundary types. Fenced sites had a significantly higher mean frequency than sites with fences, gates, grass strips and paths, and a significantly higher frequency and intensity of encroachment than sites with fences and grass strips (with and without paths) (Kolomogorov-Smirnov, $P < .05$). The latter results were not affected by whether the fences in the fenced sites with grass strips and paths were the result of a municipal fencing policy, or were installed by residents (Kolomogorov-Smirnov, $Z = .833$, $P = .491$; $Z = 1.052$, $P = .218$). In terms of differences in the categories of encroachment, fenced sites had significantly higher frequencies and intensities of waste disposal encroachment than sites with grass strips and paths, and sites with fences and grass strips (with and without pathways). These results indicate that more effective boundary demarcation policies are available to reduce, further, frequencies and intensities of encroachment, particularly those of waste disposal encroachment. Boundary demarcation policies (and other policies, such as resident education) need to be more complex to address the different categories of encroachment.

Municipal post policies are also not effective in eliminating encroachment activities. Encroachment traces were recorded in 92% and 100% of intensively and extensively sampled sites, respectively. Traces from waste disposal, yard extension, forest recreation and garden vegetation expansion categories were present; however, traces in reaction to forest encroachment were not recorded. The mean maximum extent of encroachment was 20 metres, and the maximum distance of encroachment recorded was 49 metres from the forest border. To segregate 95% of these traces from sensitive forest ecosystems would require a buffer of 37 metres, in addition to the municipal post. None of the commonly negotiated buffer widths mentioned by interviewees for limiting residential encroachment is of sufficient width to function in this capacity.

A municipal post policy significantly reduced the mean frequency and intensity of all encroachment traces relative to those of no policy (Kolomogorov-Smirnov, $Z = 1.830$, $P = .002$; $Z = 1.611$, $P = .011$, respectively). However, no individual category of encroachment was significantly reduced in municipal post sites relative to sites not subject to a municipal policy (Kolomogorov-Smirnov, $P > .05$). In addition, there was no significant difference in the mean maximum distance of encroachment between sites with municipal posts and those not subject to a municipal boundary demarcation policy (Kolomogorov-Smirnov, $Z = .773$, $P = .589$).

Kolomogorov-Smirnov tests indicated that a municipal post policy resulted in a significantly lower mean frequency of all encroachment traces than sites under a fencing policy, resulting largely from lower mean frequencies of waste disposal. However, there was no significant difference is mean maximum extent between the two policies.

Other boundary types led to lower mean frequencies, and intensities of encroachment than municipal posts. Sites with fences and grass strips had lower mean intensities of total encroachment than sites with municipal posts (Kolomogorov-Smirnov, $Z = 1.420$, $P = .035$). In addition, in terms of individual categories, sites with fences, gates, grass strips and paths; and those with fences, grass strips and paths, had significantly lower mean frequencies and intensities of yard extension encroachment than sites with municipal posts (Kolomogorov-Smirnov, $P < .05$).

The interviews indicated that the different departments (and sometimes employees in the same department) had different boundary policies for addressing residential encroachment, and for achieving other goals related to mitigating construction encroachment, or providing recreation. While planners often spoke of property line demarcation (and in a few cases, buffers), park planners indicated that positioning access points, and establishing trails and active recreation areas between residential boundaries and forest edges might deter encroachment activities. In addition, some forest managers indicated that they had management practices of removing strips of vegetation immediately adjacent to residential property boundaries, in response to resident complaints of forest vegetation encroachment. This indicates that planners and forest managers have still not integrated their disparate boundary treatments into cohesive boundary treatments in order to address the different types of encroachment. As a result, current boundary demarcation policies to address post development impacts are simplistic contrary to those established by planners to protect forest borders during the development process. Planners indicated that these latter boundary treatments might involve increasing housing setbacks or yard depths, reducing the limits of development, buffers, temporary construction fencing installed repeatedly to control different impacts during the construction process, and multiple site inspections. Planners are not currently planning post development boundaries at the same level of spatial and temporal complexity. In addition, many are not coordinating their pre and post development boundary treatments in order to protect their forest edges through time, even though many planners indicated that pre-development construction-related encroachments often led to post development residential encroachment.

Interviewees suggested that the implicit strategy of boundary demarcation policies is to establish a physical or psychological filter to reduce access to the forest edge and therefore, encroachment frequency. A focus on the boundary for protecting natural areas is supported in the literature that indicates that the filtering properties of the boundary strongly influence natural area protection (Schonewald-Cox et al., 1986; Schonewald-Cox, 1988). However, the results of the sampling of encroachment traces indicate that thicker more complex boundaries are likely to be more effective in limiting the different types of encroachment. For example, while fences appear to be effective in significantly reducing yard extensions, and the mean maximum extent of encroachment, grass strips and possibly paths are more effective in reducing the frequency and intensity of waste disposal traces.

The sampling of encroachment traces also indicated that no boundary demarcation type, even the most complex type, was effective in eliminating encroachment within these forest edges. Therefore, additional strategies that reduce the area of encroachment through spatial segregation (buffers) and that encourage more supportive adjacent land uses are required to limit residential encroachment still further. This approach to natural area protection is also supported by the literature that suggests that strategies that reduce the area of encroachment are likely to lead to lower human activity impacts than those that seek to limit the intensity of encroachment (e.g. its frequency, type or how it occurs) (Cole, 1993). Two of the environmental planners indicated that their primary policy for addressing encroachment was their buffer policy, while others indicated that they specified buffers to protect their natural areas from development impacts. The widths of these buffers, however, need to be coordinated with the boundary demarcation treatment in order to segregate these activities from sensitive forest edges. For example, while buffers for cold water streams would be wide enough to segregate 95% of the encroachment traces under Cambridge's fencing practice, it is unlikely to be effective for segregating encroachment activities within Waterloo's forest edges that have a "'living fence" boundary demarcation policy. This latter boundary treatment allows ready access to the forest edge, particularly when first established. Interviewees within both Guelph and Waterloo indicated that it had limited effectiveness for reducing residential encroachment. Based on the width of buffer required to segregate 95% of encroachment traces within sites with fences with gates, a width of approximately 37 metres would be required.

Ultimately, to determine the most effective approach for protecting these natural areas, whether it is through spatial and temporally complex boundary policies, resident or municipal surveillance of the forest edge, resident education and stewardship programs, and/or bylaw enforcement, depends on natural area features, functions, and community values. Many interviewees suggested that they were unsure whether their policies were effective because they did no know what values they wanted to protect within their natural areas. The results of this research indicate that even under very wide complex boundary filters that combine barriers, spatial separation and community surveillance, residential encroachment activities still occur within the forest edge. Placing housing and large human populations adjacent to sensitive forest ecosystems will lead to both positive and negative interaction between these two ecosystems. Significant ecological and social effects can be expected to occur on both sides of the boundary. Municipalities need to determine acceptable types and levels of edge resident encroachment depending on forest ecosystem values and functions. While some types and levels of encroachment may be undesirable, others may not be. For example, Waterloo's Partners in Parks program encourages residents to become involved in some types of encroachment, such as establishing planting beds within parkland, and performing management-related activities. However, interviewees within most of the study municipalities indicated that plans that describe the characteristics, values, goals, objectives and strategies for managing most municipal natural areas are missing. Nevertheless, many foresters indicated that they are beginning to prepare individualized management plans for some of their natural areas. Prepared in concert with surrounding communities, and particularly with edge residents, these plans have the potential to lead to more effective encroachment policies that residents in the community can help to implement.

8.2 Conclusions

The purpose of this research was to describe and evaluate the municipal policies for limiting edge-resident encroachment activities with municipal forest edges. Using a mixed method research design, these policies were evaluated based on whether they were sufficient to meet the problem presented by encroachment, the extent to which they have been implemented, and whether they are effective in meeting the intent of their municipal policies when implemented. A formal evaluation of municipal policies for protecting natural areas post development, and more specifically for addressing edge-resident encroachment activities, had been missing in municipal natural area research. Little was known about municipal policies for protecting natural areas in the post development period, or for addressing encroachment activities. In addition, little was known about the characteristics of edge resident encroachment activities, or about how municipal policies influence them.

The research concludes that current municipal policies are insufficient to meet the complexity and scope of the encroachment problem, but they are evolving in the right direction. Preventative policies have been developed and are regularly implemented within natural areas adjacent to new subdivisions. However, few municipalities have established formal preventative policies for natural areas adjacent to established subdivisions, where the bulk of the encroachments are located. In addition, all the municipalities are infrequently implementing these policies. In addition, policies to address existing encroachments rely on encroachment policy and bylaw enforcement procedures that are highly contentious, resource intensive and are infrequently implemented. Implemented policies to prevent encroachment within both new and existing subdivisions rely on simple boundary demarcation policies that do not eliminate, or minimize residential encroachment relative to other boundary types. Wider more complex boundary policies that include elements that reduce access, spatially separate, reduce forest encroachment into housing areas, and encourage informal residential surveillance (such as fences, grass strips and pathways) can further reduce encroachment levels. However, even these boundary treatments will not eliminate encroachment. Municipalities need to more frequently implement their bylaws and policies to remove existing encroachments. In addition, other policies are required to address the complexity of this problem, such as alternative adjacent land uses, and particularly, resident education and stewardship. These latter policies are particularly important to address forest-recreation, waste disposal encroachment, garden plant extensions and many of the indirect forms of encroachment (such as cat predation on sensitive forest birds) that are not significantly reduced through boundary demarcation policies. Table 9.1 summarizes this evaluation. The next chapter discusses the implications of this research for municipal planning and management of forested natural areas and makes recommendations for future research.

Table 8.1 Summary of evaluation of municipal edge resident encroachment policies

Steps	Methods	Key Results
Describe boundary planning and Ontario municipal planning theory and practice for protecting suburban natural systems from adjacent land use impacts	Literature review (Objective 1, Chapters 3,4	• Many ecological/social effects of human activities associated with housing • Impacts determined by intensity and areal extent of encroachment activities • Encroachment activities extend 70 metres from forest border, most within 30 metres • Ontario policies focus on limiting effects of development, not post development; and natural area features/functions, not adjacent ecosystems Few monitoring policies
Describe municipal concerns, goals, strategies and policies for addressing edge resident encroachment and determine level of implementation within selected municipalities in Southern Ontario.	Content analysis; Social Surveying (Objective 2, Chapter 5,6)	• Not recognized in upper policy levels as significant • Recognized as significant in lower policy levels, however forestry staff more concerned with silvicultural issues, or construction-related impacts. • No explicit encroachment goals, objectives or strategies • Implicit municipal goal to eliminate encroachment • Implicit departmental goal to minimize encroachment • Main implicit strategy to reduce frequency (reduce intensity) of encroachment • One municipality has official plan policy to regulate 'public encroachment' • Different departments different boundary policies implemented at different points in forest/house relationship • Most preventative policies focus on natural areas adjacent to newly developing subdivisions; focus on boundary demarcation/signs/some resident education • Remedial bylaws/policies focus on removing "unacceptable" encroachments • Most preventative boundary demarcation policies frequently implemented adjacent to newly developing subdivisions, but infrequently adjacent to established subdivisions • Remedial policies infrequently implemented in response to resident complaints
Determine if residential encroachment is occurring within municipal forest edges; and describe it under two different municipal boundary demarcation policies and other boundary demarcation types.	Unobtrusive measurement of encroachment traces (Objective 3; Chapter 7)	• Residential encroachment apparent in majority of sites/ under all boundary types • Encroachment intense particularly within first 8 metres • Mean maximum extent of encroachment 16 metres from forest border • Most encroachment composed of waste disposal and yard extension types • Encroachment varies by policy and boundary treatment • Fence boundary types reduce yard extension traces, concentrate waste disposal closer to forest border/ reduces extent of encroachment from the forest border, but increases waste disposal • Boundary types with fewer physical barriers lead to increased encroachment • Boundary types with multiple barriers tend to lead to decreased encroachment • No treatment effective in eliminating encroachment, or significantly reducing forest recreation, reaction of forest encroachment, plant vegetation extensions, or indirect forms of encroachment

Determine whether study municipality encroachment policies are sufficient for protecting suburban forests from edge resident encroachment activities.	Integrate results of literature review, content analysis, social surveys, and unobtrusive measurement of encroachment traces (Objective 4, Chapter 8)	• Current policies insufficient to meet the complexity and scope of encroachment problem:
		  ◦ Preventative policies regularly implemented in forests adjacent to new housing, however
		  ◦ Few preventive policies, and not implemented in forests with existing subdivisions
		  ◦ Remedial policies and bylaws contentious, resource intensive and rarely implemented
		  ◦ Implemented preventative policies no not eliminate encroachment, or minimize it relative to other boundary types

Chapter 9

Implications for Municipal Planning for the Protection of Suburban Residential Ecosystems from Adjacent Land Use Impacts

This chapter summarizes the key findings of this research in terms of its implications for the substantive and procedural theory and practice of planning for the protection of suburban residential ecosystems from adjacent land use impacts. Section 9.1and 9.2 discuss the implications of this research for the theory and practice of planning for the protection of housing/forest ecosystems from adjacent land use impacts. Section 9.3 provides recommendations for future research.

9.1 Implications for the Theory of Planning

9.1.1 Activities and Effects of Adjacent Residents on Suburban Forest Ecosystems

9.1.1.1 The Extent of Residential Encroachment in the Forest Edge

Matlack's research indicated that human activities and their effects associated with adjacent residential land uses are edge impacts, with 95% of the evidence of these activities extending approximately 70 metres into suburban forest edges without internal roads (Matlack, 1993). My research indicates that the "sociological edge effects" identified by Matlack may in fact be limited to edge- resident encroachment activities, which are unrelated to many of the recreation-related evidence of human activity recorded by Matlack.

While the distribution of yard-related encroachments was significantly biased to the forest edge, that of recreation-related encroachment was not significantly different from a random distribution. In fact, Matlack found a similar result. Although the distribution of his whole data set (including yard and recreation-related evidence) was significantly biased to the forest edge, only the yard-related activities actually exhibited this bias. The distribution of recreation-related evidence in his study forests was not significantly different from a random distribution (Matlack, 1993, p. 831). Matlack's study forests were between 0.7 and ca. 20 ha in size and my study forests ranged between approximately 1 and 50 ha in size. The forests in both studies had widths up to 300 metres. These findings suggest that recreation-related activities are not edge-related impacts within suburban forests of this size range. However, these findings do not reduce the distance in which human activity impacts occur relative to that indicated by Matlack. Rather, they suggest that those associated specifically with edge housing occur in the first 35 metres.

According to Matlack, the forest/housing boundaries in his study did not have fences or any other kind of 'natural' filter, such as wetlands or topography that might limit or influence human activities (Matlack, 1993, p. 830). Adjacent housing edges had to have at least ten detached houses within 100 metres of the forest border; however the Matlack's range of housing densities, their configurations, or their exact proximity to the forest border are unclear (Matlack, 1993). My research captured the edge activity patterns of suburban housing and forests typical of Suburbs within Southern Ontario built in the last approximately 60 years. Housing was detached or semi-detached, contiguous, with a density of 5 to 19 gross units/ha, and located directly adjacent to forest/housing borders. Forest fragments were approximately 1 to 50 ha in area and up to 300 metres wide. Under these conditions, I found that 95% of the evidence of encroachment related to housing/ forest boundaries without fences or other significant impediments was within 37 metres of the property line. However, many housing/forest boundaries had property line demarcation such as a fence, fence with gates, grass strips, or a combination of these filters. My research indicated that when municipalities do not have a property line demarcation policy, residents frequently implement their own. Therefore, a more likely distance of resident activities where there is no municipal policy would be that associated with a mixture of property line demarcation types. For all property line demarcation types in this study, 95% of the evidence of encroachment activities was within approximately 35 metres of the property line.

Contrary to Matlack, I distinguished encroachment related to edge residents from that associated with the wider community. I recorded only the types of evidence that could be clearly associated with adjacent resident activities. For example, individual pieces of consumer waste were not recorded since in many of the forests waste was apparent throughout the forest. Other types of community-related encroachment were avoided by careful site selection (see Chapter 1, Section 1.4.1).

9.1.1.2 The Intensity of Residential Encroachment in the Forest Edge

In this research, I provide information on the types of encroachment occurring, and categorize these types according to encroachment behaviour. In doing so, this research advances a normative theory of encroachment behaviour. These categories were developed from observations of the types of encroachment occurring together with their patterns in the forest edge in relation to housing edge patterns. These insights into encroachment behaviours were combined with information gathered from interviewees and casual conversations with residents to develop hypotheses regarding encroachment motivations. Five encroachment motivations were identified: 1) a need to dispose of waste, 2) a need to expand their yards or gardens, 3) a need to beautify or tidy forest views, 4) a need to recreate in the forest, and 5) a need to prevent the forest, or its components (such as vegetation or wildlife) from entering into their yards.

This research advances the theory regarding the intensity of encroachment activities within suburban forest edges. According to Cole (2003), the intensity of impact of a recreational activity within a forest is determined by the type of activity, the frequency with which it occurs, how it occurs (how different individuals perform the activity), where it occurs (type or area of the ecosystem) and when it occurs (season). To get an indication of the intensity of encroachment occurring, I calculated the mean frequency and the percentage of the sample area covered by each encroachment type, and category of encroachment behaviour. The percentage cover area was recorded according to a numeric code according to the Braun-Blanquette (1932) cover scale. This allows the calculation of mean intensity by multiplying the mean frequency by the mean intensity for each type of encroachment and for all encroachments. Planners can use this indicator of encroachment, together with information concerning the vulnerability of forest ecosystems (or areas within the forest ecosystem) and sensitive times of the year within the ecosystem, to get an idea of the intensity of encroachment that is likely to occur when considering or designing a housing development adjacent to a forest ecosystem. The method allows sampling to occur in exactly the same area of the forest edge. This means that the method can be used to determine whether residential encroachment is occurring pre and post development, whether it is occurring in the same site or forest edge through time, or whether it is occurring under different natural (e.g. closed prickly forest edges or steep slopes) or sociological filters (e.g. buffers or property line demarcation).

9.1.1.3 The Total Impact of Residential Encroachment in the Forest Edge

Determining the total impact of a variety of small, but frequent and cumulative forest edge impacts is difficult. It may require many different long-term studies (Murphy, 2006). Planners and managers cannot afford to wait for these studies, yet they need some way of evaluating these impacts so they can distribute resources and evaluate policies. This research provides a method for indicating the total impact of encroachment in general and by type based on recreation ecology theory that asserts that total impact of recreation-related activities are a product of the area and intensity of impact (Cole, 2003). Planners can combine information regarding the extent of encroachment and its intensity with information about the season and ecosystem in which the encroachment occurs to get an indication of the total impact of encroachment occurring, or likely to occur within different forest ecosystems or forest edges.

9.1.2 Structural and Functional Roles of Housing/Forest Boundaries

9.1.2.1 Human Activity Flows and Generated Edges within Suburban Forests

The sampling of edge resident activities indicated that different activities, and flows, are crossing the forest/housing border into the forest edge creating multiple generated edges within the forest edge. When categorized according to encroachment motivation or behaviour, these types produce five generated edges. They include a waste disposal edge, a yard extension edge, a garden plant extension edge, a reaction to forest encroachment edge. Less evidence exists for the generation of an edge resident recreation-related encroachment edge. These edge resident generated edges may be embedded inside a still larger edge generated by community recreation- encroachment within larger and wider forests; however, this latter theory requires empirical testing. These findings advance the theory of forest/housing boundaries, and are consistent, in principal, with boundary theory that indicates that boundaries exist at different spatial and temporal scales (Forman, 1995).

The unobtrusive measurement of encroachment indicated that encroachment behaviour affects the structure of the forest edge differently, irrespective of property line demarcation filters. For example, under all property line demarcation filters, waste disposal encroachment tends to leave nodal structures within the forest edge. Garden plant extensions, on the other hand, tend to vary with the vector that is moving the garden plants into the forest edge. Those that extend into the forest edge through vegetative reproduction tend to create coves within the forest edge. Those planted by residents, or spread after being dumped by residents as waste, tend to generate nodal patterns in the forest edge, although they become coves through time as the plants spread. Yard extensions tend to leave linear areas that run parallel to property boundaries. One or all these encroachment edges may occur, and overlap, within housing/forest borders and forest edges, leading to changes in forest edge structure. For example, yard extensions may remove the forest veil, mantel and saum (See Chapter 3, Section 3.4 for definitions of edge vegetation structure and boundary patterns).

Boundary theory currently argues that human activities tend to create straight borders with abrupt changes in conditions between adjacent ecosystems (Klee, 1964; Forman, 1995). The results of this research; however, indicate that while straight borders with high contrast may be created by humans at the time of development, these borders and forest edges tend to become more curvilinear with time. Boundary theory indicates that curvilinear boundaries tend to lead to more vertebrates, plant species exchanges, and their greater penetration into the adjacent ecosystem boundaries (Chasco & Gates, 1982; Forman et al., 1992; Stamps et al., 1987). This theory is based on curvilinear boundaries that are generated by vegetation rather than human activities. The mantel of the forest provides the necessary cover and food to support the high populations of bird and game species noted in the young edges of more remote forests (known as the edge effect) (Forman, 1995; O'Meara et al., 1981). However, many of the sites sampled did not have any, or had very little, veil, mantel or saum due to encroachment activities (particularly where there were no border fences or parallel grass strips and paths), or because of the position of the property line in relation to tree architecture (see Chapter 3, Section 3.4). This indicates that despite the creation of curvilinear borders through encroachment activities, the loss of vertical vegetation complexity means that the habitat values of these borders and edges for birds and other vertebrate animals is likely to decrease in relation to a more vertically complex pre-development border. In addition, these simplified border vegetation structures are likely to increase or maintain other negative generated edges, such as microclimatic edges within these forests (Forman, 1995).

At the same time, either residents or municipal mowing regimes often maintain the steep gradients of horizontal change between the two ecosystem structures and functions within housing/forest boundaries. Studies indicate that abrupt boundaries tend to decrease the flow of vertebrate and plant species relative to more gradual boundaries (Chasco et al., 1982; Forman et al., 1992; Stamps et al., 1987). Others indicate that the flows of human activities tend to increase where there is a high degree of contrast between the levels of protection afforded adjacent ecosystems (Schonewald-Cox, 1988). Schonewald-Cox argues that human activity flows from the area that is less protected will degrade the more protected area unless protective mechanisms are enforced. In terms of housing/forest boundaries, this theory means that if a forest edge (or forest buffer) receives little or no protection from adjacent encroachment activities, then the interior of the forest (or the designated natural area in the case of the buffer) can be expected to become degraded like the forest edge or the buffer. On the other hand, if one applied this theory to the housing side of the boundary, identifying the housing edge as the area receiving the high level of protection (by residents), and the forest edge as the less protected area, then the degrading flows move in the opposite direction. The housing edge is more likely to become degraded by flows from the forest, unless the residents enforce protective mechanisms. One can then appreciate the high level of maintenance that residents perform to protect their edges from what they view as degrading flows from the forest edge. In this case, the contrasting protection gradient appears to generate a counter flow where the less protected ecosystem (the forest edge) changes toward the condition of the more protected ecosystem (the housing edge). Boundary theory frequently only considers adjacent land use flows on one of the ecosystem edges within the boundary. This research demonstrates that it is important to consider boundary flows in both directions between land uses, particularly when one of the land uses consists of large and dense populations of humans.

All encroachment edges tend to push the forest/housing border defined by the forest veil, mantel and saum further into the forest edge relative to where it was at the time of construction. On the other hand, the forest/housing border defined by the forest canopy may remain in the location it was at the time of development, or may extend further into the forest edge as the edge trees grow. Interviewees and site observations revealed that many players might be involved with pushing the housing/forest border back into the forest edge through time. During construction, part of the forest edge may be removed to allow for the building of homes. Construction encroachment (e.g. when a machine adherently or inadvertently removes edge vegetation beyond the limit of development) may push the housing/forest border back still further. A resident then may subsequently move into a home and push the border back still further through yard extension encroachment (See Figure C.17 for an example of this pattern). However, sometimes the housing/forest border is located inside the housing side of the property line (i.e. the external area of the forest edge is within a resident's yard). Sites with this pattern were sampled, however within almost all of them the forest veil, mantel and saum had been removed by residents (or by builders) within residential yards, leaving only large trees, and their canopies in tact. Nevertheless, there were a few sites where these forest vegetation structures had been retained within residential yards (See Figure 7.11). Their forest edge canopies were closed and they were facing north. This may have led to shaded yard conditions less suitable to lawn grasses and sun-loving flowers.

Results from the field study, interviews with residents and casual conversations with site residents all indicated that forest edge components were also flowing across housing/forest borders into housing edges. For example, interviews with forest managers and informal conversations with site residents indicated that some forest or grass strip vegetation was migrating into resident yards through vegetative reproduction, and the dispersal of seeds. Some residents also complained of forest vegetation encroaching into their yards through and over fences. A few were concerned about hazardous trees falling on their families or homes. Residents with swimming pools were bothered by overhanging canopy trees that dropped leaves, fruit and branches into pools. Others complained about wildlife, such as raccoons getting into their waste containers, and about the irritation and diseases associated with mosquitoes within nearby wetlands. Many residents expressed displeasure regarding the poor aesthetics of forest edges. Some said that municipalities were not doing enough to care for the forests. Others complained about the "messy" woody debris left behind on the forest floor following hazardous tree cutting. Yet most municipal interviewees were relatively ignorant of how forest edges affected adjacent residents.

Despite the negative cross border flows indicated by residents, few generated edges were visible within adjacent housing edges. This suggests that residents are regularly implementing effective filters to these flows. Research is needed to identify and measure the biotic and abiotic flows from the forest edge into housing edges and to identify, measure and evaluate filters for limiting or encouraging these flows. Municipalities need to plan housing/forest boundaries that meet both the needs of the forest and those of residents. Residents who feel that their needs are being met, including their aesthetic preferences, are more likely to support measures that they feel do not directly address their personal needs, such as ecological objectives (Nassauer, 1999).

9.1.2.2 Sociological and Natural Filters to Human Activities within Housing/Forest Boundaries

The fact that the intensities and extents of encroachment vary according to the category of encroachment behavior and the property line demarcation type indicates that the different types of property line demarcation have different levels of permeability depending on the type of encroachment behaviour. For example, where there is no property line demarcation, residents tend to dump waste in piles along side or at the end of pathways running perpendicular to the forest border. This generates a cove (the pathway) in the forest/house border and a more or less circular node (the waste disposal pile) within the forest edge. If many residents along an edge generate similar edges, this pattern tends to lead to a curvilinear boundary with nodes (See Figure 3.2). However, the waste disposal edge structure changes when a fence defines a property boundary. The straight property line, reinforced by the fence, creates a straight housing/forest border and one or several elongated nodes (the waste disposal piles) along side the housing/forest border. If many residents along an edge generate similar edges, this pattern leads to a straight boundary with attached nodes.

However, other behaviours of encroachment besides waste disposal often occur at the same time. Each behaviour responds to the filter in a different way. Together they alter the structure of the housing/forest border and the forest edge, creating complex overlapping generated edge patterns. Two general patterns tend to form in the housing/forest border and forest edge depending on the level of accessibility afforded by the type of property line demarcation. Where property line demarcation permeability is high (e.g. no property line demarcation, post, or fences with gate filters), housing/forest borders and forest edges tend to be curvilinear with coves generated by pathways, garden plant extensions and/or reactions to forest encroachment with embedded nodes (waste disposal edges). In contrast, where property line demarcation permeability is lower (e.g. property line demarcations that include fence, grass strips and/or path filters) housing/forest borders and forest edges tend to be straight with embedded coves generated by garden plant extensions, and elongated nodes relatively close to the property line. However, at courser scales, both boundary types tend to be straight and abrupt. (See Figures C.9, C.10 and C.11 for an example of the housing/forest border and forest edge patterns in response to a permeable property line filter and Figures C.6, C.7 and C.8 for an example of the patterns associated with a semi-permeable property-line filter).

This research measured encroachment within sites with property line demarcation filters, in addition to grass strips up to 50 metres in width, with or without pathways. The results indicated that these more complex boundary treatments tended to have lower overall mean intensity of encroachment than sites with just property-line demarcation filters. The results indicate that municipalities could increase the effectiveness of property line demarcation filters by adding additional filters to their property line demarcation treatments and by utilizing grass strips with or without pathways.

9.1.2.3 Application of the Boundary Theory of Natural Area Protection to Housing/ Forest Boundaries in Suburban Landscapes

The boundary theory of natural area protection asserts that the energy required to protect a natural area is very high in boundaries where there is high degree of contrast in protection between adjacent land uses, protective mechanisms are not enforced, and where there is a low level of cooperation between adjacent land use owners. This research indicates that the housing/forest boundaries within the study municipalities have these characteristics. There is a high degree of contrast in protection between adjacent housing and forests. Relative to natural areas, adjacent lands receive very little protection from development or post development impacts. Under these conditions, natural systems are likely to change toward the state of the unprotected adjacent land use unless protection measures, such as bylaws, are rigorously enforced (Ambrose, 1987; Ambrose & Bratton, 1990; Diamond et al., 1987; Schonewald-Cox, 1988).

The intensity and extent of encroachment occurring within a majority of these sites indicates that property line demarcation filters are insufficient to protect these forests from adjacent residential activities, yet the interviews, content analysis and the unobtrusive measurement of residential encroachment, indicated that few other mechanisms for mitigating residential encroachment were frequently implemented.

The interviewees, in both planning and forest management departments, indicated that addressing adjacent land use impacts, beyond those generated by construction, was a low priority. Planners generally felt that they were responsible for protecting natural areas from being developed into housing according to official and secondary plan policies, and for ensuring that construction impacts were minimized. They felt little responsibility for protecting natural areas from post development impacts. Forest managers in a majority of the municipalities, on the other hand, indicated that their municipalities placed a low priority on managing forested natural areas beyond trail maintenance, waste disposal, and the cutting of hazardous trees, and few had management plans. This appeared to be changing in Kitchener, Oakville and Mississauga. Forest managers within these municipalities indicated that they were lobbying for, or receiving, resources to develop and implement management plans. However, they indicated that they focused these resources largely on silvicultural issues, such as disease, insect or drought-related issues. In addition, some said they avoided the edge in order to avoid conflicts with residents that impeded their management efforts, such as the removal or pruning of diseased trees. Official and secondary plans echoed this low priority afforded to boundary planning and management. Only Mississauga's Official Plan specifically refers to regulating "public encroachment" into natural areas, although the meaning of public encroachment is not clear and no method of regulating encroachment is provided (City of Mississauga OP 2006, Pol. 3.12.2.2).

In addition, interviews with municipal staff and informal conversations with residents also indicated that knowledge and support of municipal goals for the desired condition, or protection, of an adjacent forest is missing among residents. Many residents said that they did not understand why the municipalities were not maintaining their forests better and that they were ill kept and degraded. Some suspected that their municipalities did not have the resources to maintain their forests and viewed their encroachment activities as a way to serve their community by performing some of the maintenance activities they felt their municipalities should be performing. Although some forest managers said that they frequently managed housing/forest edges in response to complaints from residents about encroaching vegetation or hazardous trees, most interviewees knew little about the negative impacts that forests had on adjacent residents.

Two additional factors increase the energy required to protect forests from adjacent land use impacts within suburban landscapes that are not generally present in the protection of large nature reserves in agricultural or forested landscapes. Suburban forests tend to be small and convoluted in shape relative to the size and shape of natural reserves in less developed landscapes. Natural areas in this study were between 1 and 50 ha in size and between approximately 22 metres (in the case of stream corridors) and 300 metres in width. These sizes and shapes make them highly vulnerable to adjacent land use flows (Forman, 1995). Their forms and functions depend more on adjacent abiotic/biotic flows than on their internal characteristics (Forman, 1995; Janzen, 1983; Janzen, 1986). Furthermore, there are multiple contiguous landowners in close proximity to the forest edge in addition to a much larger human population living within walking distance to the forest. All of these factors together mean that these forested natural areas require very high levels of energy to protect them from these adjacent land use impacts.

9.2 Implications for the Practice of Planning

9.2.1 Boundary Planning Strategies

The findings of this research indicate that planners need to develop strategies to increase the effectiveness and implementation of sociological and natural filters within housing/forest boundaries, and to reduce the amount of energy required to manage negative flows across these boundaries. However, while the interviews indicated that interviewees were aware that encroachments occurring, and had developed a variety of tools to limit these activities, none had developed explicit strategies to implement these tools, and tools were only being developed to address these impacts at the scale of the housing/forest border. In addition, interviewees indicated that they were implemented comprehensively to forest edges adjacent to all new subdivisions, and to existing encroachments in reaction to resident complaints.

The content analysis, the interviews and the field study indicated that the study municipalities were following an implicit strategy of reducing the frequency with which encroachment occurred through tools, such as property line demarcation, educational materials, signs and bylaw enforcement, although a few were also specifying buffers to segregate these impacts from the designated forest area. However, many studies evaluating the effectiveness of strategies to limit the impacts of recreational activities within backcountry forests by reducing their frequency indicate that these strategies are not very effective in reducing the total impacts of these activities because near maximum impacts occur with low frequency of use. After many years of study, recreation ecologists have concluded that total impacts can more effectively be reduced through reducing the area in which the impacts occur. Applied to residential encroachment, this means that strategies that reduce the area of single-family housing and that of other high impact land uses, adjacent to a forest will lead to a greater reduction in total encroachment impact than strategies that are currently being implemented by the study municipalities. Despite the support for this strategy, managers of recreational impacts in backcountry forests have found that it is also important to incorporate strategies that limit the intensity of impacts, in a multiple-strategy rather than a single-strategy approach (Leung & Marion, 1999). Furthermore, landscape ecology, ecosystem management, boundary, ecosystem planning,, and recreation ecology theory all indicate that to be effective, planning and management of natural areas, and their boundaries, have to occur at multiple spatial and time scales (White et al., 1999; Allen et al., 1993; Grumbine, 1994; Tomalty et al., 1994; Schonewald-Cox et al., 1986; Schonewald-Cox, 1988). Therefore, while I focus on strategies to reduce the area of impact at multiple scales, I also refer to other strategies to reduce the intensity of impact as supplementary strategies.

The following section outlines nine strategies for improving current municipal performance in managing housing/forest boundaries to reduce the impacts of residential encroachment activities, and other adjacent land use impacts, on suburban forest ecosystems. The strategies reduce the vulnerability of natural systems as well as manage incoming ecological flows. To maximize their effectiveness, municipalities should implement many of these strategies at different spatial scales. The combination chosen depends on the goals of the core natural system. The strategies are categorized according to four spatial planning units: 1) Neighbourhood 2) Adjacent Landscape element, 3) Landscape element/forest border and forest edge, and 4) forest interior. A neighbourhood is composed of landscape elements in contact with the forest patch or corridor, in addition to "nearby elements of the local mosaic linked by active interactions (Forman, 1995, p. 103). An adjacent landscape element is a patch, corridor or area of the matrix that is in contact with the forest landscape element. Together landscape elements make up the landscape (Forman, 1995). (See Figure 3.1 for an illustration of these elements of the housing/forest relationship). Table 9.1 summarizes the nine strategies.

9.2.1.1 Neighbourhood Strategies: Neighbourhood Buffers

Boundary theory indicates that similarly protected landscape elements require less energy to protect because they have fewer degrading flow interactions (Ambrose, 1987; Ambrose et al., 1990; Diamond et al., 1987; Schonewald-Cox et al., 1986; Schonewald-Cox, 1988). The Ontario government appears to be encouraging municipalities toward the identification of more supportive adjacent land uses through a new PPS 2005 policy that requires municipalities to evaluate the ecological functions of adjacent land uses (PPS, 2005, Pol. 2.1.6). However, the content analysis indicated that few of the municipalities have yet implemented this policy within their official and secondary plans.

A neighbourhood buffer strategy protects landscape elements that support core natural area system forms, functions and values through time (See Table 9.1, Strategy 1, Neighbourhood buffer).They also limit the areal extent of landscape elements that undermine these forms, features and values through segregation and concentration. Less supportive land uses, such as single-family housing, are concentrated elsewhere, in areas that are already developed for housing, or in other areas that are less ecologically important. This strategy is akin to the "smart growth" strategy in that it promotes the intensification of development within already developed parts of cities to reduce sprawl into the countryside. However, rather than intensifying all residential neighbourhoods, this strategy seeks to intensify those that are not associated with sensitive natural areas.

This strategy reflects a “precautionary approach” and an adaptive planning and management approach to protecting these vital suburban ecosystems. This research, along with results of many others that have determined the impacts of other adjacent land use flows (See Chapter 2), suggest that adjacent housing has significant impacts on natural system components. In addition, few, if any, studies have demonstrated that natural systems composed of small and narrow patches, corridors and narrow buffers are able to retain their pre-development features and functions through time, in the absence of their supportive surrounding landscape elements. However, the spatial boundaries of neighbourhoods are ill defined. In theory, the extent is dictated by the "active interactions" that support the forms, functions and values of a forest landscape element. Thus, neighbourhood buffers are defined at a variety of spatial and temporal scales, depending on core system goals. Because of the high level of uncertainty, these buffers are ecological hypotheses that require monitoring to determine if they are effective, and adaptive management (Holling, 1978) is required to alter their planning and management in response to new knowledge (Golley & Bellot, 1991).

In non-urban forested landscapes, segregation strategies at coarse scales have been developed to accommodate species with the largest area requirements (such as the wide-ranging Florida panther). Seasonal or non-seasonal buffer zones restrict humans, roads and other structures (Bruinderink et al., 2003) within certain distances of the species’ core habitats (Fernandez-Juricic et al., 2001). Within suburban landscapes, many of the space-requiring and disturbance-sensitive species found within these forested landscapes are missing, or municipalities have decided that these species are not compatible with human communities. However, interior birds, migratory amphibians, or large herbivorous mammals, such as white-tailed deer, have been promoted for this role (Lofvenhaft et al., 2002). Other neighbourhood buffers have been designed in support of key ecological services to human communities, such as the protection of water quantity and quality. The Oak Ridges Moraine Plan is an example of a coarse-scaled buffer strategy formulated largely to support key hydrological services for Greater Toronto Area communities (Ministry of Municipal Affairs and Housing, 2002). Similarly, the Region of Waterloo has recently designated the Blair Bechtel Cruikston Creek area and the area in support of the Laurel Creek Headwaters as "sensitive landscapes" to segregate harmful land uses from sensitive features and their supporting landscapes (C. Gosselin, Region of Waterloo, personal communication, September 28, 2007). Both areas restrict certain land use types, and place limits on the subdivision of existing residential land uses; however, neither designation defines the characteristics of supportive land uses in support of specific ecological or cultural goals or objectives.

The content analysis revealed a neighbourhood buffer for North Hespeler in Cambridge. It was designed to support of a natural area corridor consisting of a watercourse, wetlands, floodplain, ESPAs (regionally-designated environmentally sensitive policy areas), and steep slopes. The purpose of this coarse-scaled buffer was to support the habitat of white-tailed deer and the area’s sensitive hydrological functions (Planning & Engineering Initiatives Ltd., 2002). The core corridor together with its supporting land uses was between 250 to 300 metres in width. The functions of the adjacent landscape elements were: 1) to provide habitat and functions previously played by the agricultural matrix, and 2) to ensure that the negative human impacts of human proximity, such as yard extensions, waste disposal, chemical use, light, noise, pets and human presence did not prevent the formation of “interior conditions” within the core area necessary to support keystone species and hydrological goals (Planning & Engineering Initiatives Ltd., 2002, p. E-3). The protected land uses adjacent to the core consisted of LSNAs (locally significant natural areas), “enhancement areas” and “complementary land uses.” Enhancement areas are areas of restored natural area that enhance, or supplement core habitat, and core ecosystem functions. Their primary function is to perform the supportive role previously played by the agricultural matrix. Planning & Engineering Initiatives assumed that complementary land uses are: 1) parkland, 2) seasonally-used playing fields, 3) institutional land uses associated with relatively large open spaces, 4) cemeteries, and under certain conditions, 5) storm water management facilities, and 6) infrequently used single-loaded streets (Planning & Engineering Initiatives Ltd., 2002, p. E-3). However, research has not empirically tested the supportive role played by these land uses. For example, some forest manager interviewees said that playing fields are typically characterized by highly compacted soils, and may not play a significant hydrological role in support of adjacent forests. In addition, many forest manager interviewees argued that some institutions with large areas of open space, such as schools, bring intensive recreational uses to adjacent forests that degrade them. Research is required to identify and measure the ecological functions played by different land use types and configurations in support of adjacent core natural systems.

9.2.1.2 Neighbourhood Strategies: Community Support

Boundary theory indicates that increasing the cooperation of adjacent property owners decreases the amount of energy that municipalities require to protect adjacent natural systems (Schonewald-Cox et al., 1986; Schonewald-Cox, 1988). The theory also suggests that by obtaining the support of residents in the wider community, municipalities, and their staff, can increase their political influence and therefore the effectiveness with which they implement protective strategies and tools (Schonewald-Cox, 1988). Encouraging surrounding communities to support, and manage their local forests is an essential step in protecting municipal forests from encroachment, particularly forests that already have adjacent development because few opportunities exist for establishing either coarse or fine scaled buffers. This can be done by: 1) identifying, communicating and rallying support for desirable forest and housing conditions and protection goals, 2) spreading awareness of positive and negative impacts of cross border flows, 3) encouraging developers and residents to design and manage their residential properties more like forest ecosystems, and 4) promoting community forest management. This strategy should be focused on two related, but different residential groups: 1) edge residents, and 2) the surrounding community (Table 9.1, Strategy 2, Rally support of surrounding community, and Strategy 6, Rally support of edge residents).

Interviewees and informal conversations with residents indicate that staff and residents do not know the desirable condition or protection goals for either the forest or the housing area. For example, interviewees indicated many of their natural areas had not been inventoried to identify their forms, functions, or their value to surrounding communities. In addition, few interviewees were able to provide explicit goals for addressing adjacent land use impacts, such as residential encroachment. Furthermore, many forest managers indicated that resources for managing the large and increasing number of municipally owned forests were lacking. Watershed, subwatershed, and site-scaled EIS are often required by municipalities prior to development of significant natural systems, and contain substantial amounts of information that could assist in the identification of desirable conditions and protection goals. However, forest and park manager interviewees indicated that this information was rarely incorporated into management plans, or community-involved exercises to identify and agree upon desired conditions or protection goals. Yet, informal conversations with edge residents indicated that they were unsure of what their municipalities were trying to achieve through their management actions, or lack of action within their adjacent forests. For example, several residents mentioned that hazardous trees cut and left by forestry staff to rot on the forest floor were “messy” and unsightly. Others complained about the aesthetics and lack of utility of naturalizing areas.

Boundary theory suggests that educating adjacent landowners about the positive and negative impacts of cross border flows is important for reducing negative flows. However, the content analysis revealed that promoting stewardship among residents was a very low priority not only within the study municipalities, but also at regional and provincial government levels. The policies of study municipalities were largely limited to those requiring developers to promote stewardship to first residents, or supporting the efforts of regional governments who largely focus their stewardship programs on rural residents. Some stated an intention to encourage stewardship among residents, without specifying how this would be achieved. Planner interviewees indicated they required developers or builders to distribute pamphlets that contained information related to encroachment to first time residents as a condition of development. However, none was able to say how many of the pamphlets were delivered to residents, or whether residents understood, or retained the information regarding encroachment. While some of the forest managers said they occasionally distributed pamphlets to residents, they indicated these efforts were haphazard, with most occurring in response to existing encroachments. Furthermore, none of the interviewees knew whether any of their educational efforts were effective. Municipalities need to take a more positive and proactive approach to encouraging stewardship among residents. In part, they can do this by identifying, restoring, and demonstrating the positive forms and functions within surrounding communities, particularly within the housing edge, that support adjacent forests, toward the creation of “neighbourwoods.”

9.2.1.3 Adjacent Landscape Element Strategies: Adjacent Landscape Element Buffers

Adjacent landscape element buffers are defined in support of finer scaled interactions, such as microclimate or residential encroachment. For example, these buffers occupy the edge of the landscape element, in this case the housing edge, immediately adjacent to the forest edge. Their purpose is to 1) maximize open space, 2) minimize the area of the forest edge exposed to residential encroachment, 2) reduce the microclimatic edge, and 3) improve the habitat functions of the forest edge by increasing the area of the forest and by creating a more gradual and complex housing/forest border transition between intensive surrounding land uses and the forest ecosystem (See Table 9.1, Strategy 3, Adjacent landscape element buffer).

Building footprints and building density should be minimized, but could accommodate the same number of households through medium density cluster development (Arendt, 1996; Arendt, 1997). Zero lot line development should maximize building setbacks from the housing/forest border. Housing side yards, rather than backyards should face the housing/forest border to direct the flow of human activity away from the forest edge.

Part of the open space left by smaller building footprints should be dedicated to enhancing the habitat values of the forest edges by ensuring a more gradual border transition between the vegetation of intensively managed gardens and the relatively unmanaged forest edge. Complex vertical, and in strategic places dense and prickly, housing/forest borders should be encouraged to reduce microclimatic and encroachment flows.

Some condominium complexes, and conservation subdivisions, could be designed according to these principles. Interviewees indicated that they noticed less encroachment adjacent to condominium complexes where the grounds are managed by an administrative board, rather than by individuals. In the event of an encroachment, interviewees said they tend to be easier to address because the municipality only has to deal with one administrative board rather than many individual residents. In addition, the board may ensure the removal of encroachments by residents, rather than the municipality.

The content analysis did not identify any official or secondary plan policies that encouraged development with these characteristics adjacent to natural areas. Although the secondary plan for Waterloo's Laurel Creek lands identify the adjacent lands as “constraint lands,” protective policies only relate storm water management practices, wetland creation, and housing densities determined in part by the adjacent natural area (City of Waterloo OP 2004, Pol. 6.33.5.5, 12 viii). The City of Waterloo also has a policy that states that they “may give preference” to multi-unit residential buildings adjacent to significant natural areas rather than single family housing (City of Waterloo OP 2004, Pol. 3.1.2.8). In addition, the content analysis revealed a Mississauga Official Plan policy that "suggests" protection of large canopy trees and the water recharge functions of large lots within older low-density single-family housing subdivisions, in the face of intensification. However, policies to protect these forms and functions are few. Only existing trees receive protection, and protection is “suggested” rather than required (City of Mississauga Official Plan (2003), Pol. 3.12.2.2j).

9.2.1.4 Adjacent Landscape Element Strategies: Sociological Physical Filters

Sociological housing edge and housing/forest border filters are physical tangible structures, such as property line demarcation, recreational or utility facilities, or signs, that are designed as filters to negative adjacent land use flows. They are located in the adjacent landscape element, or at the adjacent landscape element/forest border. They may be on private and/or public land. The focus of this discussion is on property line demarcation and recreational or utility facilities that take the form of grass strips or paths. Interviews and the measurement of encroachment within forest edges indicated that signs prohibiting resident activities, particularly waste disposal, are regularly posted at park entries, however little is known of their effectiveness in reducing encroachment activities. However, the high intensities and extents of encroachment measured within the edges of forests with signs suggest that currently placed signs are not effective in significantly reducing edge resident encroachment activities.

The results of the unobtrusive measurement of residential encroachment within residential forest edges clearly indicates that property line demarcation, grass strips and paths all function as sociological filters to residential encroachment within housing/forest borders and within the forest edge (Table 9.1, Strategy 4, Sociological Housing Edge and Housing./Forest Border Filters). In addition, informal conversations with edge residents suggested these elements, along with resident maintenance routines, serve to filter forest encroachment into residential yards. However, this latter hypothesis needs more formal empirical testing. In terms of elements that filter residential encroachment within the housing/forest border and forest edge, the research indicated that elements, such as fences, fences with gates, or posts had different levels of permeability to residential encroachment activities depending on the type of activity. For example while fences were effective for limiting yard extensions (as long as municipal staff monitoring ensured fences remained in place), they were not effective in reducing other types of encroachment such as waste disposal, garden plant extensions, reaction to forest encroachment or recreation-related encroachment.

In general, filtering that served as barriers to resident entry tended to be more effective in reducing encroachment activities. In addition, encroachment activities decreased where filters effective at addressing different types of encroachment were combined. For example, grass strips with or without paths, when combined with fences, were more effective in reducing multiple types of encroachment, particularly yard extensions and waste disposal. Furthermore, informal conversations with residents revealed that many edge residents preferred to have the forest vegetation positioned away from their property boundaries. Therefore, sociological filters that included grass strips tended to reduce forest encroachment related encroachment, while meeting edge-resident needs. In addition, forest manager interviewees indicated that grass strips and paths receive frequent use by the community, facilitating community monitoring of the housing edge and the housing/forest border. In addition, they commented that grass strips, in particular, were effective in 1) clarifying property boundaries so that staff could determine where to manage, and when residential encroachment was occurring and 2) enabling access and regular monitoring of these areas on foot, or using a small-motorized vehicle. Furthermore, grass strips and paths play important recreational functions and can be designed to play vital storm water management roles. Their position in the forest edge concentrates the impacts of many human activities within one high impact zone, rather than in more sensitive forest interiors.

Nevertheless, this combination of filters generally results in a wider filter than just one that focuses on the property line. Many of the grass strips adjacent to study sites were relatively wide (up to 50 metres) and their construction may reduce the widths of already narrow forest patches and corridors. Further research is required to determine if narrow grass strips, with or without pathways, lead to similar reductions in total encroachment. Despite this significant shortcoming, there is an opportunity to apply the pattern strategically where forest edges are particularly sensitive to encroachment, or where adjacent land uses are likely to lead to intensive encroachment activities.

9.2.1.5 Adjacent Landscape Element Strategies: Sociological Regulatory Filters

Sociological regulatory filters are not physically tangible. They include the administrative property line (not demarcated) and encroachment policies or bylaws (Table 9.1, Strategy 5, Sociological Regulatory Filter). Encroachment policies and bylaws are also sociological regulatory filters. Boundary theory indicates that these filters, in addition to the above physically-tangible sociological filters, are particularly important where adjacent land uses have significantly different levels of protection (i.e. where there are no buffers). Unless these filters are strictly enforced, boundary theory predicts that the condition of the forest will move toward that of the adjacent land use (Dasmann, 1984; Dasmann, 1988; Diamond et al., 1987; Schonewald-Cox et al., 1986; Schonewald-Cox, 1988).

The results of the measurement of encroachment within forest edges indicate that the administrative property line is not an effective filter to edge resident encroachment activities within Southern Ontario forest edges. The intensities and extents of encroachment were significantly higher within forest edges protected by administrative property lines than in forest edges with demarcated property lines.

Forest and park manager interviewees indicated that encroachment policies and bylaws were infrequently implemented relative to the number of existing encroachments. This was confirmed by the measurement of encroachment within municipal forest edges. Interviewees and the content analysis indicated that this lack of enforcement was due to were a lack of sufficient resources, a lack of significance attributed to the issue by municipalities, and edge resident political influence. Many planner and forest manager interviewees were concerned that the lack of enforcement undermined their efforts to convince residents that they should care for and protect their community forests. Interviewees indicated that this lack of consistent enforcement irritates encroaching residents, and those applying for "legal encroachments" such as building extensions into forested public land, because while they have to remove their encroachments, or are prevented from encroaching, their neighbours continue to encroach. Furthermore, some planners argued that this lack of care undermined their ability to negotiate protective mechanisms, such as strip buffers. These developers are reluctant to do their share in protecting this land when the municipality is unwilling to protect it following development. These interviewees argued that the lack of enforcement communicates to residents that the municipality does not care about their forests. This lack of care was also apparent in the near absence of preventative encroachment policies within official or secondary plans, particularly for forests adjacent to established subdivisions, and within interviews. Many planners did not feel that addressing encroachment through planning was a significant part of their job. Park managers were more concerned with their active recreation areas, and many forest managers were more concerned with silvicultural issues and managing the interior areas of their forests.

The results of the measurement of edge resident encroachment in municipal forest edges and the interviews indicated that bylaw enforcement is not effective in reducing the frequency of encroachment through time without filters to reduce its recurrence, such as physically tangible sociological filters, the restoration of natural filters and municipal and community monitoring. Without these latter filters, encroachment is likely to recur following bylaw enforcement. However, interviews and measurement of encroachment within municipal forest edges indicated that only Mississauga was combining bylaw enforcement with structural sociological filters within forest edges where these structures were missing.

9.2.1.6 Landscape Element/Forest Border and Forest Edge Strategies: Strip Buffer

The content analysis indicated that segregation strategies involving relatively narrow forested strips, or strip buffers, between the housing/forest border and the boundary of the designated forest are relatively common official and secondary plan policies for protecting natural areas and systems. They commonly involve the use of relatively-narrow set backs which define how far back from a natural area a structure must be placed, or vegetated "buffers," which are strips of undeveloped vegetated land, generally between 5 and 30 metres, that repel or absorb the negative flows between two land uses. They are positioned within the boundaries between adjacent local ecosystem elements, such as between housing and waterways or between housing and designated upland forests (Table 9.1, Strategy 7, Strip Buffer).

The content analysis and interviewees indicated that goals for these strip buffers were missing. Although two of the environmental planners interviewed mentioned that the purpose of the buffer strips was to segregate residential encroachment activity from the designated forest edge, none of the official or secondary plans mentioned this as a goal. In fact, interviewees indicated that the purpose of these areas were largely directed at reducing the impacts of construction on forest edges; however many functions were applied to these narrow areas. The unobtrusive measurement of encroachment activities indicated that these strip buffers currently function as reservoirs for encroachment activity; however many interviewees were uncomfortable with this function. For some planner interviewees the most important role attributed to strip buffers is the provision of supplementary habitat, particularly within narrow or small forest patches and corridors. Interviewees were concerned that these functions were being degraded by encroachment activities. Other planners viewed their ecosystem service functions, such as the hydrological functions, as the most important. They too were concerned that these functions were being degraded by encroachment activities. This latter concern was reflected in the literature on riparian buffer design. Concern was expressed that these human activities may remove and alter vegetation designed to reduce the velocity, or filter, water; compact and erode soils; channelize drainage water, and reduce the porosity of riparian buffers (Norman, 1996; Schueler, 1987; U.S. Environmental Protection Agency, 1995). In short, the research indicates that these narrow strips of land, many only 5 metres in width, are not only expected to provide significant habitat functions in support of adjacent natural areas, but also to filter, largely without any ongoing management, all negative flows arriving from the adjacent land through time.

Very little research is available, beyond riparian buffer research, to support the largely normative theory that these strips of land are able to provide some of these functions, never mind providing multiple functions through time without management. Given the intensity and extent of encroachment activities, together with the negative flows across housing/forest borders indicated by other studies, the protection expectations applied these areas are unrealistic. Municipalities need to define specific buffer functions, and how they will be maintained through time in the face of ongoing flows from adjacent lands that change the structures and functions of forest edges. They then need to monitor these areas to determine if these buffers are performing these functions through time.

9.2.1.7 Landscape Element/Forest Border and Forest Edge Strategies: Natural Filters

Boundary research indicates that the natural characteristics of forest edges alter ecological flows. For example, field/forest border vegetation that transitions gradually, rather than abruptly, and is vertically complex, tends to increase the flow of plants and animals into the forest edge (Giles, Jr., 1978; Leopold, 1933; Thomas, DeGraaf, & Mawson, 1977; Yahner, 1988), and decrease the width of micro-climatic edges (Chen, Franklin, & Spies, 1992;

Franklin & Forman, 1987; Harris, 1984). Characteristics of the housing/forest border and forest edge may also filter human activities. For example, vertically-complex borders and edges, particularly those with dense prickles or uncomfortable plants, such as burrs, may deter human entry into forest edges, and such vegetation is commonly used to manage recreation-related impacts, such as trampling, within forests (Magill, 1970). However, there is only weak support for its filtering capacity in terms of residential encroachment. Both my research and Matlack's did not find that closed forest edges prevented human activity impacts within forest edges (Matlack, 1993), although they may have reduced their frequency and extent. However, this research did not measure encroachment occurring with prickly and dense closed forest edges, or those with plants, such as poison ivy, that affect human health. Steep slopes could also deter some encroachment activities. For example, waste disposal may be deterred in upward facing slopes. Poorly drained areas may also serve as barriers to entry for humans. Forests, and forest segment edges, with these characteristics should be identified and monitored to determine if these characteristics serve as natural filters that could be combined with sociological, and filters at coarser scales, to minimize encroachment impacts (Table 9.1, Strategy 8).

9.2.1.8 Interior Forest Strategies: Large Forest Areas and Low Edge to Interior Ratios

Municipal performance in protecting forested natural areas from residential encroachment can also be improved by designating and restoring forest ecosystems that are less vulnerable to adjacent land use impacts (Table 9.1, Strategy 8, Large forest areas and low edge to interior ratios). Larger and less convoluted forests have lower exposure to surrounding land uses than forests that are smaller and more convoluted in shape (Forman, 1995). To plan the sizes, arrangement or location of these patches, municipalities require specific goals and objectives. Large forest patches may support native species with large home ranges that are rare or at risk in developed landscapes, at the same time as they protect other key ecosystem services, such as the protection of aquifers and the connection of headwater streams. Any number of small forest patches cannot perform these functions.

According to the PPS (2005) municipalities "should" maintain the biodiversity of their natural heritage systems; "shall protect, improve and restore" sensitive surface and ground water features and functions; and shall maintain linkages between these latter features and functions and natural heritage features (PPS, 2005, Sec. 2.1.2, and 2.2.1). Yet, the content analysis revealed that few municipalities had biodiversity goals that were specific and forceful enough to guide planning decisions regarding the size, configuration or location of forested natural systems that implement these provincial policies within their municipalities.. Part of the problem is that the Ontario provincial policy on biodiversity is as vague and non-committal as the regional and local municipal policies when it comes to biodiversity. The use of the word "should" instead of "shall" in reference to natural heritage systems, signals to municipalities that maintaining biodiversity is optional. In addition, policies do not specify what biodiversity will be maintained, or at what scale. If these parameters are not defined biodiversity, policies are meaningless. Many studies have demonstrated that high biodiversity exists within urban environments, but most of this biodiversity results from the high number of exotic species that are not at risk. In fact, some threaten native biodiversity. In addition, for the most part, native biodiversity at coarser scales are at risk, rather than at finer scales. Maintaining or even increasing biodiversity in a specific natural area may be accomplished; however, a municipality can still lose native biodiversity at the landscape scale.

Unfortunately, few studies have been conducted to determine the size and configuration required to both support native landscape-scaled biodiversity and protect surface and ground water systems within suburban or urban landscapes. These studies are required to account for the influence of the intensive adjacent land use impacts associated with developed landscapes. This means that in the planning of these essential ecosystems, municipalities need to plan according to the precautionary principal, one interpretation of which says that where there is uncertainty, a margin of error should be built into decision making (Stewart, 2002). This approach is supported by one of the principles for ecosystem planning, that says that planning should proceed under the assumption that the consequences of planning are uncertain and potentially damaging (Tomalty et al., 1994).This means that plans need to be adapted over time as knowledge becomes available (Tomalty et al., 1994). However, the literature review and the content analysis indicate that Ontario municipalities are still not monitoring their natural systems to determine if planning objectives, and therefore goals, are being met. The content analysis indicated that many of the study municipalities are relying on regional monitoring. It also indicated that monitoring is largely being conducted at the watershed or subwatershed level, and focuses on water quality and quantity. However, it also indicated that some of the study municipalities are beginning to require developers to monitor the impacts of their developments at the site scale. This indicates that these municipalities are beginning to subscribe to another ecosystem-planning principal that states that the consequences of planning need to be considered at multiple scales (Tomalty et al., 1994). However, both the content analysis and interviews with planners indicated that study municipalities are unsure of what to monitor and how to use the results of monitoring in future planning. This means that these municipalities are still struggling to plan according to another principal of ecosystem planning that asserts that planners need to sort out what, and how, to learn from planning mistakes so that they can heal previous negative impacts and work toward fewer impacts in the future (Tomalty et al., 1994).

A major barrier is the lack of goals. It is difficult to develop and use monitoring effectively if there are no goals that specify what a municipality is trying to achieve. The trend toward multi-scaled monitoring is a positive step forward. Coarse-scale indicators such as water quality and quantity, in addition to the monitoring of keystone target species, such as area-demanding birds and mammals, or migratory amphibians, are important. However, the intensity and extent of residential encroachment indicated in this study, together with the adjacent land use impacts indicated by other studies, such as microclimatic and recreation-related impacts, indicate that these micro-scale impacts on natural systems are significant, and must be monitored. Each impact event may be insignificant by itself and its effect subtle and difficult to measure; however, many such events occur over time, and their effects accumulate over time, leading to significant degradation of natural areas (Murphy, 2006).

Table 9.1 Filtering Strategies for Managing Adjacent Land Use Impacts on Core Natural Systems

Scale	Strategy	Form	Characteristics	Precedent
NEIGHBOURHOOD STRATEGIES				
Strategy 1:Neighbourhood buffer				
Neighbourhood	Support coarse-scaled positive ecological flows/ Segregates negative flows/ Concentrates housing in already developed, less sensitive areas	Large Patch, Corridors, and very large lots	• Supports keystone species/ vital ecosystem flows • Supplementary Habitat • Passive recreational use at Agricultural/forest borders • Low resident population • Small number landowners • Low lot coverage	Laurel Creek Headwaters (1998) ORM (2002) Blair, Bechtel Cruikston Creek (2007) North Hespeler Watershed (2002)
Strategy 2: Rally Support of Surrounding Community				
Neighbourhood	Alters Behavior; reduces frequency		• Rallies support for desirable condition & protection goals for housing/forest landscape elements • Spreads awareness of positive/negative impacts of adjacent land use flows • Encourages “neighbourwoods” through demonstration/awards • Promote community management	Waterloo's Partners in Parks; Oakville's Adopt a trail; Mississauga's "Facility Watch"
ADJACENT LANDSCAPE ELEMENT STRATEGIES				
Strategy 3: Adjacent Landscape element buffer				
Adjacent Landscape Element	Supports finer scaled positive l flows/ Segregates negative flows; Concentrates housing away from housing/forest border	Mixed Residential Neighbourhood (2)	• Low to medium density resident population • Small number landowners or management agencies • Low lot coverage • Deep building setback • Clustered buildings • Streets perpendicular to housing/forest border • Passive recreational use at housing/ forest border	Condominium complexes; Conservation Subdivisions
Strategy 4: Sociological Physical Filters				
Adjacent landscape element Edge	Segregate	Property line demarcation, grass strips or paths/ greenways/ utility corridors	• Varies depending on sociological and natural filters present • Fences useful for reducing incidence of yard extensions; trespassing, informal trail creation and delimiting management responsibilities • Filter located on private and/or public property	Fence: Oakville (1983) Living Fence: Guelph (1996)
Strategy 5: Sociological Regulatory Filters				
Adjacent land use/forest border	Reduce frequency Removes encroachment	Administrative property line; encroachment policies or bylaws	• Identify and agree to desirable boundary conditions with edge residents • Follow established procedure to have encroachments removed • Establish sociological and natural • Forestry staff/Edge resident/Community monitoring	By-law: Mississauga (2004); Encroachment Policy: Cambridge (1999)/ Kitchener (1994)
Strategy 6: Edge Resident Support				
Adjacent land use & Adjacent land use/forest border	Alter Behavior ; reduce frequency		• Identify, communicate, rally support for desirable conditions/protection goals • Spread awareness of positive/negative impacts of edges on housing and forest • Encourage “neighbourwoods” through demonstration/awards • Promote edge management	Waterloo's Partners in Parks; Mississauga's "Facility Watch"
ADJACENT LANDSCAPE ELEMENT/FOREST BORDER AND FOREST EDGE STRATEGIES				
Strategy 7: Strip Buffer				
Adjacent land use/forest border	Segregate	Narrow Vegetative Strip buffers	• Forested; vertically complex; curvilinear borders • Attractive/dense/prickly vegetation • Designed to perform measurable functions	
Strategy 8: Natural Filters				
Patch or Corridor	Segregate	Many different	• Wet areas; Steep slopes; Prickly dense vegetation	
FOREST INTERIOR STRATEGIES				
Strategy 9: Large Areas with Low Edge to Interior Ratios				
Patch or Corridor	Reduces Forest vulnerability		• Larger and wider forest patches and corridors with less edge exposed to adjacent land uses	

9.2.2 Boundary Planning Procedures

The implementation of these nine boundary strategies has significant implications for planning practice. The implementation of coarse scale buffer strategies requires planning at coarser spatial and temporal scales than is currently being practiced. The literature review, summarized in Chapter 4, the content analysis and the interviews indicated that Ontario municipalities have begun to expand this planning scale to coarser spatial scales and long time periods in the last 10 to 15 years. Watershed and subwatershed plans are being developed, and connected natural system components are increasingly being protected from development, or restored, rather than just individual patches, or corridor fragments. However, the content analysis and the interviews indicated that despite this courser scale focus, planners still view suburban natural systems as consisting of only these components, rather than as watershed or subwatershed natural systems. Therefore, planners are still focused on site scale impacts of development, during the period in which these natural system components and those immediately adjacent to them, are being considered for development. This is indicated by the lack of clear ecological goals, and protection policies for land uses outside of designated natural areas, within the official and secondary plans of the study municipalities. Establishing goals to support native biodiversity, and vital ecological processes at coarse scales, in addition to policies that support the achievement of these goals over areas defined by keystone species, and key ecological flows, are essential to protecting suburban natural systems for the long term.

The results of this research also indicate that planning needs to occur over longer spatial time scales than is currently occurring within the study municipalities. Planning within these municipalities is not currently focused on protecting natural areas and systems following development. For example, only Oakville and Mississauga had policies that indicated that they would address residential encroachment, and only Mississauga had official plan policies for managing their natural systems. The results of the measurement of encroachment within suburban forest edges indicates that this gap has left many suburban natural systems vulnerable to degrading adjacent land use flows. To fill this gap, planning practice needs to extend beyond the point of substantial completion to anticipate protection requirements throughout the lifetime of housing/forest ecosystems from pre-development to post development to re-development. In terms of implementing boundary planning, this means that municipal planners have to anticipate the future impacts brought by adjacent land uses at coarse spatial scales, and plan far in advance of housing edge development.

According to the principles of ecosystem planning, plans for watersheds and subwatersheds need to be prepared in response to the forms and functions of their natural systems. Municipalities need to define: 1) the condition in which they would like to maintain these systems, 2) their protection goals, and 3) their adjacent land use planning protection policies at these coarser scales. They need to identify and measure the forms and functions of natural system components at this time. These measures can serve as baseline data with which to compare future forms and functions to determine whether protection measures are effective. This information guides the preparation of site specific EIS which guide site-scale development. Within these documents, the desired conditions, and protection goals for individual natural system components together with their surrounding neighbourhoods should be specified. Interviews within Oakville indicated that they were now preparing watershed, subwatershed plans, as well as inventories of natural areas, and that developers were preparing site-scaled EIS; however, it is unclear how these plans relate to each other I terms of protecting natural systems different scales.

This research indicates that the study municipalities have focused on planning their ecosystems, but not on managing them. According to the concept of environmental or ecosystem management developed by Dorney (1987) planning, which focuses on the development process, a government process, or policy development, is just one phase of the ecosystem management process. The second protection phase that followed planning included planning implementation, as well as the management of government-owned facilities (e.g. a natural area) monitoring of these facilities, and research (Dorney,1987, p. 15). He viewed this phase as vital to successful ecosystem management. Yet, the results of this research indicate that the latter protection phase of environmental management that includes facility management, monitoring and research is missing, or not adequately integrated into the planning phase, or the ecosystem management process in general.

The content analysis and interviews revealed few management or monitoring policies at any level of government. Landscape ecology theory indicates that boundary management is essential for protecting natural system features and functions, particularly small and narrowed forested natural systems embedded within intensively developed landscapes. Yet, the measurement of residential encroachment clearly indicated that they are receiving insufficient care to ensure that study municipality suburban forests maintain their pre-development forms and functions for the long time. The content analysis revealed few management policies in official and secondary plans. Many forest mangers argued that they had insufficient resources to manage their forests beyond maintaining pathways, emptying waste receptacles, and reacting to resident complaints. In addition, the staff within some forestry departments did not have the skills to implement more sophisticated management activities, such as silvicultural activities, or the establishment and implementation of resident stewardship programs.

In addition, these research indicated that not only are management, monitoring and research vital to long term protection of natural systems, but that management considerations must be integrated along side planning considerations at multiple scales, rather than following site-scaled plan development and implementation. Planning and management needs to become more closely integrated. While forest managers in Mississauga and Oakville indicated that forest management involvement in planning was increasing, most agreed that forest managers have minimal involvement with ensuring that designated natural systems can be managed to maintain their pre-development forms and functions, and that the necessary watershed, and site-scaled planning occurs to protect natural systems post development.

Not only do natural systems need to be managed through time, but also their supportive adjacent land uses, to ensure these systems continue to be supported in the face of changes, such as housing intensification.. The content analysis and interviews indicated that policies to protect residential forms and functions in support of adjacent natural systems were largely missing, although some were beginning to appear (City of Mississauga Official Plan (2003), policy 3.12.2.2f).

To address adjacent land use impacts on natural areas through both planning and management, forestry and planning staff need to be educated in urban forest ecosystems and their management, in addition to development planning adjacent to natural areas, and how they effect one another. Forestry managers need to ensure that post-development protection and management issues are integrated into planning at multiple scales so that they do not inherit costly management regimes, or forests that will be degraded through time by post development impacts.

9.3 Recommendations for Future Research

9.3.1 Why are local, regional and municipal policies lacking coarse-scaled goals and objectives for their natural systems?

The content analysis and the interviews indicated that local, regional and provincial governments were missing coarse-scaled goals and objectives to drive the conservation, enhancement and protection of their natural systems. For example, while all mention maintaining biodiversity as a goal, few mention the type or scale of biodiversity or provide policies that strongly state that it shall be preserved in the face of development. Similarly, clear goals that outline the ecological services to be maintained in suburban landscapes are frequently missing. Interviews with planners and managers indicated that a lack of clear natural system protection goals and objectives impeded their efforts to develop and implement effective protective policies. They argued that they do not know what features or functions they are trying to protect in the long term. Research is required to identify: 1) the features and, more importantly, the social and ecological functions of municipal natural area systems, 2) realistic goals and objectives for their protection, 3) policy implications of these goals, and 4) objectives to measure the achievement of goals.

9.3.2 What are the Intensities and Extents of Edge Resident Encroachment Activities in Other Suburban landscapes and Ecosystems?

The results of this research are limited to deciduous and mixed municipally owned forests adjacent to suburban housing subdivisions within Southern Ontario. Similar studies need to be conducted involving: 1) other municipal ecosystems, 2) different types of forest ownership (e.g. private or semi-private), 3) different types of subdivisions and other land use, and 4) different communities. These studies will determine whether these variables lead to the same or different types, frequencies, intensities and extents of edge-resident encroachment.

9.3.3 What are the Effects of Encroachment Activities on Forested Natural Area Forms, Functions and Values?

Research is required to determine the effects of residential encroachment activities on the forms, functions and values of suburban forest ecosystems. Research is also required to determine how residential encroachment edges individually and together alter other negative flows into the forest edge, such as microclimate or exotic species. This information would assist in the identification of sociological and natural filters that perform multiple filtering functions.

Similarly, studies are required to measure the impacts of community recreation-related encroachment, construction-related impacts, and silvicultural impacts on suburban forests. The long-term survival of municipal forests is a function of these impacts through time, but little monitoring or research has been performed to determine their significance, relative significance, or whether municipal planning and management policies are effective in reducing these impacts.

For example, further research is required within large forest patches and corridors (i.e. larger than 300 metres wide when surrounded by housing) to determine the edge associated with community-related recreation encroachment. This research suggested that community recreation activities affect the whole of fragments up to approximately 300 metres wide when surrounded by housing, rather than just their edges. Nevertheless, recreation activities may be edge phenomena in larger forests; indicating two overlapping encroachment edges, one associated with edge residents, the other with community recreation.

9.3.4 What are the Effects of Intensified Land Uses on Adjacent Forested Natural Systems?

As the remaining undeveloped land in Southern Ontario municipalities becomes developed, and high residential growth continues, these municipalities will be pressured to intensify housing areas in and around all municipal natural systems. Research is required to determine the effects of intensification on adjacent natural systems. In addition, research is needed to determine whether planning policies developed to protect these systems are effective.

9.3.5 What Land Uses and Configurations Constitute Effective Neighbourhood and Adjacent Landscape Element Buffers?

Little is known about suburban land uses and configurations that support adjacent forested natural systems. The suburban housing that was the subject of study in this research led to substantial edge-resident encroachment, but other residential land use patterns may lead to greater or lesser encroachment levels. Some of the interviewees also suggested that other land uses, such as agricultural, multi-unit residential dwellings, light industry or institutional land uses, such as churches or schools, might be supportive to sensitive natural areas. The impacts, including encroachment, associated with other residential land use patterns, and these other land uses are unknown. Perhaps of even greater importance, we do not know what ecological forms and functions within these ecosystems are important for supporting adjacent forested natural area forms and functions. Further research is required in different types and densities of land use to determine the characteristics of both positive and negative adjacent patterns of development and land uses. This would allow municipalities to meet policy 2.1.6 of the PPS (2005) that requires municipalities to evaluate the ecological functions of adjacent land uses prior to development within and adjacent to natural systems.

9.3.6 Effectiveness of Physical Sociological Filters

This research evaluated the effectiveness of a number of boundary treatments for limiting edge-resident encroachment. An insufficient number of sites were found to evaluate some of the boundary types effectively (for example, sites with just grass strips or just paths). More of these sites need to be evaluated to isolate the effects of individual policy components, such as grass strips or paths. In addition, the effective characteristics of boundary treatments need to be further identified. For example, is there an effective fence height for reducing waste disposal and is there a type of fence that residents find attractive and desirable? Do grass strips have to be mown to be effective? Does the width of the grass strip influence its effectiveness? Furthermore, other complex boundary treatments need to be evaluated in order to identify an effective protective boundary treatment for highly sensitive areas. Recently developed boundary treatments, such as living fences and private buffers need to be evaluated.

9.3.7 Effectiveness of Regulatory Sociological Filters

Interviewees indicated that their municipalities had established, or were implementing, encroachment policies and bylaws that dictate procedures for mitigating existing encroachments; programs directed at educating residents regarding encroachment activities; natural area signage prohibiting encroachment activities or stating the protection status of a natural area; and edge monitoring for residential encroachment. These filters were not implemented within the study sites with sufficient consistency to evaluate their effectiveness. Further studies are required to evaluate these filters singly and in combination with other natural and sociological filters.

Studies are also required to identify and evaluate the effectiveness of natural filters, such as poorly drained areas, or those with steep inclines. The permeability of dense and prickly forest border vegetation to human activities also needs further study. Sites with closed forest edges were sampled within this research, but none deterred either waste-disposal, garden plant extension, or recreation-related encroachments, such as informal pathway or tree house construction. Matlack also found that closed side canopies were insufficient to deter encroachment (Matlack, 1993). Nevertheless, vegetation is commonly used as a tool to guide the location of human activities in park planning, and closed side canopies are important for reducing microclimatic edges, and for supporting the habitat functions of boundaries, particularly for edge birds and small mammals.

9.3.8 Why do Residents Encroach in Forested Natural Systems?

Future research is required to empirically test whether the five motivations for encroachment behaviour identified through this research are valid. Understanding the motivations of residents will lead to more effective policy development. In addition, understanding how residents are affected by forest edges may also lead to the development of more positive boundary relationships. Observations of encroachment patterns in some forest edges indicated that some encroachment behaviour occurred in response to forest encroachment into housing ecosystems. This hypothesis needs to be empirically tested. The following questions need to be answered: 1) What are the effects of adjacent forests on edge residents 2) How do residents respond to these impacts? 3) How far do the impacts extend into the housing edge?

A number of planner interviewees said that they would like to keep as much of the original forest edge following development as possible. Some were making informal or legal agreements with residents, such as private buffers, to encourage, or force them, to keep the veil, mantel and saum vegetation structures in tact when housing/forest borders are located within private property. Research is required to determine whether these agreements are effective filters for reducing human activities that push back the housing/forest border into forest edges. Similarly, further research is required to determine what motivates residents to retain housing/forest borders, expand housing/forest borders into residential yards, and what factors, (such as canopy closure, or the direction an edge is facing) influences the retention of housing/forest borders.

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Appendix A

Interview Guide

Introduction

1.1 What is your role in your Municipality?
1.2 How long have you worked in this capacity in your Municipality? Elsewhere?

Definitions of residential encroachment and its significance

2.1 How would you define residential encroachment?
2.2 What effects do you feel are the most significant?
2.3 Do you feel that these encroachment activities are common among residents who live immediately adjacent to your municipal forest edges?
2.4 Generally speaking, do you feel that these effects are significant relative to other factors affecting these forests, such as the affects of subdivision construction or the affects of recreational users?

Who is responsible for addressing encroachment?

3.1 Which department in your municipality is responsible for preventing or limiting residential encroachment activities before it occurs? After it occurs?
3.2 Are residential encroachment activities, and/or their effects on the forest, considered during the park/natural area selection process? By whom?

Residential encroachment goals

4.1 If the planning department is involved in limiting residential encroachment activities before they occur, do you have specific planning goal(s) for dealing with residential encroachment activities?

4.2 What are your goals ?
4.3 Do your goals apply to residential encroachment within all municipal parks/forests ?

Residential encroachment strategies

5.1 Has your planning department developed specific planning strategies for limiting residential encroachment or for achieving your residential encroachment planning goals?

5.2 Please indicate whether your municipality's strategy fits within any, all or none of the following strategies to mitigate residential encroachment activities

<u>Strategy 1: Alter the way residents interact with the forest edge</u>

( ) reduce the number of times encroachment activities occur

( ) reduce the frequency of particularly offensive types of activities
( ) alter the way in which they occur

( ) alter when they occur
( ) alter where they occur

<u>Strategy 2: Reduce the vulnerability of the forest edge</u>

( ) within all forests, vulnerable forests or areas of the forest edge?

( ) increase resistance of forest or area of forest to effects of encroachment

( ) increase resilience of forest or area of forest to effects of encroachment

Strategy 3: Restrict and/or alter the location, form and/or function of the housing subdivision

( ) reduce the density of housing
( ) Increase or reduce the lot size of houses along the edge
( ) Reduce the length of forest edge with adjacent housing
( ) Reduce the accessibility of the forest for edge residents/community
( ) Alter the housing type
( ) Alter the land use (i.e. zone for non-residential land use)
( ) Alter the building setback from the municipal property boundary

5.3 Do your strategies apply to all residential encroachment within all municipal forests?

Residential encroachment policies

6.1 Does your municipality have policies and/or other tools or mechanisms to address residential encroachment activities and/or their effects?

6.2 Are any of the following policy components included in your municipality's approach?

( ) Municipal boundary posts
( ) Fence
( ) Living fence
( ) Pathway
( ) Vegetative strip, SWM, buffer or active recreation area?
( ) Forest or edge maintenance activities
( ) Municipal monitoring activities
( ) Neighbourhood monitoring activities
( ) Signs prohibiting certain activities or *behaviours*
( ) Bylaws prohibiting certain types/behaviours of encroachment activities
( ) Forest or park activity zoning
( ) Education

( ) Fulfillment of resident needs
( ) Municipal bylaws control/manage the spread of noxious weeds
( ) Selling/leasing of municipal land

6.3 Other policy, tool or mechanism not mentioned?
6.4 Do all these policy components or tools apply to all municipal forests?

Residential encroachment policy implementation

7.1 Have all policy components been implemented?
7.2 Have they been implemented within all municipal forests?
7.3 What do you think are the barriers to implementation

Residential encroachment strategy/policy evaluation

8.1 Have policy components/tools been evaluated for their effectiveness?
8.2 Do you think that your policy/tools are effective?

Appendix B

Data Input Sheets

__Key to data input sheets__

Waste disposal- related activities

ASH: Fireplace or barbeque ash or charcoal
CRB: Construction rubble (e.g. bricks, concrete, lumber and other materials related to building or landscape construction)
CTR: Discarded Christmas Tree
CMP: Compost (Organic material made up of kitchen food waste)
CBN: Compost bins
FCD: Dog Feces
GRJ: Junk. Relatively large non-organic waste materials not food related nor construction-related, e.g. appliances or cars that are not being stored for future use.
GRM: Miscellaneous waste, such as paper, bottles, cans, bottle caps and other smaller waste materials many related to food packaging
GRN: Granular material such as top soil, sand, gravel, vermiculite, mulch or a mixture of these materials. This is distinguish from CGM (City placed granular material) by its position relative to the yard (city-placed material generally located adjacent to city-created pathways/beds). Beds closely related to residential boundaries may be placed by the resident or the city.
GRS: Grass clippings
ODD: Miscellaneous organic yard debris such as branches, whole or pruned pieces of herbaceous plants, shrubs or trees (not compost or city-cut hazardous trees (these latter tend to be characterized by large trunks and brances near these trunks)). Resident generated ODD may be piled on top of municipally-cut trees. Please categorize the evidence according to what is on top of the pile. Note: in some cases pile could be a community dumping pile. Please make a note that you suspect a community pile, even if it is not apparent in a quadrat.
HRC: Human placed rock e.g. flagstones, or rock thrown into the forest edge from the garden. This rock is distinguished from NRC (nature placed rock) by its type (e.g. slate in woodlots in which slate is not indigenous), form (e.g. sheets of rock where only round field stone form is indigenous), or its relationship to the earth (e.g. sits on top of earth instead of being embedded and or in piles).
LEF: piles of leaves (distinguished from naturally fallen leaves by their thickness/ size of the pile (naturally fallen leaves tend to be random thickness and less evenly spread)
PIP: Swimming pool discharge pipes and or pipes used to direct storm water run off from the yard into the forest edge.

Yard extension-related activities:

BUI: Construction of buildings or other structures (but not composters) within the forest edge (within a matrix of forest vs. within areas of the forest floor that are cleared (if buildings and/or structures are within areas in which the forest floor is cleared, a structure found within this area would be categorized as FFR (forest floor removal).
CUT: Cut trees and branches where you are not sure that they are dumped by the resident (e.g. hazard trees cut by the municipality.) Resident may add to the debris pile generated by this activity therefore confusion can exist as to whether the pile was generated by the city or the city and the resident combined. Record what is on top vs. underneath the pile. Therefore if you think resident cut organic debris is on the top of a municipally-cut tree/branches, then record this as ODD.
FFR: Forest floor removal. Areas in which forest floor is removed or partially removed but not replaced by lawn, herbaceous borders, patio-like areas, or invasive garden-related ground covers such as perriwinkle, gout weed or english ivy. This category takes precedent over other ways of categorizing these areas such as soil, native plants, exotic plants etc.

FIR: Stacked firewood
FIP: Fire rings generated by residents making fires within the forest edge
FRN: Lawn furniture e.g. swings, benches, picnic tables within the forest edge. If it sits within a patio like area, record area as PTO, not FRN.
GPX: Areas in which invasive garden plants have spread, such as perriwinkle, gout weed or english ivy. These areas may have been planted by the resident or not. The area must be adjacent to the residential boundary vs. an isolated island within the forest edge not clearly associated with the yard. Isolated islands of exotics will be recorded as VGX, or exotic plants. The native shrubs, saplings and/or trees may grow within the GPX or VGX areas, and will be recorded as NVG, native vegetation.
GPO: Garden pool
HTR: Hacked woody plants (individuals versus forest floor removal)
LNX: Areas of lawn extension
ODM: Old dump assumed to exist prior to residence built
OFN: Old fences assumed to exist prior to residence built
ORP: Old rock pile assumed to exist prior to residence built
POL: Swimming pool
PTO: Patio or deck
STR: Equipment, vehicle or other goods storage
VGX: Exotic vegetation not growing directly adjacent to the resident border, or clearly not planted by the resident

Recreation-related activities:

BAL: Any ball or piece of equipment related to recreation
FOR: Ground level play forts or homeless shelters
UPT: Unauthorized pathways (refered to as informal vs. formal pathways) created by residents but not necessarily the residents, or only the residents, living within the study residence.
SPR: Sports fields/courts such as horse shoe pits created by resident.

Forest-related elements:

BUR: wildlife burrows and nests
DET: forest floor detritus including leaves, dead woody material (not cut by municipality), shells, bones, cones etc.
FCO: the feces of wild animals
FUN: mushrooms, fungus and liverworts
MOS: Mosses and lichens
NRC: Rock that appears to be consistent in type, form and placement as other rocks apparent on the forest floor (usually embedded)
NVEG: Native vegetation (including edge vegetation, such as golden rod)
SOL: Bare soil

Municipal structures/activities:

SSB: Survey stakes or municipal bollards
APT: Authorized Pathways
MGM: City-placed granular material, e.g. gravel, mulch etc. usually located beside authorized Pathways or within city-created/maintained planting beds

Distance measurements and other information possibly related to encroachment activities:

BMRK: What structure, plant or marker demarcates the resident/municipal boundary?

0: Nothing
1: Resident-constructed fence or plant material that covers > 50% of the boundary
2: One or more survey stakes

3: One or more municipal bollards
4: Municipal fence and/or plant material that covers > 50% of the boundary
5: Resident or Municipal fence plus survey stake or municipal bollard

BTP: What type out of the following types characterizes the residential/municipal boundary?

(0) **Integration:** Lots where the residents have chosen not to demarcate the boundary shared with the municipally-managed forest, although there may be a survey stake or bollard at a corner where their lot meets their neighbours

(1) **Integration with Grass Strip:** Lots where the residents have chosen not to demarcate the boundary shared with the municipally-managed grass strip that exists between the residential boundary and the forest edge

(2) **Integration, Grass strip and Municipal Pathway:** Lots where the residents have chosen not to demarcate the boundary shared with the municipally-managed grass strip and pathway that exists between the residential boundary and the forest edge

(3) **Fence with Gate:** Lots where the residents have chosen to demarcate their boundary with a fence and gate that allows access to the forest edge

(4) **Fence with Gate, Grass Strip:** Lots where the residents have chosen to demarcate the boundary shared with the municipally-managed grass strip that exists between the residential boundary and the forest edge with a fence and gate

(5) **Fence with Gate, Grass Strip, Municipal Pathway:** Lots where the residents have chosen to demarcate the boundary shared with the municipally-managed grass strip and pathway, that exists between the residential boundary and the forest edge, with a fence with gate

(6) **Fence:** Lots where the residents or municipality has chosen to demarcate their boundary with a fence

(7) **Fence with Grass Strip:** Lots where the residents and or municipality has chosen to demarcate the boundary shared with the municipally-managed grass strip that exists between the residential boundary and the forest edge with a fence

(8) **Fence, Grass Strip, Municipal Pathway:** Lots where the residents and or municipality have chosen to demarcate the boundary shared between the municipally-managed grass strip and pathway, that exists between the residential boundary and the forest edge, with a fence.

Note: A grass strip is frequently used as a throughway, but unless an authorized pathway is clearly delineated, e.g. a strip of the grass is mown by the municipality) grass strips are categorized as not having a pathway.

IP: Are there unauthorized pathways of any orientation (either perpendicular or parallel to the residential border) within the study area (20 metres of border)?

Yes (1) No (0)

DUPB: Distance from the residential boundary to the closest unauthorized pathway that runs roughly parallel rather than perpendicular to the property boundary.
DUPQ: Distance from the quadrat to the closest unauthorized pathway that runs roughly parallel rather than perpendicular to the property boundary.
WUP: Width of the closest unauthorized pathway that runs roughly parallel rather than perpendicular to the property boundary

DAPB: Distance from the property boundary and the nearest authorized pathway that runs roughly parallel, rather than perpendicular, to the property boundary

DAPQ: Distance from the quadrat and the nearest authorized pathway that runs roughly parallel rather than perpendicular to the property boundary.

WAP: Width of the closest formal pathway that runs roughly parallel rather than perpendicular to the property boundary

DCDB: Distance between the property boundary and the canopy dripline of the first municipal forest edge tree with a dbh of > 10cm.

DCDQ: Distance between the quadrat and the canopy dripline of the first municipal forest edge tree with a dbh of > 10 cm.

DFTB: Distance between the property boundary and the trunk of the first municipal forest edge tree > 10 cm dbh.

DFTQ: Distance between the quadrat and the trunk of the first municipal forest edge tree > 10 cm dbh.

WGS: Width of the grass strip

DPTH: Distance between the property boundary and the pathway within or adjacent to the grass stip

WPTH: Width of the pathway within or adjacent to the grass strip

DEGS: Maximum distance between private boundary and encroachment evidence within grass strip

NB: Are there any natural barriers (e.g. a ditch, dense and/or prickly edge plants, large patches of poison ivy, prolific mosquitoes, sloping land etc)

(0) No significant barrier

(1) Partial and/or seasonal barrier that may impede encroachment activities at least part of the year

(2) Full barrier that impedes entry a significant amount of the year

HF: height of fence if any *(leave blank if no fence)*

TB: transparency of the boundary treatment

Transparent (0)

Semi-transparent (1)

Opaque (2)

SP: Does the resident own a swimming pool?

(1) yes

(0) no

ESD: What is the estimated amount of debris generated from this property? This is assumed to be a function of the area of the back yard, and the amount of plant material that is not lawn. Since it is difficult to compare yards on the basis of the amount of plant material, area was used as the indicator.

(0) < = 25m2

(1) 26-40 m2

(2) > 41 m2

CGR: Do the residents cut the grass in the strip?

(0) Residents do not cut the grass

(1) Residents sometimes cut the grass

(2) Residents only cut the grass

YW: Width of the yard

YD: Estimated depth of the back yard (often measured through measuring one side fence panel and counting number of panels from side of house)

NBT: Do the neighbours of the resident follow the same boundary treatment?

(0) Not the same

(1) One neighbour the same

(2) Both neighbours the same

Table B.1 Intensive study data input chart

Date:				Municipality							Forest name				Transect 1 (right)																
House Address:																															
Waste Disposal - related Activities														Yard Extension Related																	
QUD	ASH	CRB	CTR	CMP CBN	FCD	GRJ	GRM	GRN	GRS	ODD	HRC	LEF	PIP	BUI	CUT	FFR	FIW	FIP	FRN	GPX	GPO	GNX	HTR	LNX	ODM	OFN	ORP	POL	PTO	STR	VGX
1																															
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															
10																															
11																															

Date:				Municipality								Forest name			Transect 1 (right)															
House Address:																														
Recreation related					Forest related														Distance measurements											
QUD	BAL	FOR	UPT	SPR	BUR	DET	FCO	FUN	MOS	NRC	NVG	SOL	SSB	APT	MGM	BMRK	BTP	UP	DUPB	DUPQ	RP	DAPQ	WAP	DCDB	DCDQ	DFTB	DFTQ	WGS	DPTH	WPTH
1																														
2																														
3																														
4																														
5																														
6																														
7																														
8																														
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10																														
11																														

Table B.2 Extensive study data input chart

Date: :	Municipality	Forest name

Waste Disposal - related Activities															Yard Extension Related																	
ADDRESS	ASH	CRB	CTR	CMP	CBN	FCD	GRJ	GRM	GRN	GRS	ODD	HRC	LEF	PIP	BUI	CUT	FFR	FIW	FIP	FRN	GPX	GPO	GNX	HTR	LNX	ODM	OFN	ORP	POL	PTO	STR	VGX

Date: :	Municipality	Forest name

Recreation related					Maximum distance from the property boundary (or forest edge, if grass strip)	Notes
BAL	FOR	UPT	SPR			

Appendix C
Study Site Information

This appendix provides additional information about the study forests, subdivisions and sites within the intensive and extensive studies. It provides information about the municipal, residential and combined boundary demarcation policies and treatments implemented at the sites, in addition to other policies that may have influenced encroachment activities within the sites. I describe at least one study site for each municipality in detail to illustrate the range of natural areas, subdivisions and boundary treatments in the studies. I chose the sites that had the best aerial and digital photographs for communicating the site boundary types.

C.1 Municipality of Cambridge Study Sites

Residential boundary treatments are the primary variables that may influence residential encroachment activities within these sites. There was no municipal boundary demarcation, or other boundary treatment, within any of the study sites. Three resident boundary treatments were apparent in these two woodlots: no treatment (referred to as 'Integration'), Fence and Fence with gate. There were no visible survey stakes. Resident fences or adjacent resident fences were assumed to locate the legal property line.

Cambridge's has not implemented its encroachment policy within any of the intensive study sites (PM1, FM1) Cambridge has installed a 'no dumping sign' within the entry to Winston Blvd. Woodlot off Pezzack Street. Residential forest edges have been infrequently monitored for hazardous trees, encroachment and recreation-related negative impacts (FM1). No stewardship or education programs have been implemented (FM1).

Tables C.1 provides a summary of the intensive and extensive study sites in Cambridge according to the boundary treatment variables and other variables that may influence encroachment activities, including signage within the parks, stewardship programs, and management activities.

Table C.1 Cambridge study sites by address, boundary and management variables

Study [1]		Address	Boundary variables					Other Variables		
Int.	**Ext.**		**Surv. Stake.[2]**	**Mun. Boundary Policy Type[3]**	**Other Mun. Bound[4]**	**Res. Bound.[5]**	**Total Bound.[6]**	**Signage.[7]/ Stewardship.[8]**	**By-law enforce.[9]**	**Monitor.[10]**
	√	30 Pezzack St.		None		F	F	D/		IM
√	√	34 Pezzack St.		None		None	None	D/		IM
√	√	38 Pezzack St.		None		None	None	D/		IM
√	√	42 Pezzack St.		None		F	F	D/		IM
	√	46 Pezzack St.		None		None	None	D/		IM
√	√	50 Pezzack St.		None		F,G	F,G	D/		IM
	√	54 Pezzack St.		None		None	None	D/		IM
√	√	338 Winston Blvd.		None		F,G	F,G	D/		IM
√	√	**342 Winston Blvd.**		None		**F,G**	**F,G**	**D/**		**IM**
	√	346 Winston Blvd.		None		F,G	F,G	D/		IM
	√	350 Winston Blvd.		None		F,G	F,G	D/		IM
	√	354 Winston Blvd.		None		F	F	D/		IM
√	√	102 Kribs St.		None		F,G	F,G			IM
√	√	108 Kribs St.		None		F,G	F,G			IM
√	√	116 Kribs St		None		None	None			IM
√	√	120 Kribs St		None		None	None			IM
√	√	45 Thomas St.		None		F,G	F,G			IM
√	√	49 Thomas St.		None		F,G	F,G			IM
√	√	53 Thomas St.		None		F,G	F,G			IM
√	√	57 Thomas St.		None		F	F			IM
√	√	61 Thomas St.		None		F,G	F,G			IM
	√	65 Thomas St.		None		F,G	F,G			IM
	√	69 Thomas St.		None		F,G	F,G			IM

[1] Int. = Intensive Study; Ext. = Extensive Study; √ = site sampled in study
[2] √ = survey stake present; blank cell = no survey stake
[3] policy types = Fence-Corporate Policy (FCP); Fence-Condition of Development (FCD); Fence, gate (with permit)-Corporate Policy; Post ,Departmental practice (PDP); No policy (None)
[4] Grass strips or paths implemented to achieve goals not related to-encroachment mitigation
[5] Boundaries: MP = municipal Post; GS = grass strip; GS,P = grass strip, path; F,G = Fence (or thick hedge) with gate; F,G,GS = Fence (or thick hedge) with gate, grass strip; F,G,GS,P = Fence (or thick hedge) with gate, grass strip, path; F = Fence (or thick hedge); F,GS = Fence (or thick hedge), grass strip; F,GS,P= Fence (or thick hedge), grass strip, path; None = No or minimal treatment (e.g. a few small rocks or flower bed).
[6] All visible boundary treatments combined;
[7] Sign message: D = 'no dumping;' F = pick up dog waste; T = no damaging or removing trees, soils, wood; V = no vehicles; N = naturalization area; No fires = FI; Stay on trails (TR); no forts (FOR)
[8] (Year education or stewardship conducted); Blank cell = little active stewardship
[9] (Year by-law was enforced); blank cell = no recorded by-law enforcement
[10] IM = irregular monitoring; RM = regular monitoring

Fence with Gate Boundary Treatment: Winston Boulevard Woodlot at 342 Winston Blvd.

Winston Boulevard woodlot is a 5-hectare deciduous, second growth terrestrial fragment within the Hespeler community of Cambridge. Dominant tree species are Sugar maple, and American Beech, with some White ash, and Black Cherry, White pine and Red and White Oak. Dominant Under story species are Chokecherry and Alternate-leaved dogwood. Within most of the forest, the herbaceous layer is patchy, with large areas of exposed mineral soils surrounding recreational pathways that run through the centre of the forest. A significant proportion of this layer, within the outer forest edge, is composed of introduced plant species.

Continuous single-family detached housing largely surrounds the forest. A public elementary school lies along its western boundary, and a small parkette lies at its northeastern corner. An ‘X’ marks the location of the study site, 342 Winston Boulevard (Figure C.1).

Figure C.1: Winston Boulevard Woodlot, Cambridge, Ontario
Source: Region of Waterloo 2006 ortho imagery.

Developers built the single-family detached homes along Winston Boulevard in 1988. Most residential lots are approximately 16 metres wide by 33 metres deep, with a yard depth of approximately 8 metres. The first ‘naturally-established’ forest tree along this residential edge is located approximately 2.5 metres from the property line. The forest canopy stretches approximately 3 metres over the yards of the residents. The side canopy of the forest edge is partially closed. An ‘X’ locates 342 Winston Boulevard in Figure C.2. I have outlined the sample area within the forest edge immediately adjacent to the property line.

The resident has erected a 1.1-metre green chain link fence with a trellised gateway. A survey stake is apparent at the corner between this and the adjacent property indicating that the fence is on the boundary line. Figure C.3 shows the boundary treatment and part of the sample area for this site. The resident has cleared a portion of the forest vegetation, established a lawn within the forest edge, and Day lilies. Alternatively these latter plants may have spread, vegetatively, through the fence.

Figure C.2: Forest/residence boundary relationships at 342 Winston Blvd., Winston Boulevard Woodlot
Source: Region of Waterloo 2006 ortho imagery

Figure C.3: Fence with gate boundary treatment @ 342 Winston Boulevard
Source: W. McWilliam digital photography June 27, 2005.

C.2 Municipality of Guelph Study Sites

Boundary demarcation is the primary variable that may affect encroachment activities within all sites. There is a municipal fence demarcating the boundaries within the sites at Hanlon Creek and Marksam Parks. Guelph erected this fence in accordance with a Planning departmental boundary demarcation procedure that existed prior to 1996. This procedure specifies that the developer will pay for and erect a 1.5-metre black-vinyl chain link fence with 50mm fabric, with galvanized posts and rails between all areas of a stormwater management facility, wetland, parkland, walkway or greenway where they abut private property. Residents could install gates within the fence with City approval. In addition, residents within existing subdivisions could apply to have this fence put in, sharing the cost of doing so with the municipality. The year this procedure was established is unknown. The houses along Dovercliffe Road were not subject to this municipal boundary demarcation. Site residents have demarcated this boundary with a fence with gate. The municipality has established a grass strip between the residential boundary and the forest edge according to an official plan policy that requires a minimum area of active recreation space per resident. There are no survey stakes apparent along any of the property boundaries.

None of the residents in the study sites were approached regarding encroachment (J. Stokes, personal communication, January 18, 2007,). Marksam Park has entry signs that specify 'no dumping.' Parks staff monitored the residential edges of Hanlon Creek and Marksam Parks infrequently for hazardous trees, encroachment and recreational impacts. Some invasive species may also have been removed (FM2). Parks staff monitored the residential edge adjacent to Crane park more frequently while mowing the grass strip (J. Sperling, personal communication, July 21, 2004). In addition, some invasive species may have been cut down within the Crane Park forest edge (A. Berberich, District Park Manager, City of Guelph, personal communication, July 21, 2004). Tables C.2 provides a summary of the intensive and extensive study sites in Guelph according to the boundary treatment variables and other variables that may influence encroachment activities, including signage within the parks, stewardship programs, and management activities.

Table C.2: Guelph study sites by address, boundary and management variables

Study[1]		Address	Boundary treatment variables					Other variables		
Int.	Ext.		Surv. Stake.[2]	Mun. Boundary Policy Type[3]	Other Mun. Bound[4]	Res. Bound.[5]	Total Bound.[6]	Signage.[7]/ Stewardship.[8]	By-law enforce.[9]	Monitor.[10]
	√	138 Dovercliff		None	GS,P	F	F,GS,P	F/		RM
√	√	142 Dovercliff	None	None	GS,P	F,G	F,G,GS,P	F/		RM
√	**√**	**146 Dovercliff**	**None**	**None**	**GS,P**	**F,G**	**F,G,GS,P**	**F/**		**RM**
√	√	150 Dovercliff	None	None	GS,P	F,G	F,G,GS,P	F/		RM
	√	162 Dovercliff		None	GS,P	F,G	F,G,GS,P	F/		RM
	√	45 Koch Dr.		FCP	GS,P	None	F,GS,P			IM
	√	49 Koch Dr.		FCP	None	None	F			IM
	√	51 Koch Dr.		FCP	None	None	F			IM
	√	53 Koch Dr.		FCP	None	None	F			IM
	√	55 Koch Dr.		FCP	None	None	F			IM
	√	57 Koch Dr.		FCP	None	None	F			IM
	√	59 Koch Dr.		FCP	None	None	F			IM
	√	61 Koch Dr.		FCP	None	None	F			IM
√		63 Koch Dr.	None	FCP	None	None	F			IM
√		65 Koch Dr.	None	FCP	None	None	F			IM
√		67 Koch Dr.	None	FCP	None	None	F			IM

	√	68 Wimbeldon Rd.		None	None	F,G	F,G	D,F/		IM
	√	74 Wimbeldon Rd.		None	None	F,G	F,G	D,F/		IM
	√	76 Wimbeldon Rd.		None	None	F,G	F,G	D,F/		IM
	√	78 Wimbeldon Rd.		None	None	F,G	F,G	D,F/		IM
	√	92 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	94 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	96 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	98 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	100 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	102 Stephen Dr.		FCP	None	None	F	D,F/		IM
√		104 Stephen Dr.	None	FCP	None	None	F	D,F/		IM
√		106 Stephen Dr.	None	FCP	None	None	F	D,F/		IM
√		108 Stephen Dr.	None	FCP	None	None	F	D,F/		IM
	√	110 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	112 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	114 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	116 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	118 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	120 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	122 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	124 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	126 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	128 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	130 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	132 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	134 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	138 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	142 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	146 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	150 Stephen Dr.		FCP	None	None	F	D,F/		IM
	√	154 Stephen Dr.		FCP	None	None	F	D,F/		IM

[1] Int. = Intensive Study; Ext. = Extensive Study; √ = site sampled in study
[2] √ = survey stake present; None - no survey stake apparent; blank cell = no data
[3] policy types = Fence-Corporate Policy (FCP); Fence-Condition of Development (FCD); Fence, gate (with permit)-Corporate Policy; Post ,Departmental practice (PDP); No policy (None)
[4] Grass strips or paths implemented to achieve goals not related to-encroachment mitigation; no other municipal policy (none)
[5] Boundaries: MP = municipal Post; GS = grass strip; GS,P = grass strip, path; F,G = Fence (or thick hedge) with gate; F,G,GS = Fence (or thick hedge) with gate, grass strip; F,G,GS,P = Fence (or thick hedge) with gate, grass strip, path; F = Fence (or thick hedge); F,GS = Fence (or thick hedge), grass strip; F,GS,P= Fence (or thick hedge), grass strip, path; None = No or minimal treatment (eg. a few small rocks or flower bed); None = No or minimal boundary
[6] All visible boundary treatments combined;

[7] Sign message: D = ‘no dumping;’ F = pick up dog waste; T = no damaging or removing trees, soils, wood; V = no vehicles; N = naturalization area; No fires = FI; Stay on trails (TR); no forts (FOR)
[8] (Year education or stewardship conducted); Blank cell = little active stewardship
[9] (Year by-law was enforced); blank cell = no recorded by-law enforcement (note. data only recorded for intensive study sites)
[10] IM = irregular monitoring; RM = regular monitoring

Fence, Gate, Grass Strip and Path Boundary Treatment: Crane Park at 146 Dovercliffe Road

Crane Park is an approximately 15-hectare corridor lowland woodland that edges the Speed River. The Speed River bound the woodlot on its east side by continuous single-family detached housing and on the west side. An ‘X’ locates 146 Dovercliffe Road in Figure C.4. I have outlined the sample area within the forest edge. This photo was taken in 2000. Regeneration of the forest edge was more advanced in 2004 when the sampling was conducted, than is apparent within the photo in Figure C.4.

The woodlot is largely deciduous, second growth forest. The forest canopy is dominated by White cedar; however, Buckthorn predominates within the outer portion of the forest edge. White ash, black ash, sugar maple, and elderberry are also apparent. There were few understory species, and the herbaceous layer was non-existent. Relatively little recreation disturbance was apparent.

Figure C.4 Crane Park at 146 Dovercliffe Road
Source: Ortho imagery 2000, Grand River Conservation Authority

Figure C.5 Fence, gate, grass strip and path boundary treatment at 146 Dovercliffe Road
Source: W. McWilliam digital photograph November 3, 2005.

Developers built the single-family detached homes along Dovercliffe Road in approximately 1974. Most of the lots are approximately 16 metres wide by approximately 50 metres deep. Yard depth is approximately 28 metres. The housing is low density, with a mean housing density for the district of x houses/ ha. The first 'naturally-established' forest tree along this residential edge is located approximately 12 metres from the property line. The forest canopy does not stretch over the yards of the residents, but rather over the grass strip and pathway. The side canopy of the forest edge is closed. Although the grass strip is approximately 7 metres in width, the city is only currently mowing a two-metre strip centred on an informally created pathway. Residents periodically mow the remainder of this grass strip behind their homes (Pers. Con. with resident at 146 Dovercliffe Road, Sept. 4, 2004). The resident at 146 has erected a 1.5-metre chain link fence with a gate. (Figure C.5).

C.3 Municipality of Kitchener Study Sites

There is no municipal boundary demarcation within any of the Kitchener study sites, except for one site in Tilt's Bush where there is a municipal boundary post. However, all sites in Tilt's Bush are subject to the municipal post policy (a departmental practice). Survey stakes were visible along the boundaries of eight out of the fifty-one study sites. The City of Kitchener has also established grass strips between the forest edges and private property boundaries within three its natural areas, Arrowhead Park, Idlewood Park (at Wren Place) and Meinzinger Park (at Southmoor Drive). The municipality mows the strips regularly with widths ranging from 13 to 26 metres. Kitchener has also established grass strips and paths between the residential boundaries and two other natural areas, Stanley Park (at Hallwell and Hickson) and Georgian Park (at Matthew Court). These grass strips are mown regularly and, together with their pathways, have widths ranging from 4 to 33 metres.

Two of the study sites (Stanley Park Conservation Area and Chicopee Conservation Area) belong to the GRCA (Grand River Conservation Authority), but the City of Kitchener manages them. The GRCA has a current unwritten practice for developers to erect a 1.5 metres chain link fence, without gates (D.G.Graham Ltd. 1996). However, there is no GRCA boundary demarcation at either of the study natural areas.

In 1996, Forestry staff conducted an encroachment survey along the entire forest edge of Stanley Park Conservation Area, Forfar Park, Idlewood Park (at Idlewood Drive), Tilt's bush, and Monarch Woods. Shortly afterward, the forestry staff approached some of the encroachers to educate them about their encroachments and ask them to remove them. Staff was unable to say which residences were approached. Staff also installed some 'no dumping' signs within Stanley Park along the residential edge where people were dumping yard waste. Some residents complained about the signs and the forestry department had to remove many of them. Since then there are no records of the City contacting any of the study site residents regarding encroachment (FM3, BE2).

Kitchener has signs installed within most of the entries to its natural areas prohibiting a variety of encroachment activities (dumping, damaging trees, forts, fires, and going off trails). The study natural areas have received monitoring for hazardous trees, residential encroachment, and recreation affects every three years (FM3). The city has developed a number of leaflets on encroachment, but they have been infrequently distributed (FM3). Although the City of Kitchener received a Trillium foundation grant to encourage education and stewardship of residents in 2006, this program had not been implemented within the study areas at the time of the field research. (FM3). The GRCA has not implemented any additional measures to address encroachment within Stanley Park and Chicopee Conservation Areas (PM3). Table C.3 summarizes the intensive and extensive study sites in Kitchener by boundary treatment.

Table C.3 Kitchener study sites by address, boundary and management variables

Study		**Address**	**Boundary Variables**					**Other variables**		
Int.	**Ext.**		**Surv. Stake**[2]	**Mun. Boundary Policy Type**[3]	**Other Mun. Bound**[4]	**Res. Bound.**[2]	**Total Bound.**[5]	**Signage.**[6]**/ Stewardship**[7]	**By-law enforce.**[8]	**Monitor.**[9]
√	√	106 Arrowhead Cr.	None	None	GS	F,G	F,G,GS	D,T,V,FI,TR/		IM
	√	40 Underhill Cr.		None	None	F,G	F,G			IM
√	√	44 Underhill Cr.	None	None	None	F,G	F,G			IM
	√	48 Underhill Cr.		Non	None	F,G	F,G			IM
	√	52 Underhill Cr.		Non	None	F,G	F,G			IM
	√	56 Underhill Cr.		Non	None	F	F			IM
	√	60 Underhill Cr.		Non	None	F	F			IM
	√	64 Underhill Cr.		Non	None	F,G	F,G			IM
√	√	68 Underhill Cr.	None	Non	None	F,G	F,G			IM
	√	70 Underhill Cr.		Non		F,G	F,G			IM
√	√	341 Country Hills Dr.	None	None		None	None			IM
√	√	345 Country Hills Dr.	√	None		None	None			IM
	√	346 Country Hills Dr.		Non		F,G	F,G			IM
	√	347 Country Hills Dr.		Non		None	None			IM
√	√	349 Country Hills Dr.	√	Non		None	None			IM
	√	320 Carson Rd.		Non		F,G	F,G	D,T,TR,FOR/		IM
	√	326 Carson Rd.		Non		F,G	F,G	D,T,TR,FOR/		IM

√	√	332 Carson Rd.	None	Non		None	None	D,T,TR,FOR/		IM
	√	340 Carson Rd.		Non		F,G	F,G	D,T,TR,FOR/		IM
	√	346 Carson Rd.		Non		F,G	F,G	D,T,TR,FOR/		IM
√	√	615 Manchester Rd.	None	None		F,G	F,G	D,T,TR,FOR/		IM
√	√	623 Manchester Rd.	None	None		None	None	D,T,TR,FOR/		IM
√	√	627 Manchester Rd.	None	None		F,G	F,G	D,T,TR,FOR/		IM
√	√	631 Manchester Rd.	None	None		F,G	F,G	D,T,TR,FOR/		IM
	√	1 Marketa Cr.		None		None	None			IM
√	√	3 Marketa Cr.	None	None		None	None			IM
√	√	5 Marketa Cr.	None	None		F,G	F,G			IM
√	√	7 Marketa Cr.	None	None		F,G	F,G			IM
√	√	9 Marketa Cr.	None	None		F,G	F,G			IM
√		14 Matthew Ct.	None	None	GS,P/CP	F,G	F.G,GS,P			IM
√		18 Matthew Ct.	None	None	GS,P/CP	F,G	F,G,GS,P			IM
√		22 Matthew Ct.	None	None	GS,P/CP	F,G	F,G,GS,P			IM
	√	8 Idlewood	None	None		F,G	F,G	D,F,V,T,TR,FOR/		IM
√	√	12 Idlewood	None	None		F,G	F,G	D,F,V,T,TR,FOR/		IM
√	√	16 Idlewood	√	None		F/G	F,G	D,F,V,T,TR,FOR/		IM
	√	20 Idlewood		None		F/G	F,G	D,F,V,T,TR,FOR/		IM
	√	24 Idlewood		None		F/G	F,G	D,F,V,T,TR,FOR/		IM
√	√	28 Idlewood	√	None		None	None	D,F,V,T,TR,FOR/		IM
	√	32 Idlewood		None		F/G	F,G	D,F,V,T,TR,FOR/		IM
√	√	36 Idlewood	None	None		None	None	D,F,V,T,TR,FOR/		IM
√	√	40 Idlewood	√	None		None	None	D,F,V,T,TR,FOR/		IM
√	√	44 Idlewood	√	None		None	None	D,F,V,T,TR,FOR/		IM
	√	48 Idlewood		None		F,G	F,G	D,F,V,T,TR,FOR/		IM
	√	52 Idlewood		None		None	None	D,F,V,T,TR,FOR/		IM
	√	83 Wren		None		F,G	F,G			IM
√		87 Wren	None	None	GS	F,G	F,G,GS			IM
√		91 Wren	None	None	GS	F,G	F,G,GS			IM
√		95 Wren	None	None	GS	F,G	F,G,GS			IM
√		99 Wren	None	None	GS	F,G	F,G,GS			IM
√		103 Wren	None	None	GS	None	GS			IM
√		107 Wren	√	None	GS	None	GS			IM
√	√	97 Southmoor Dr.	None	None	GS	F,G	F,G,GS	D.F/		IM
√	√	111 Southmoor Dr.	None	None	GS	F,G	F,G,GS	D.F/		IM
√	√	113 Southmoor Dr.	None	None	GS	F,G	F,G,GS	D.F/		IM
√	√	117 Southmoor Dr.	None	None	GS	F,G	F,G,GS	D.F/		IM
√	√	14 Stoke Cr.	None	None		F	F	D,F,V/		IM
√		18 Stoke Cr.	√	None		F	F	D,F,V/		IM
√		24 Stoke Cr.	None	None		None	None	D,F,V/		IM
√	√	28 Stoke Cr.	None	None		None	None	D,F,V/		IM
	√	32 Stoke Cr.		None		None	None	D,F,V/		IM
	√	36 Stoke Cr.		None		None	None	D,F,V/		IM
	√	40 Stoke Cr.		None		None	None	D,F,V/		IM
	√	90 Stoke Cr.		None		None	None	D,F,V/		IM
	√	94 Stoke Cr.		None		F,G	F,G	D,F,V/		IM
√	√	98 Stoke Cr.	None	None		F,G	F,G	D,F,V/		IM
√	√	102 Stoke Cr.	√	None		F,G	F,G	D,F,V/		IM
	√	134 Stoke Cr.		None	GS,P	None	GS,P	D,F,V/		IM

	√	138 Stoke Cr.		None	GS,P	F,G	F,G,GS, P	D,F,V/		IM
	√	142 Stoke Cr.		None	GS,P	F,G	F,G,GS, P	D,F,V/		IM
	√	252 Stoke Cr.		None		F,G	F,G	D,F,V/		IM
	√	256 Stoke Cr.		None		None	None	D,F,V/		IM
	√	260 Stoke Cr.		None		None	None	D,F,V/		IM
	√	274 Stoke Cr.		None		None	None	D,F,V/		IM
	√	278 Stoke Cr.		None		None	None	D,F,V/		IM
	√	282 Stoke Cr.		None		None	None	D,F,V/		IM
√	√	92 Hickson	√	None		None	None	D,F/		IM
	√	96 Hickson	√	None		None	None	D,F/		IM
	√	100 Hickson		None		None	None	D,F/		IM
	√	104 Hickson		None		None	None	D,F/		IM
	√	108 Hickson		None		F,G	F,G	D,F/		IM
	√	112 Hickson		None		F,G	F,G	D,F/		IM
	√	116 Hickson		None		F,G	F,G	D,F/		IM
	√	120 Hickson		None		F,G	F,G	D,F/		IM
√	√	124 Hickson	None	None	GS,P	F,G	F,G,GS, P	D,F/		IM
√	√	128 Hickson	None	None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	132 Hickson		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	12 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	20 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	24 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	28 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	32 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	36 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	40 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	44 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	48 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	52 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	56 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	60 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	64 Hallwell		None	GS,P	None	GS,P	D,F/		IM
	√	68 Hallwell		None	GS,P	None	GS,P	D,F/		IM
	√	76 Hallwell		None	GS,P	F,G	F,G,GS, P	D,F/		IM
√	√	80 Hallwell	None	None	GS,P	F,G	F,G,GS, P	D,F/		IM
√	√	84 Hallwell	None	None	GS,P	F,G	F,G,GS, P	D,F/		IM
	√	69 Sabrina		PDP		F,G	F,G	D,F/		IM
	√	73 Sabrina		PDP		F,G	F,G	D,F/		IM
√	√	77 Sabrina	None	PDP		F,G	F,G	D,F/		IM
√	√	81 Sabrina	None	PDP		F	F	D,F/		IM
√	√	85 Sabrina	√	PDP		None	MP	D,F/		IM
√	√	**215 Bechtel Dr.**	None	PDP		**F**	**F**	D,F		IM
	√	217 Bechtel Dr.		PDP		F,G	F,G	D,F		IM
	√	219 Bechtel Dr.		PDP		F,G	F,G	D,F		IM
	√	221 Bechtel Dr.		PDP		F	F	D,F		IM
	√	223 Bechtel Dr.		PDP		F	F	D,F		IM
√	√	225 Bechtel Dr.	None	PDP		F,G	F,G	D,F/		IM

√	√	227 Bechtel Dr.	None	PDP		F	F	D,F/		IM
√	√	229 Bechtel Dr.	None	PDP		F,G	F,G	D,F/		IM

[1] Int. = Intensive Study; Ext. = Extensive Study; √ = site sampled in study
[2] √ = survey stake present; None - no survey stake apparent; blank cell = no data
[3] policy types = Fence-Corporate Policy (FCP); Fence-Condition of Development (FCD); Fence, gate (with permit)-Corporate Policy; Post ,Departmental practice (PDP); No policy (None)
[4] Grass strips or paths implemented to achieve goals not related to-encroachment mitigation; no other municipal policy (none)
[5] Boundaries: MP = municipal Post; GS = grass strip; GS,P = grass strip, path; F,G = Fence (or thick hedge) with gate; F,G,GS = Fence (or thick hedge) with gate, grass strip; F,G,GS,P = Fence (or thick hedge) with gate, grass strip, path; F = Fence (or thick hedge); F,GS = Fence (or thick hedge), grass strip; F,GS,P= Fence (or thick hedge), grass strip, path; None = No or minimal treatment (eg. a few small rocks or flower bed); None = No or minimal boundary
[6] All visible boundary treatments combined;
[7] Sign message: D = 'no dumping;' F = pick up dog waste; T = no damaging or removing trees, soils, wood; V = no vehicles; N = naturalization area; No fires = FI; Stay on trails (TR); no forts (FOR)
[8] (Year education or stewardship conducted); Blank cell = little active stewardship
[9] (Year by-law was enforced); blank cell = no recorded by-law enforcement (note. data only recorded for intensive study sites)
[10] IM = irregular monitoring; RM = regular monitoring

Fence Boundary Treatment: Tilt's Bush at 215 Bechtel Drive

Tilt's Bush is located in the southwestern corner of Kitchener. This mixed 44-hectare corridor surrounds Strasburg Creek. It is 135 to 200 metres wide. The study site, 215 Bechtel Drive is marked with an 'X' in Figure C.6.

Figure C.6: Tilt's Bush at 215 Bechtel Drive
Source: Region of Waterloo 2004 Ortho Imagery

The semi-detached, single-family residences along Bechtel Drive are 30 years old. The Lots are approximately 9 metres wide, with varying lot and yard depths. The lot depth of 215 Bechtel is 44 metres, with a yard depth of 20 metres. The gross district housing density is 9 houses per hectare. The first 'naturally-established forest tree is located at the boundary and the forest tree canopies hang up to 4 metres over residential yards. The side canopy of the forest is largely open. In Figure C.7, 215 Bechtel is marked with an 'X' and the sample area is outlined in red.

The resident at 215 Bechtel Drive has erected a 1.2-metre snow fence along the property line. Although there are no visible survey stakes, the fence is in alignment with those of neighbouring properties. Figure C.8 illustrates the fenced boundary, and a large amount of organic debris dumped over the fence into the forest edge.

Figure C.7: Forest/residence boundary relationships at 215 Bechtel Dr., Tilt's Bush
Source: Region of Waterloo 2006 Ortho Imagery

Figure C.8: Fenced boundary treatment at 215 Bechtel Dr., Kitchener, Ontario
Source: W. McWilliam, Digital photograph October 20, 2005

C.4 Municipality of Mississauga Study Sites

The study sites within Deer Run Park have municipal fences. The City of Mississauga negotiated the fence as a condition of development. No other site has municipal boundary demarcation. One of the natural areas has a mown grass strip (Willowcreek Park) and three of the natural areas (all the Applewood Hills Park natural areas) have mown grass strips and paths, established between their forest edges and the abutting residences. The grass strips, together with paths, have average widths of between 16- 30 metres. These areas were established, according to official plan policy, to provide active recreation facilities, and linkages between natural areas and subdivisions. Residents have established their own boundary demarcations including no boundary demarcation, fence with gates, and less frequently, fences. Survey stakes were visible in five out of fifty-four study sites.

Forestry staff responded to reported encroachments within Camilla Park, Britannia Woods, Tom Chater, and Creditview woods between 1998 and 2002 under the authority of their Parks by-law. They identified encroachments within all the study sites at Camilla Park in 1998, and Britannia Woods in 2000. Mississauga sent letters to these residents requesting the removal of the encroachments. Compliance to this request was not field checked within Camilla Park, and residents had not complied within Britannia Woods by 2002 when forestry staff conducted a field check. The City did not identify encroachments within the study sites at Tom Chater Park or Creditview woods (Email Jan. 17, 2006 from S. Butt, Assistant to Forest Ecologist, City of Mississauga).

The City began to proactively survey for encroachments with all their woodlots in 2004. The encroachments were still apparent in Britannia Woods at this time. Letters were re-sent to these residents, under the authority of the new 2004 encroachment by-law, but by the summer of 2005, the encroachments had not been removed, nor had land leases or purchases been secured (Email Jan. 17, 2006 from S. Butt, Assistant to Forest Ecologist, City of Mississauga). Creditview and Deer Run Parks were monitored for encroachment in 2005, but no encroachments were identified within the study sites. No lease or purchase agreements were signed with any of the residents of the study sites as of 2005 (Pers. con. S. Butt, Jan. 22, 2007).

There is a ‘no dumping’ sign at the entry to Creditview Park, and a sign that prohibits the damage or removal of trees, soils and wood posted at the entry to Deer Run Parr. None of the other natural areas have signs installed that educate residents regarding encroachment activities. Management of the residential edge has largely been in response to resident calls regarding hazardous trees or encroachments. The City may have conducted periodic monitoring for garbage, tree forts, and hazardous trees within these natural areas. This is done at the discretion of the district managers (FM4).

Education of residents has occurred periodically in the past, but there is little record of these activities. Individual residents may have received some education through direct contact with forestry staff, or through talks given by the Forest ecologist and Forest manager at community group meetings managers (FM4). Some district forest managers have distributed pamphlets to all their edge residents, but this has occurred informally at the discretion of district managers, and there are few records of these activities. Between 2002 and 2003, the district manager hand delivered brochures regarding encroachment to the edge residents surrounding both Applewood Creek and Britannia woods (FM6). Between 2004 and 2005 the forestry department sent letters and brochures to the encroaching residents within Britannia woods following the identification of their encroachments. Table C.4 summarizes the intensive and extensive study sites in Mississauga by boundary treatment.

Table C.4: Mississauga Study Sites, boundary and management variables

Study[1]		Address	Boundary variables					Other variables		
Int.	**Ext.**		**Surv. Stake[2]**	**Mun. Boundary Policy Type[3]**	**Other Mun. Bound[4]**	**Res. Bound.[2]**	**Total Bound.[5]**	**Signage.[6]/ Stewardship.[7]**	**By-law enforce.[8]**	**Monitor.[9]**
√		3414 Grand Forks Dr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		3424 Grand Forks Dr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		3430 Grand Forks Dr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		3434 Grand Forks Dr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		3440 Grand Forks Dr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		4260 Greybrook Cr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		4262 Greybrook Cr.	None	None	GS,P	F	F,GS,P	F/IE		IM
√		4266 Greybrook Cr.	√	None	GS,P	None	GS,P	F/IE		IM
√		4268 Greybrook Cr.	√	None	GS,P	None	GS,P	F/IE		IM
√		3272 Lonefeather Cr.	None	None	GS,P	None	GS,P	F/IE		IM
√		3284 Lonefeather Cr.	None	None	GS,P	F,G	F,G,GS,P	F/IE		IM
√		3288 Lonefeather Cr.	None	None	GS,P	None	GS,P	F/IE		IM
√		3199 Queen Frederica Dr.	None	None	GS	F,G	F,G,GS	F/IE		IM
	√	443 Turnberry Cr.		None		F,G	F,G	F/IE	(2000)	IM
	√	447 Turnberry Cr.		None		None	None	F/IE	(2000)	IM
√	√	451 Turnberry Cr.	None	None		None	None	F/IE	(2000)	IM
√	√	455 Turnberry Cr.	None	None		F,G	F,G	F/IE	(2000)	IM
√	√	459 Turnberry Cr.	None	None		F,G	F,G	F/IE	(2000)	IM
√	√	463 Turnberry Cr.	√	None		None	None	F/IE	(2000)	IM
√	√	467 Turnberry Cr.	√	None		None	None	F/IE	(2000)	IM
√	√	471 Turnberry Cr.	√	None		None	None	F/IE	(2000)	IM
	√	475 Turnberry Cr.		None		None	None	F/IE	(2000)	IM
	√	479 Turnberry Cr.		None		None	None	F/IE	(2000)	IM
	√	483 Turnberry Cr.		None		None	None	F/IE	(2000)	IM
	√	487 Turnberry Cr.		None		None	None	F/IE	(2000)	IM
	√	497 Turnberry Cr.	√	None		F,G	F.G	F/IE	(2000)	IM
	√	503 Turnberry Cr.	√	None		F	F	F/IE	(2000)	IM
√	√	2200 Camilla Road	None	None		F	F	F/	(1998)	IM
√	√	2206 Camilla Road	None	None		F,G	F,G	F/	(1998)	IM
√	√	2212 Camilla Road	None	None		F,G	F,G	F/	(1998)	IM
√	√	2216 Camilla Road	None	None		F,G	F,G	F/	(1998)	IM
√	√	2222 Camilla Road	None	None		F	F	F/	(1998)	IM
√		4210 Wakefield	None	None		F,G	F,G	F,D,V/		IM
√		4214 Wakefield	None	None		None	None	F,D,V/		IM
√	√	4234 Wakefield	None	None		F	F	F,D,V/		IM
√	√	4238 Wakefield	None	None		F,G	F,G	F,D,V/		IM
√	√	4242 Wakefield	None	None		F	F	F,D,V/		IM
√	√	4246 Wakefield	None	None		F,G	F,G	F,D,V/		IM
	√	4250 Wakefield		None		F,G	F,G	F,D,V/		IM
√		808 Buckingham	None	None		None	None	F,D,V		IM
√		1044 Deer Run Rd.	None	FCD		None	F	F,T/		IM
	√	1100 Deer Run Rd.		FCD		None	F	F,T/		IM
	√	1104 Deer Run Rd.		FCD		None	F	F,T/		IM
	√	1108 Deer Run Rd.		FCD		None	F	F,T/		IM
	√	1112 Deer Run Rd.		FCD		None	F	F,T/		IM
	√	1116 Deer Run Rd.		FCD		None	F	F,T/		IM
	√	4072 Deer Run Ct.		FCD		None	F	F,T/		IM
	√	4076 Deer Run Ct.		FCD		None	F	F,T/		IM
√	√	4080 Deer Run Ct.	None	FCD		None	F	F,T/		IM
√	√	4159 Deer Run Ct.	None	FCD		None	F	F,T/		IM
√	√	4163 Deer Run Ct.	None	FCD		None	F	F,T/		IM
	√	4167 Deer Run Ct.		FCD		None	F	F,T/		IM
	√	4171 Deer Run Ct.		FCD		None	F	F,T/		IM

	√	1211 Shagbark Cr.		FCD		None	F	F,T/		IM
	√	1213 Shagbark Cr.		FCD		None	F	F,T/		IM
	√	1217 Shagbark Cr.		FCD		None	F	F,T/		IM
	√	1219 Shagbark Cr.		FCD		None	F	F,T/		IM
	√	1223 Shagbark Cr.		FCD		None	F	F,T/		IM
	√	1225 Shagbark Cr.		FCD		None	F	F,T/		IM
	√	1229 Shagbark Cr.		FCD		F,G	F,G	F,T/		IM
√		1306 Dexter Cr.	None	None		F,G	F,G	F/		IM
√	√	1310 Dexter Cr.	None	None		F,G	F,G	F/		IM
√	√	1314 Dexter Cr.	None	None		F,G	F,G	F/		IM
√	√	1318 Dexter Cr.	None	None		None	None	F/		IM
√	√	1322 Dexter Cr.	None	None		None	None	F/		IM
√	√	1326 Dexter Cr.	None	None		None	None	F/		IM
√		3091 Fieldgate Dr.	None	None	GS	F,G	F,G,GS			IM
√		3093 Fieldgate Dr.	None	None	GS	F,G	F,G,GS			IM
√		3095 Fieldgate Dr.	None	None	GS	F,G	F,G,GS			IM
	√	3569 Colonial Dr.		None		None	None	F,V/		IM
	√	3573 Colonial Dr.		None		None	None	F,V/		IM
	√	3579 Colonial Dr.		None		None	None	F,V/		IM
	√	3581 Colonial Dr.		None		None	None	F,V/		IM
	√	3585 Colonial Dr.		None		F,G	F,G	F,V/		IM
√		3593 Colonial Dr.	None	None		None	None	F,V/		IM
√		3589 Colonial Dr.	None	None		None	None	F,V/		IM
√		3601 Colonial Dr.	None	None		None	None	F,V/		IM
√		3605 Colonial Dr.	None	None		None	None	F,V/		IM
	√	3473 Kelso Cr.		None		F/G	F/G	F,V/		IM
	√	3477 Kelso Cr.		None		F/G	F/G	F,V/		IM
	√	3481 Kelso Cr.		None		F/G	F/G	F,V/		IM
	√	3485 Kelso Cr.		None		F/G	F/G	F,V/		IM
	√	3489 Kelso Cr.		None		F/G	F/G	F,V/		IM
√	√	3493 Kelso Cr.	None	None		F,G	F,G	F,V/		IM
√	√	3497 Kelso Cr.	None	None		F,G	F,G	F,V/		IM
	√	3501Kelso Cr.		None		F,G	F,G	F,V/		IM
√		3505 Kelso Cr.	None	None		F,G	F,G	F,V/		IM

[1] Int. = Intensive Study; Ext. = Extensive Study; √ = site sampled in study
[2] √ = survey stake present; None - no survey stake apparent; blank cell = no data
[3] policy types = Fence-Corporate Policy (FCP); Fence-Condition of Development (FCD); Fence, gate (with permit)-Corporate Policy; Post ,Departmental practice (PDP); No policy (None)
[4] Grass strips or paths implemented to achieve goals not related to-encroachment mitigation; no other municipal policy (none)
[5] Boundaries: MP = municipal Post; GS = grass strip; GS,P = grass strip, path; F,G = Fence (or thick hedge) with gate; F,G,GS = Fence (or thick hedge) with gate, grass strip; F,G,GS,P = Fence (or thick hedge) with gate, grass strip, path; F = Fence (or thick hedge); F,GS = Fence (or thick hedge), grass strip; F,GS,P= Fence (or thick hedge), grass strip, path; None = No or minimal treatment (eg. a few small rocks or flower bed); None = No or minimal boundary
[6] All visible boundary treatments combined;
[7] Sign message: D = 'no dumping;' F = pick up dog waste; T = no damaging or removing trees, soils, wood; V = no vehicles; N = naturalization area; No fires = FI; Stay on trails (TR); no forts (FOR)
[8] (Year education or stewardship conducted); Blank cell = little active stewardship
[9] (Year by-law was enforced); blank cell = no recorded by-law enforcement (note. data only recorded for intensive study sites)
[10] IM = irregular monitoring; RM = regular monitoring

<u>Integration Boundary Treatment</u>: Britannia Woods at 471 Turnberry Crescent

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Brittania Woods is located northwest of central Mississauga. The study site is located within Britannia woods west, which is a 6-hectare mesic deciduous forest fragment. A subdivision lies along its southern and western edges. A small pocket of industry is located along its northwestern edge. An 'X' marks the location of 471 Turnberry Crescent in Figure C.9.

The topography of the site is rolling, with some steeply sloping areas. The forest canopy closed and is dominated by 90 to 110 year old Sugar maple (*Acer saccharum ssp. saccharum*), and American beech (*Fagus Americana*). Dominant under story species are Choke cherry (*Prunus virginica ssp. virginiana*) and Alternate-leaved Dogwood (*Cornus alternifolia*). Common herb species include Running strawberry bush (*Euonymus obovata*), and White trillium *Trillium grandilorum*). (Mississauga. Natural Areas Survey 2005).

Continuous single-family detached housing characterizes the subdivision. Residential lots along Turnberry Street are approximately 10 metres wide by 30 metres deep, with yard depths of approximately 6 metres. The mean housing density for the gross district housing density is 16 houses per hectare. The first forest tree stands at the property line and the canopy stretches approximately five metres onto the properties of the residents. The side canopy is open. Figure C.10 illustrates the boundary relationships between the residential properties and the forest edge. An 'X' marks the location of 471 Turnberry Avenue. The curved lines indicate the area of lawn extension encroachments visible in the aerial photograph. The rectangle outlines the approximate location of the sample site. In this study site the encroachment area is not visible in the aerial photograph because of the overhanging tree canopy.

The resident at 471 Turnberry Avenue has chosen to demarcate his boundary with a garden. Survey stakes were apparent between some of the lots indicating the property boundary. Figure C.11 illustrates the no, or minimal boundary demarcation treatment, and the area of encroachment (indicated in bright green).

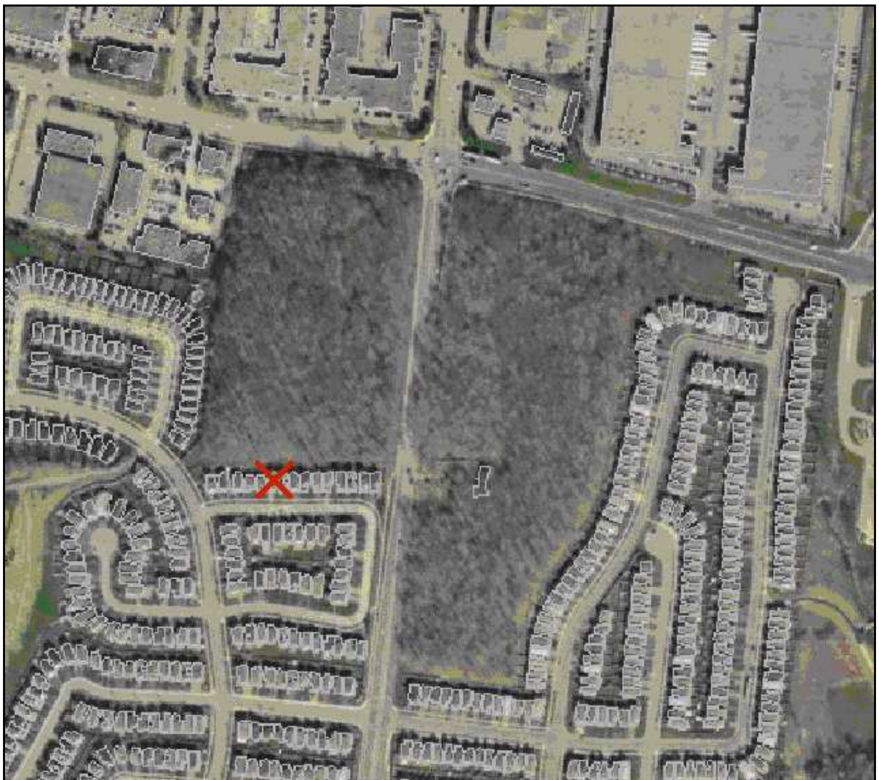

Figure C.9: Britannia Woods (west) at 471 Turnberry Crescent, Mississauga, Ontario
Source: City of Mississauga 2004 Aerial Photograph

Figure C.10 Forest/housing boundary relationships at 471 Turnberry Ave., Brittania Woods (west)
Source: City of Mississauga 2006 Aerial Photograph

Figure C.11 Integration/No boundary treatment at 471 Turnberry Ave.
Source: W. McWilliam Digital Photograph September 8, 2004

C.5 Municipality of Oakville Study Sites

All the sites had a 1.2m municipal fence, according to the 1984 fencing policy. Residents at 2180, 2182, 2184, 2188 and 2190 Margot installed their own fences or hedges along side the municipal fence. Residents at 182 Chalmers Street (Village Wood Park) and 2164 Oakmead Place (Pelee Woods) installed illegal gates within the municipal fence.

The City of Oakville established a mown grass strip, and a mown grass strip and path between the abutting residences and the forest edges at Beechnut and Margot Parks, respectively. The width of the grass strip at Beechnut Park was a mean of 17 metres. The mown grass strips and paths were established in fulfillment of Oakville official plan recreation-related policies. According to the 1984 fencing policy, residents adjacent to active park areas could apply for gate permits. The study sites at Margot Park and Beechnut Park were subject to this policy, but none of the study site residents installed gates. Survey stakes were not visible along any of the boundaries of the study sites.

The bylaw has not been enforced within any of the intensive study areas (Email from P. Bouillon, Assistant Town Clerk, City of Oakville, Feb. 11, 2007). Oakville has infrequently monitored the residential boundaries for hazardous trees, encroachments, recreation impacts and other safety-related concerns. However, Oakville monitors Margot Park regularly because of the existence of the trail adjacent to the residential edge. An employee drives a six-wheeled vehicle along all natural area trails to identify any of the above issues (FM5) Under the authority of the Parks by-law, signs prohibiting dumping and the removal of plants, soil and wood, have been placed at the entry points of four out of the nine parks sampled. Margot Park may have been subject to Oakville's trail and park adoption program that encourages residents or groups to monitor trails for encroachment (FM5). Table C.5 summarizes the intensive and extensive study sites in Oakville by boundary treatment.

Table C.5 Oakville study sites, boundary treatments, management, and waste collection

Study[1]		Address	Boundary variables					Other variables		
Int.	Ext.		Surv. Stake.[2]	Mun. Boundary Policy Type[3]	Other Mun. Bound[4]	Res. Bound.[5]	Total Bound.[6]	Signage.[7]/ Stewardship.[8]	By-law enforce.[9]	Monitor.[10]
√		356 Aspen Forest Dr.		FGCP	GS	None	F,GS	D,F,T/IE		IM
√		358 Aspen Forest Dr.		FGCP	GS	None	F,GS	D,F,T/IE		IM
√		360 Aspen Forest Dr.		FGCP	GS	None	F,GS	D,F,T/IE		IM
	√	394 Bonney Meadow Rd.		FCP		None	F	D,F,T/IE		IM
	√	398 Bonney Meadow Rd.		FCP		None	F	D,F,T/IE		IM
	√	2314 Bow Valley Ct.		FCP		None	F	D,F,T/IE		IM
	√	2316 Bow Valley Ct		FCP		Gate	F,G	D,F,T/IE		IM
	√	2318 Bow Valley Ct		FCP		None	F	D,F,T/IE		IM
√	√	1304 Sir. David Dr.		FCP		None	F	/IE		IM
√	√	1308 Sir. David Dr.		FCP		None	F	/IE		IM
	√	1312 Sir. David Dr.		FCP		None	F	/IE		IM
√	√	1316 Sir. David Dr.		FCP		None	F	/IE		IM
	√	2297 Barrister Place		FCP		None	F	/IE		IM
	√	2301 Barrister Place		FCP		None	F	/IE		IM

	√	1432 Stationmaster Lane		FCP		None	F	/IE		IM
√	√	1436 Stationmaster Lane		FCP		None	F	/IE		IM
√	√	1440 Stationmaster Lane		FCP		None	F	/IE		IM
	√	1460 Stationmaster Lane		FCP		None	F	/IE		IM
	√	1464 Stationmaster Lane		FCP		None	F	/IE		IM
	√	1468 Stationmaster Lane		FCP		None	F	/IE		IM
	√	1472 Stationmaster Lane		FCP		None	F	/IE		IM
	√	1476 Stationmaster Lane		FCP		None	F	/IE		IM
	√	1394 Stonecutter Dr.		FCP		None	F	/IE		IM
	√	1398 Stonecutter Dr.		FCP		None	F	/IE		IM
	√	1402 Stonecutter Dr.		FCP		Gate	F,G	/IE		IM
	√	1404 Stonecutter Dr.		FCP		None	F	/IE		IM
	√	1408 Stonecutter Dr.		FCP		None	F	/IE		IM
√	√	2178Margot St.		FGCP	GS,P	None	F,GS,P	/IE		RM
√	√	2180 Margot St.		FGCP	GS,P	F	F,GS,P	/IE		RM
√	√	2182 Margot St.		FGCP	GS,P	F	F,GS,P	/IE		RM
√	√	2184 Margot St.		FGCP	GS,P	F	F,GS,P	/IE		RM
√	√	2186 Margot St.		FGCP	GS,P	None	F,GS,P	/IE		RM
√	√	2188 Margot St.		FGCP	GS,P	F	F,GS,P	/IE		RM
√	√	2190 Margot St.		FGCP	GS,P	F	F,GS,P	/IE		RM
√		2192 Margot St.		FGCP	GS,P	None	F,GS,P	/IE		RM
	√	1323 Deerwood Tr.		FCP		None	F	D,F/IE		IM
	√	1327 Deerwood Tr.		FCP		None	F	D,F/IE		IM
	√	1331 Deerwood Tr.		FCP		None	F	D,F,T/IE		IM
	√	1335 Deerwood Tr.		FCP		None	F	D,F,T/IE		IM
√	√	1339 Deerwood Tr.		FCP		None	F	D,F/IE		IM
√	√	1343 Deerwood Tr.		FCP		None	F	D,F/IE		IM
	√	1359 Deerwood Tr.		FCP		None	F	D,F/IE		IM
√	√	1466 Queensbury Cr.		FCP		None	F	D,F,T/IE		IM
√	√	1470 Queensbury Cr.		FCP		None	F	D,F,T/IE		IM
√	√	1474 Queensbury Cr.		FCP		None	F	D,F,T/IE		IM
√	√	2156 Oakmead Pl.		FCP		None	F	/IE		IM
√	√	2160 Oakmead Pl.		FCP		None	F	/IE		IM
√	√	2164 Oakmead Pl.		FCP		Gate	F,G	/IE		IM
√	√	2168 Oakmead Pl.		FCP		None	F	/IE		IM
	√	2172 Oakmead Pl.		FCP		None	F	/IE		IM
	√	2176 Oakmead Pl.		FCP		None	F	/IE		IM
	√	2184 Oakmead Pl.		FCP		None	F	/IE		IM
	√	2188 Oakmead Pl.		FCP		None	F	/IE		IM
	√	2192 Oakmead Pl.		FCP		None	F	/IE		IM
√	√	182 Chalmers St.		FCP		Gate	F,G	D,F,T/IE		IM
√	√	184 Chalmers St.		FCP		None	F	D,F,T/IE		IM
√	√	186 Chalmers St.		FCP		None	F	D,F,T/IE		IM
√	√	188 Chalmers St.		FCP		None	F	D,F,T/IE		IM
	√	190 Chalmers St.		FCP		None	F	D,F,T/IE		IM
	√	192 Chalmers St.		FCP		None	F	D,F,T/IE		IM
	√	194 Chalmers St.		FCP		None	F	D,F,T/IE		IM
	√	196 Chalmers St.		FCP		None	F	D,F,T/IE		IM

[1] Int. = Intensive Study; Ext. = Extensive Study; √ = site sampled in study
[2] √ = survey stake present; None - no survey stake apparent; blank cell = no data
[3] policy types = Fence-Corporate Policy (FCP); Fence-Condition of Development (FCD); (FGCP) Fence, gate (with permit)-Corporate Policy; Post ,Departmental practice (PDP); No policy (None)
[4] Grass strips or paths implemented to achieve goals not related to-encroachment mitigation; no other municipal policy (none)
[5] Boundaries: MP = municipal Post; GS = grass strip; GS,P = grass strip, path; F,G = Fence (or thick hedge) with gate; F,G,GS = Fence (or thick hedge) with gate, grass strip; F,G,GS,P = Fence (or thick hedge) with gate, grass strip, path; F = Fence (or thick hedge); F,GS = Fence (or thick hedge), grass strip; F,GS,P= Fence (or thick hedge), grass strip, path; None = No or minimal treatment (eg. a few small rocks or flower bed); None = No or minimal boundary
[6] All visible boundary treatments combined;

[7] Sign message: D = 'no dumping;' F = pick up dog waste; T = no damaging or removing trees, soils, wood; V = no vehicles; N = naturalization area; No fires = FI; Stay on trails (TR); no forts (FOR); [8] (Year education or stewardship conducted); Blank cell = little active stewardship
[9] (Year by-law was enforced); blank cell = no recorded by-law enforcement (note. data only recorded for intensive study sites)
[10] IM = irregular monitoring; RM = regular monitoring

<u>Fence, grass strip and path:</u> Margot Park at 2186 Margot Street

Margot Park was a 2.8-hectare deciduous, regenerating wooded lowland corridor centred on Munn's Creek. An 'X' marks the location of 2186 Margot Street in Figure C.12. The dominant tree species was European Buckthorn, with some White ash. The trees were approximately 3-4 metres in height and formed a dense prickly forest with a closed forest edge. There were few understory species and the dominant herbaceous species was Garlic mustard. The forested corridor was relatively narrow, approximately 25 metres wide and sloped gently southward to a wet meadow surrounding the creek.

The housing was built in 1983. Lots measured approximately 33 metres in length and 9 metres in width. Yard depths are approximately 6 metres. The mown grass strip between the residential boundary and the sample sites ranged from 2.5 to 17.5 metres in width. This included a 1.5 metre crushed stone pathway located immediately adjacent to the forest edge. An 'X' marks the location of 2186 Margot Street in Figure C.13.

Figure C.12 Margot Park, Oakville Ontario
Source: City of Oakville 2006 aerial photograph

Figure C.13 Forest/house boundary relationships at 2186 Margot Street, Margot Park
Source: City of Oakville 2006 Aerial Photograph

Figure C.14 Fence, grass strip and path boundary treatment @ 2186 Margot Street
Source: W. McWilliam digital photograph October 12, 2005

Some of the residents of the study sites along Margot Street have put in their own fences and/or hedges along side the municipal fence. These treatments create an opaque boundary, providing residents with greater privacy. Three out of eight are higher than the municipal fence, ranging from 1.5 to 2.25 metres. The combined boundary treatment adjacent to 2186 Margot street consists of municipal fence (with resident-grown Virginia creeper), 9 metre grass strip, including 1.5 metre crushed limestone pathway (Figure C.14).

C.5 Municipality of Waterloo Study Sites

Waterloo has implemented its forestry departmental practice of erecting 1 metre cedar posts every 30 metres, or where required, between the early to mid 1990s, within the study sites at Sugar Bush, Anndale, Benjamin, and Twin Oaks Parks. Encroachment activities prompted their installation (FM7). The Forestry department did not install posts along the boundaries of 113 Longwood and 121 Greenbrier (Sugar Bush Park) or along the boundaries of the sample sites at Twin Oaks Crescent (Twin Oaks Park). The Forestry department did not feel that it was necessary to install posts at these locations because they could distinguish the boundary location without them (FM7).Therefore, from a resident's point of view, there is no apparent municipal boundary demarcation at these sites. These residents have installed fences with gates. Within this study the boundary demarcation for these sites are those apparent to the resident (rather than the municipality), and therefore the combined boundary type for these sites is fence with gate.

In 2001, the resident in 111 Longwood @ Sugar Bush Park was asked to remove a pile of brush (it was discovered by parks staff who were investigating a skunk complaint by the resident). There is no record of whether the resident subsequently complied with this request (A.M. Cipriani, Environmental Enforcement Officer June 2004). Anndale, Benjamin and Sugar Bush Parks were surveyed for encroachment in 1996; however, no encroachments were reported in any of the study sites (BE4, FM7).

Under the authority of the 2004 parks by-law, most natural area entry points have signs prohibiting 'dumping' and the removal of plants, soil and wood. Waterloo has monitored the study areas annually for safety-related issues, including hazardous trees, encroachments and recreation impacts (FM7). The City of Waterloo sent the Sugar bush residents newsletters in 2002 and 2004, describing the history and ecological characteristics of the forest, in addition to educating residents about encroachment activities (BE4). Table C.64 summarizes the intensive and extensive study sites in Waterloo by boundary treatment.

Table C.6 Waterloo study sites by address, boundary and management variables

Study[1]		Address	Boundary variables					Other variables		
Int.	Ext.		Surv. Stake.[2]	Mun. Boundary Policy Type[3]	Other Mun. Bound[4]	Res. Bound.[5]	Total Bound.[6]	Signage.[7]/ Stewardship.[8]	By-law enforce.[9]	Monitor.[10]
	√	521 Anndale Ct.		None	GS/P	None	GS,P	F,V/		IM
	√	525 Anndale Ct.		None	GS/P	None	GS,P	F,V/		IM
√	√	527 Anndale Ct.		None	GS/P	None	GS,P	F,V/		IM
√	√	529 Anndale Ct.		None	GS/P	None	GS,P	F,V/		IM
√	√	531 Anndale Ct.		None	GS/P	None	GS,P	F,V/		IM
√	√	533 Anndale Ct.		None	GS/P	None	F,GS,P	F,V/		IM
	√	579 Guildwood Ave.		PDP		None	MP			IM

	√	581 Guildwood Ave.		PDP		None	MP			IM
√	√	583 Guildwood Ave.		PDP		None	MP			IM
√	√	585 Guildwood Ave.		PDP		None	MP			IM
	√	587 Guildwood Ave.		PDP		None	MP			IM
	√	187 Old Abbey Rd.		PDP		None	MP			IM
√	√	189 Old Abbey Rd.		PDP		None	MP			IM
√	√	191 Old Abbey Rd.		PDP		None	MP			IM
√	√	195 Old Abbey Rd.		PDP		None	MP			IM
√	√	197 Old Abbey Rd.		PDP		None	MP			IM
√	√	634 Blackforest Park	√	PDP		None	MP	F,N/		IM
	√	638 Blackforest Park	√	PDP		None	MP	F,N/		IM
√	√	357 Northlake Dr.		PDP		None	MP	F,N/		IM
√	√	559 Hemingway Pl		None		F,G	F,G			IM
√	√	561 Hemingway Pl		None		F,G	F,G			IM
√	√	113 McCrae Pl.		None	GS,P	F	F,GS,P			IM
√		137 MacKay		None	GS	F,G	F,GS,P	F,V,N/		IM
√		139 MacKay		None	GS	F,G	F,GS,P	F,V,N/		IM
√		141 MacKay		None	GS	F,G	F,GS,P	F,V,N/		IM
√		143 MacKay		None	GS	F,G	F,GS,P	F,V,N/		IM
	√	470 Parkwood		PDP		F,G	F,G	F/IE		IM
	√	472 Parkwood		PDP		None	None	F/IE		IM
	√	474 Parkwood		PDP		None	None	F/IE		IM
	√	476 Parkwood		PDP		None	None	F/IE		IM
	√	478 Parkwood		PDP		None	None	F/IE		IM
√		480 Parkwood		PDP		F	F	F/IE		IM
	√	484 Parkwood		PDP		F,G	F,G	F/IE		IM
	√	486 Parkwood		PDP		F,G	F,G	F/IE		IM
	√	488 Parkwood		PDP		None	None	F/IE		IM
	√	490 Parkwood		PDP		F	F	F/IE		IM
	√	105 Longwood		PDP		F,G	F,G	F/IE		IM
	√	107 Longwood		PDP		None	None	F/IE		IM
	√	109 Longwood		PDP		None	None	F/IE		IM
√	√	111 Longwood	√	PDP		None	MP	F/IE	(2001)	IM
√	√	113 Longwood	√	PDP		F,G	F,G	F/IE		IM
	√	119 Longwood		PDP		None	None	F/IE		IM
	√	121 Longwood		PDP		None	None	F/IE		IM
	√	123 Longwood		PDP		None	None	F/IE		IM
	√	125 Longwood		PDP		None	None	F/IE		IM
	√	111 Greenbrier		PDP		None	None	F/IE		IM
	√	113 Greenbrier		PDP		None	None	F/IE		IM
	√	115 Greenbrier		PDP		None	None	F/IE		IM
	√	117 Greenbrier		PDP		None	None	F/IE		IM
√	√	121 Greenbrier		PDP		None	None	F/IE		IM
	√	123 Greenbrier		PDP		None	None	F/IE		IM
	√	125 Greenbrier		PDP		None	None	F/IE		IM
	√	127 Greenbrier		PDP		None	None	F/IE		IM
	√	129 Greenbrier		PDP		None	None	F/IE		IM
	√	131 Greenbrier		PDP		None	None	F/IE		IM
	√	133 Greenbrier		PDP		None	None	F/IE		IM
	√	135 Greenbrier		PDP		F,G	None	F/IE		IM
	√	137 Greenbrier		PDP		None	None	F/IE		IM
	√	4 Wildwood		PDP		F	F	F/IE		IM
	√	10 Wildwood		PDP		None	None	F/IE		IM

	√	12 Wildwood		PDP		F,G	F,G	F/IE		IM
	√	14 Wildwood		PDP		None	None	F/IE		IM
	√	229 Parklawn Pl.		PDP		None	INT	D/		IM
	√	231 Parklawn Pl.		PDP		None	INT	D/		IM
√	√	233 Parklawn Pl.		PDP		None	INT	D/		IM
√	√	237 Parklawn Pl.		PDP		None	MP	D/		IM
√	√	239 Parklawn Pl.		PDP		None	MP	D/		IM
√	√	522 Twin Oaks Cr.		PDP		F,G	F,G	D/		IM
√	√	524 Twin Oaks Cr.		PDP		F,G	F,G	D/		IM
√		526 Twin Oaks Cr.		PDP		F,G	F,G	D/		IM

[1] Int. = Intensive Study; Ext. = Extensive Study; √ = site sampled in study
[2] √ = survey stake present; None - no survey stake apparent; blank cell = no data
[3] policy types = Fence-Corporate Policy (FCP); Fence-Condition of Development (FCD); Fence, gate (with permit)-Corporate Policy; Post ,Departmental practice (PDP); No policy (None)
[4] Grass strips or paths implemented to achieve goals not related to-encroachment mitigation; no other municipal policy (none)
[5] Boundaries: MP = municipal Post; GS = grass strip; GS,P = grass strip, path; F,G = Fence (or thick hedge) with gate; F,G,GS = Fence (or thick hedge) with gate, grass strip; F,G,GS,P = Fence (or thick hedge) with gate, grass strip, path; F = Fence (or thick hedge); F,GS = Fence (or thick hedge), grass strip; F,GS,P= Fence (or thick hedge), grass strip, path; None = No or minimal treatment (e.g. a few small rocks or flower bed); None = No or minimal boundary
[6] All visible boundary treatments combined;
[7] Sign message: D = ‘no dumping;’ F = pick up dog waste; T = no damaging or removing trees, soils, wood; V = no vehicles; N = naturalization area; No fires = FI; Stay on trails (TR); no forts (FOR)
[8] (Year education or stewardship conducted); Blank cell = little active stewardship
[9] (Year by-law was enforced); blank cell = no recorded by-law enforcement (note. data only recorded for intensive study sites)
[10] IM = irregular monitoring; RM = regular monitoring

<u>Municipal Boundary Marker Boundary Treatment</u>: Sugar Bush Park at 111 Longwood Drive

Sugar Bush Park is an approximately 10-hectare Dry-fresh sugar maple deciduous second growth forest. Sugar Maple, with some Black cherry, Yellow birch and Hop hornbeam, dominate the tree canopy. The under story is primarily regenerating Sugar maple saplings and Choke cherry. The herb flora is rich with many patchily distributed native species. There are some areas of exotic plants along the outer forest edge, including European Buckthorn and Garlic mustard. Many resident-generated pathways connect edge housing with the internal recreational trail. An ‘X’ marks the location of 111 Longwood in Sugar Bush Park in Figure C.15.

Continuous single-family detached housing, built between 1964 and 1967, is the principle land use surrounding the forest. A road runs along its eastern border, and a strip mall, and multiple-family housing lines its western boundary. Developers built the house at 111 Longwood in 1965. The residential lots generally measure 18 metres wide by 33 metres long, with back yards of 12 metres. The first forest tree lies 113 cm from the private property boundary and the canopy stretches 6 metres over the abutting residential yards. An ‘X’ marks the location of 111 Longwood and the sample area is roughly outlined in Figure C.16.

Figure C.15 Sugar Bush Park @ 111 Longwood Drive, Waterloo, Ontario
Source: Region of Waterloo 2003 Aerial Photograph

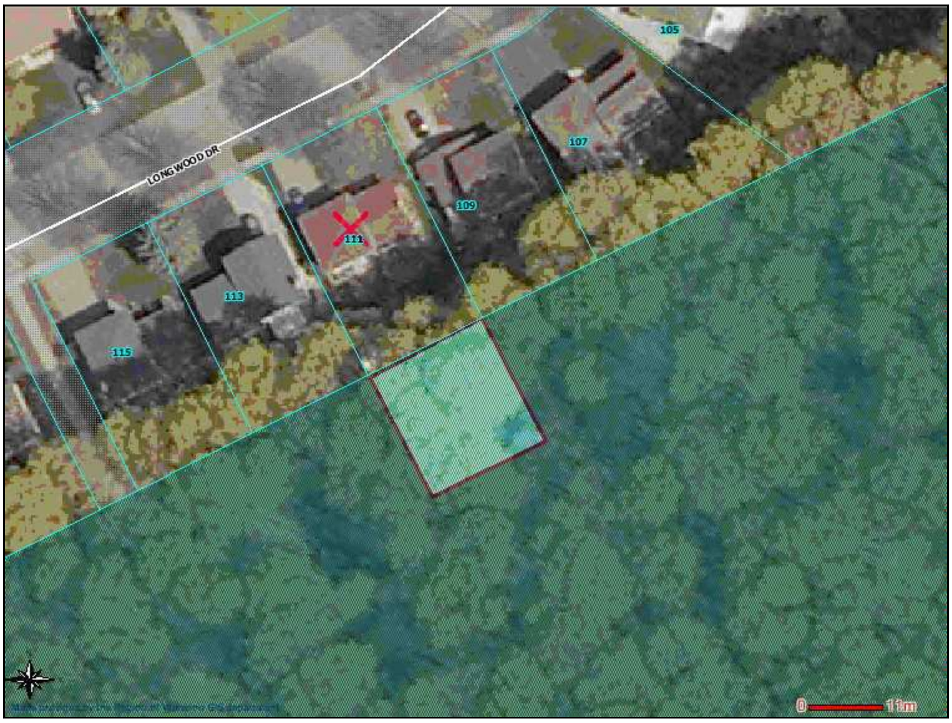

Figure C.16 Forest/resident boundary relationships at 111 Longwood Drive
Source: Region of Waterloo 2006 Aerial Photograph

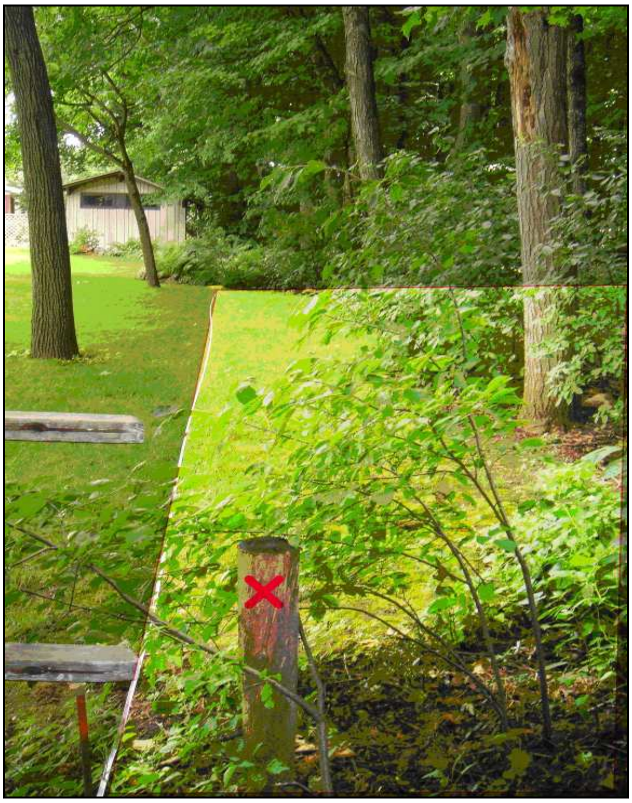

Figure C.17 Municipal boundary post @ 111 Longwood Drive
Source: W. McWilliam Digital Photography July 21, 2004

The Municipality has installed a 1-metre high cedar post (marked by an ‘X’ in bottom centre of Figure C.17). The Survey stake is visible to the left of this post. The white measuring tape marks the property boundary. Note the lawn extension encroachment to the right outlined in light green.

Fence, Gate and Grass Strip Boundary Treatment: 143 MacKay Crescent at Moses Springer Park

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Moses Springer park reserve is a .03-hectare regenerating Sugar maple – lowland Ash deciduous forest corridor surrounding Laurel Creek. Continuous 50-year-old single-family detached housing lines the forested corridor on the west side (Figure C.18). An ‘X’ marks the location of 143 MacKay Crescent.

Dominant tree species include Sugar maple, White ash and Black willow. The canopy is open, and the under story and herb flora are dominated by native and many exotic light and disturbance-tolerant species. The park has a mown grass strip maintained by the City of Waterloo between the private property boundary and the forest edge. At one time, Waterloo mowed this corridor to the water’s edge; however, in the last ten years, they naturalized part of this corridor and reduced the width of the mown grass strip to approximately 5 to 7 metres. Residents planted a number of native tree species, such as White Pine, in the mown grass strip prior to naturalization (Resident of 143 MacKay Cres., Personal communication, June 2005).

Figure C.18 Moses Springer Park Reserve at 143 MacKay Crescent, Waterloo, Ontario
Source: Region of Waterloo 2003 Aerial Photograph

Lots are approximately 19 metres wide by 39 metres long with yard depths of approximately 15 metres. The first forest tree lies approximately 9 metres from the private property boundary. The canopy drip line lies 6 metres from the residential property boundary. The resident at 143 MacKay Crescent has erected a 1.5-metre chain link fence with gate, together with a cedar hedge (to right of photograph in Figure C.20). The white 'X' in the foreground of the photo marks the boundary of the mown grass strip maintained by the City. The mown area to the left of this X, indicated in white, is the area of encroachment into the Moses Springer Park Reserve.

Figure C.20 Fence, gate, and grass strip at 143 MacKay Crescent, Moses Springer Park Reserve
Source: W. McWilliam Digital Photo June 30, 2005

Grass Strip and Path Boundary Treatment: Anndale Park at 531 Anndale Court

Anndale Park is a 10-hectare natural area surrounding Colonial Creek. It is largely made up of a wetland surrounded by Fresh – moist Ash lowland deciduous forest in the south where the residences along Anndale Court abut the park. Study sites along Old Abbey Road and Guildwood Place are located in the northwestern corner of the Park adjacent to a Dry-fresh Sugar maple –Beech deciduous forest fragment. The forested area associated with Anndale Court appears to be a regenerating lowland forest, dominated by tree species such as Black Ash, Balsam poplar, and European Buckthorn. The herb flora is tall and lush dominated by moisture and sun loving native and exotic species. An ‘X’ marks the location of 531 Anndale Court in Figure C.21

Figure C.21 Anndale Park at 531 Anndale Court, Waterloo, Ontario
Source: Region of Waterloo, 2006 Aerial Photograph

Continuous single-family housing almost surrounds the natural area. A community centre lies along a portion of the southwest boundary. The single-family detached homes along Anndale Court are 28 years old. Most residential lots are approximately 24 metres in width and 40 metres long, with yard depths of 16 metres. The mown grass strip (with pathway included) is between 23 and 37 metres in width. The first forest tree is located approximately 20 metres from the residential boundary, and the canopy dripline is 14 metres from the residential boundary. The forest side canopy is closed. In Figure C.22 a portion of the sample area is represented by the triangle in the top of the photo. In C.23, the yellow line indicates the boundary line. The garden, left of the measuring tape, is extending into the municipally owned grass strip.

Figure C.22 Forest/residence Boundary Relationships at 531 Anndale Court, Anndale Park
Source: Region of Waterloo Aerial Photograph 2006

Figure C.23 Grass strip and Path Boundary: 531 Anndale Court @ Anndale Park
Source: W. McWilliam Digital Photograph, July 7, 2005

Appendix D

Analysis of Official and Secondary Plan Policies by Study Municipality

This appendix provides a content analysis of the official and secondary plan policies of each municipality in the context of provincial and regional policy requirements. The basic, enhanced and pathfinder policies revealed are the building blocks of those summarized in Chapter 6. The municipalities of Cambridge, Kitchener and Waterloo lie within the Region of Waterloo. I will review the policies from these three municipalities first, followed by those of Guelph, Oakville and Mississauga. The policies for each municipality are followed by a summary table. To avoid repetition, policies that apply to both natural heritage and hydrological functions will only be described under natural heritage policies; however, their application to areas serving a hydrological function will be noted within the accompanying summary charts.

Charts summarize basic, enhanced and pathfinder policies for natural heritage area policies and hydrological function policies. On the left hand side of the charts, the policies are listed. Basic and enhanced policies are listed according to whether they are provincially or regionally required or, in the case of enhanced policies, suggested. The italicized type indicates the policy and the non-italicized type indicates the designation to which it is applied. On the right hand side of the chart, a checkmark (√) indicates whether the local municipality has a policy (in the case of pathfinder policies) or whether it meets the provincially or regionally required policy (in the case of basic or enhanced policies). 'OP-W', and 'SP-W' stand for official plan natural area policies, and secondary plan natural area policies, respectively. 'OP-A' and 'SP-A' stand for official plan policies for areas adjacent to natural areas and secondary plan policies for areas adjacent to natural areas, respectively. The initials 'N.A.' indicate that there is no required policy. 'Partial' indicates that provincial or regional policy requirements are partially met. The symbol * indicates that sites meeting the natural area designation criteria have not been identified within the planning area. When a cell in the chart is blank, it means that the policy requirement has not been met. In some cases, it may mean that within the planning area, no sites have been identified that meet the natural area or hydrological function designation.

D.1 Municipality of Cambridge

The municipality of Cambridge is a lower-tier municipality within the Regional Municipality of Waterloo. The Regional Municipality of Waterloo (the region) approved the official plan (OP) for Cambridge in 1999. In 2004, Cambridge amended its OP. This plan was written in response to conditions existing within the late 1990s following the 1995/96 reforms to the Provincial Planning Act. The municipal OP postdates that of the region, and it would have been required to comply with the Region of Waterloo's OP.

The policy recommendations within the Forbes Creek Watershed study (2002) for the secondary plan for the North Hespeler area will be reviewed here as an example of the environmental policies that Cambridge is currently promoting. The secondary plan for the North Hespeler area was unavailable for review. However, interviewees indicated that the North Hespeler Secondary Plan incorporates almost all of the recommendations of the Watershed Plan without alteration (DP1). Therefore, the following policy analysis assumes that the policies indicated in the watershed study are consistent with those of the secondary plan. Note that the Official Plan of Cambridge does not incorporate the policies of its secondary plans (DP1). Therefore, these policies do not carry the same legal authority as Official Plan policies and operate more as guidelines (Estrin & Straigen 1993).

The Forbes Creek Watershed drains into the Speed River. The Forbes Creek natural system contains a provincially significant wetland complex, a proposed ESPA, the Forbes Creek floodplain, cold and warm water fisheries, and many locally significant natural areas including upland and lowland woodlands and wetlands. In addition, there are a number of sensitive groundwater and groundwater discharge areas (Planning & Engineering Initiatives Ltd., 2002).

Urban land uses cover approximately 20% of the watershed, consisting of residential, and a small amount of commercial development. The remainder of the watershed is agricultural. The agricultural land use generally supports the natural area system, allowing for multiple linkages between natural areas, and the continuation of sufficient habitat cover to support a diversity of wildlife, including white-tailed deer. Site-specific studies indicated that white-tailed deer currently migrate between the creek's headwaters to an over-wintering area where the creek meets the Speed River. In addition, the existing topography, vegetative cover, and soil texture support the sensitive hydrological system, and maintain the functional linkages between the ground and surface water systems. The secondary plan must accommodate new urban land uses, primarily residential and commercial (Planning & Engineering Initiatives Ltd., 2002).

Cambridge's Official Plan goal is to preserve the integrity of its ecosystem by maintaining and improving its natural resources including its natural areas, surface, ground water, and atmospheric resources (Cambridge OP 2004, Pol. 2.3 a., p.6). Cambridge has six objectives for achieving this goal in terms of its natural areas. These objectives include:

1. To identify its significant natural areas,
2. To undertake watershed and sub-watershed planning;
3. To enhance their natural areas and protect them from development (limited to structures), 'where possible;'
4. To protect them from recreation impacts;
5. To protect natural areas from the construction and operation of infrastructure 'where possible;'
6. To restore their natural areas, where possible (Cambridge OP 2004, Pol. 2.3 b,d,f,i and j, p.6).

D.1.1 Natural Heritage Area Policies

Basic Policies

City of Cambridge Official Plan and Forbes Creek Subwatershed Plan

Policies within the Official plan are in partial compliance with the requirements of the PPS 2005, and in full compliance with those of the Region of Waterloo Official Plan (City of Cambridge OP, Pol. 6.2.3.1.2, 6.2.3.2.3, 6.2.3.3.5, 6.1.3.2, 6.1.3.3, 6.1.3.4). There are no policies for protecting the significant habitat of endangered species or threatened species (identified by the Province), or their adjacent lands within the official plan (City of Cambridge OP, Pol. 6.1.1.2). The province may not have identified areas meeting designation criteria within Cambridge. Woodlands and wildlife habitat have not been designated as provincially significant, but as ESPAs or LSNAs (locally significant natural areas). However, Cambridge is still in the process, along with the Region of

Waterloo, the province and the GRCA, of identifying regionally and locally significant woodlands (City of Cambridge OP, Pol. 6.1.1.7). For lands adjacent to provincial ANSIs (protected under the ESPA designation) there are no policies that require the assessment of the ecological functions of adjacent lands within the Official Plan (City of Cambridge OP, Pol. 6.1.3), therefore this provincial policy requirement is not met within the Official Plan.

Policy suggestions contained within the Forbes Creek subwatershed plan are in full compliance with the policies of the Region of Waterloo and the Province. Provincial policy requirements for hazardous lands are in full compliance (Planning & Engineering Initiatives Ltd. 2002, A-2.5.5, p. A-15). The Forbes Creek subwatershed study did not identify any of these areas (Planning & Engineering Initiatives 2002, p. A-9), or ANSIs (Planning & Engineering Initiatives Ltd. 2002, p. C-2). Regional policy requirements will be met through the policy recommendations of the subwatershed plan, if ESPAs are designated (Planning & Engineering Initiatives 2002, pp. A-7, 8, 9). See Table D.1 for summary of basic policies for preserving and protecting natural heritage areas.

Table D.1: Municipality of Cambridge Basic Policies: Natural Heritage Areas

PPS 2005 Policies	**OP-W**1	**OP-A**2	**SP-W**1	**SP-A**2
Development may be permitted if risk to public safety minor/mitigated according to provincial standards (Pol. 3.1.2c.)				
Hazardous sites (steep slopes, erosion prone, unstable soils)	√	N.A	√	N.A.
Prohibition of Development and Site Alteration within and no development or site alteration adjacent lands to unless demonstrates 'no negative impacts' on features and functions and ecological function of adjacent lands evaluated				
Provincially designated portions of habitat of endangered or threatened species *(Pol. 2.1.3a, 2.1.6)*			*	*
No development or Site Alteration unless demonstrates 'no negative impacts' on features/functions and ecological function of adjacent lands evaluated				
Provincial ANSIs (Pol. 2.1.4e., 2.1.5)	√	Partial	*	*
Significant Woodlands (Pol 2.1.4b., 2.1.5)				
Significant Wildlife Habitat (Pol. 2.1.4d., 2.1.5)				
Region of Waterloo Policies				
*No development of Site Alteration unless demonstrates through EIS no serious adverse impacts on features/function*s**)**				
ESPAs (Pol. 4.3.13)	√	√	√ (	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area; Secondary plan policies are assumed to be consistent with those recommended within the Forbes Creek Subwatershed plan.
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* These areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

City of Cambridge Official Plan

LSNAs have been designated that function as linkages between significant natural areas (City of Cambridge OP, Pol. 6.1.4.2). An EIS is required for proposals within and adjacent, but only if it is judged that the proposal 'may impact' them, and only proposals for 'development' (or structures), not site alteration (City of Cambridge OP, Pol. 6.1.4.7, 6.1.4.8).

The municipality requires a more rigorous 'comprehensive' EIS where a variety of natural heritage elements are affected, contiguous properties are proposed for development and contain natural heritage elements, a Secondary Plan is being undertaken, or where watershed studies have not identified elements of the natural heritage system (City of Cambridge OP, Pol. 6.1.5.7). In some cases, subwatershed studies may be used to fulfill proposal impact assessment at the site level, therefore removing the requirement for proponents to prepare EIS (City of Cambridge OP, Pol. 6.1.5.6).

In terms of biodiversity, Cambridge has a policy to 'where appropriate, encourage the conservation and enhancement of the Region's native biodiversity' (City of Cambridge OP, Pol. 6.4.3.1, p. 60). Among LSNAs are areas that may serve as habitat for woodland interior species (many of which are currently threatened due to habitat fragmentation) and areas that support 'moderate to high diversity of life forms' (City of Cambridge OP, Pol. 6.1.4.2 b. iii, and v., p. 41). Regional or Provincial designations may protect other species important to conserving regional biodiversity.

Cambridge also has a standardized management policy to use, and encourage the use of, native species, 'where feasible and appropriate,' and to discourage the use of non-native species within and adjacent to elements of the open space system (City of Cambridge OP, Pol. 6.4.3.3, 6.4.3.4, 6.4.3.5, p. 60).

The municipality has a policy to conduct watershed and subwatershed studies that will guide EIS based on significance and sensitivity of the features and functions, dependent on a number of factors, including funding availability (City of Cambridge OP, Pol. 6.2.1.1, 6.2.1.2). These studies are to result in 'detailed targets and objectives for resource management, environmental protection and storm water management practices and development standards' (City of Cambridge OP, Pol. 6.2.1.3). Cambridge will establish these targets prior to the approval of a secondary plan or amendments to the Official Plan (City of Cambridge OP, Pol. 6.2.1.6).

Forbes Creek Subwatershed Plan

The policies recommendations within the Forbes Creek Subwatershed Plan include all of the Enhanced policies of the Official Plan (Planning & Engineering Initiatives Ltd. 2002, p. A-11). The protection of a wide central corridor, focused around the most significant natural areas, enhances connectivity throughout the planning area (Planning & Engineering Initiatives Ltd. 2002, p. E-24). The preservation or regulation of hedgerows, small woodlots, and utility corridors creates linkages within residential and commercial areas (Planning & Engineering Initiatives Ltd. 2002, p. E-11).

Policies have also been established to restore habitat in areas where degraded (designated 'Enhancement areas'), particularly within upland areas in support of missing riparian areas in the southern area of Forbes Creek (see below under hydrological function policies) (Planning & Engineering Initiatives Ltd. 2002, p. E-13). The purpose of this strategy is to offset the loss of the agricultural matrix by enhancing habitat and connectivity, and the indirect impacts of urban proximity, thereby maintaining and protecting terrestrial resources and hydrological functions (Planning & Engineering Initiatives Ltd. 2002, p. E-11). Recommendations suggest a full site EIS for development proposals within and adjacent to ESPA, LSNA, and Enhancement areas (Planning & Engineering Initiatives Ltd. 2002, p. E-12).

This plan focuses its biodiversity conservation efforts on native biodiversity within the subwatershed. In terms of subwatershed biodiversity conservation, the natural area system appears to have been planned for interior birds, amphibians and white-tailed deer (Planning & Engineering Initiatives Ltd. 2002, p. E-18), which studies indicate require relatively large and/or connected habitat areas to support their populations (Planning & Engineering Initiatives Ltd. 2002, p. C-30 – C-33). The assumption behind this plan is that other species, with similar or less demanding requirements, will be supported, if the habitat and migration corridors for these more demanding species are provided.

The development of stewardship programs that involve landowners within both agricultural and urban areas are encouraged to reduce municipal management activities within these areas, and to assist in on-going monitoring (Planning & Engineering Initiatives Ltd. 2002, p. C-34). It is suggested that information be provided to key groups (schools, neighbourhood associations, real estate and development industries), distributed by developers to buyers as a condition of development, and that educational signage be erected during the construction period (Planning & Engineering Initiatives Ltd. 2002, p. E-26). Cambridge, other jurisdictional agencies, and the public are recommended to perform the monitoring pre and post-development, and the developer is to monitor during the construction period, from pre-development through to the guarantee period (Planning & Engineering Initiatives Ltd. 2002, p. E-17-E-19).

Pathfinder Policies

City of Cambridge Official Plan

Preservation of ESPAs (including ANSIs) receives additional preservation under this plan through the prohibition of development and site alteration within ESPAs (City of Cambridge OP, Pol. 6.1.3.2). In addition, there is a course of action, including acquisition or refusal of the development application, should an EIS indicate that development within or ‘contiguous to’ a LSNA will lead to serious ‘adverse impact’ (City of Cambridge OP, Pol. 6.1.4.10, p. 42).

LSNAs have been designated that function as habitat, buffers and/or perform other significant ecological or aesthetic functions within Cambridge (City of Cambridge OP, Pol. 6.1.4.2). An EIS is required for proposals within and adjacent to these areas, but only if it is judged that the proposal ‘may impact’ them, and only proposals for structures, not site alteration (City of Cambridge OP, Pol. 6.1.4.8, p. 42). In addition, adjacent lands to ESPAs and locally significant areas are defined in terms of those where specific impacts may be produced, rather than lands within a certain distance of the natural area (City of Cambridge OP, p. 215). This may reduce, or expand, the area in which an EIS is required relative to the standardized distances of other municipalities, depending on the strength of the evidence supporting adjacent land use impacts or the significance attributed them. Specific conditions of development are required in the form of tree preservation policies throughout the urban areas of Cambridge.

Forbes Creek Subwatershed Plan

The Forbes Creek Subwatershed Plan suggests all the City of Cambridge Official Plan pathfinder policies (Planning & Engineering Initiatives Ltd. 2002, p. A-11). Additional pathfinders include policies that minimize the future impacts of adjacent residents through the provision of fencing (Planning & Engineering Initiatives Ltd.

2002, p. E-12). In addition, policies to limit the impacts of recreational activities include restricting access to certain areas and the placement of community trails away from sensitive environmental features (Planning & Engineering Initiatives Ltd. 2002, E-12, 13). See Table D.2 for a summary of enhanced and pathfinder policies for preserving and protecting natural heritage areas.

Table D.2 Cambridge Enhanced and Pathfinder Policies: Natural Heritage Features and Areas

Enhanced Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Provincially recommended policies				
Policies that restore natural heritage areas and their connectivity				
Areas of potential natural habitat are protected or restored			√	√
Other terrestrial corridors or linkages protected	√	√	√	√
Policies that conserve biodiversity as a goal in planning				
Supporting the function of Biodiversity or native biodiversity is one of the goals of environmental policies	√		√	√
Policies that support areas and/or corridor fragments specifically planned to fulfill a biodiversity role	√	√	√	√
Policies that support a system of areas/corridors to support biodiversity at the landscape scale			√	√
Monitoring of ecological systems			√	
Regionally recommended policies				
A requirement that site EIS occur in conjunction with subwatershed/watershed planning				
Standardized Management Policies				
Encouraging use of Native plants	√	√	√	√
Discouraging use of invasive exotic plants	√	√	√	√
Natural area specific management policies				
Individualized management plans				
Stewardship and Education Policies				
within and adjacent to privately-owned natural areas	√		√	
within and adjacent to publicly-owned natural areas	√	√	√	√
Pathfinder Policies				
Increased level of preservation for designated areas	√			
Other natural areas protected (beyond those designated by the Province or Region)	√	√	√	√
Rigorous assessment criteria for demonstrating development compatible with features and functions	partial	partial	√	√
Specific conditions of development required				
Tree preservation	√	√	√	√
Mitigation of future impacts of adjacent residents				
Fencing			√	
Mitigation of future impacts of recreation				
Placement of trails away from sensitive natural areas			√	
A course of action should an EIS indicate 'significant negative impacts' to a locally significant area	√	√	√	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* these areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.1.2 Hydrological Function Policies

Basic Policies

City of Cambridge Official Plan

The generalized policies of the Official Plan are in compliance with regional policies, but only partially with provincial policies. Provincial policy requirements are met for regulating development proposals within floodplains, provincially significant wetlands, ANSIs (with a hydrological function), and Fish habitat. 'Significant valley lands' ('regionally-significant natural corridors) are still being defined in conjunction with the region of Waterloo, and other agencies (City of Cambridge OP, Pol. 6.1.1.5). Policies for areas adjacent to provincially significant wetlands, ANSIs (with a hydrological function) do not comply with provincial policy since they do not require an assessment of the ecological functions of adjacent lands (City of Cambridge OP, Pol. 6.1.2 and 6.1.3).

Land use restrictions required by the Province of Ontario to 'protect, restore and improve' vulnerable and sensitive surface and ground water features and functions (PPS 2005, Pol. 2.2.1d) are in the process of being developed in accordance with the Regional Water Resources Protection Strategy, initiated in 1994 (City of Cambridge OP, Pol. 6.2.2.1). Meanwhile, ESPAs (with a hydrological function), regionally designated sensitive groundwater areas, and regionally designated environmentally significant discharge areas, are protected according to Regional policy (City of Cambridge OP, Pol. 6.2.2.4). According to these policies, certain types of land uses are prohibited within regionally sensitive groundwater areas, and all development is prohibited development within Regional environmentally significant discharge areas (Region of Waterloo OP, Pol. 5.2.1.4).

There are no policies for restricting development near sensitive surface and ground water features to ensure that their features and hydrologic functions are protected, improved or restored (PPS 2005, Pol. 2.2.2). Similarly, there are no policies to maintain 'linkages, and related functions' between ground water, surface water and natural heritage features and areas (Region of Waterloo OP, Pol. 5.2.1 and 5.2.2).

Cambridge has a policy to encourage and support the Cambridge community to 'reduce, re-use, recycle and recover' its natural resources (City of Cambridge OP, Pol. 2.3m), and the Region of Waterloo requires that Cambridge 'inform and consult with the community regarding water resource protection' (Region of Waterloo OP, Pol. 5.2.1c). However, there is no specific mention of promoting the 'efficient and sustainable use of water resources' (PPS 2005, Pol. 2.2.1f). In addition, while there is a policy that requires proponents to follow storm water management policies (City of Cambridge OP, Pol. 6.2.2.5), there are no policies within the official plan that require that practices 'minimize storm water volumes and contaminant loads and maintain, or increase, the extent of vegetation and pervious surfaces' (PPS 2005, Pol. 2.2.1g).

Forbes Creek Subwatershed Plan

The policy suggestions of the Forbes Creek Subwatershed Plan fulfill all the provincial and regional requirements. The features and functions of the surface water system (including fish habitat and wetlands) and much of the groundwater system are protected through the preservation of these systems, and the provision of buffers, enhanced areas and complementary land uses within adjacent areas (Planning & Engineering Initiatives Ltd. 2002, p. E-2 to E-6). Although sensitive groundwater areas do exist outside of these areas, they are assumed to be protected within this Plan, if the recommended storm water management practices are followed (Planning & Engineering Initiatives Ltd. 2002, p. E-3). Storm water management practices minimize storm water volumes, contaminant loads and maximize the extent of vegetation and pervious surfaces (Planning & Engineering Initiatives Ltd. 2002, p. E-8, 9). Public education programs are recommended in both rural and urban parts of the watershed to alter land use practices and water use that degrade water quality and quantity (Planning & Engineering Initiatives Ltd. 2002, p. C-20).

In addition, connectivity between natural heritage areas, surficial and groundwater systems are maintained. Areas that support key hydrological functions, and are provincially and regionally significant, are designated as high constraint areas and consist of wetlands, floodplains, ESPAs, areas with steep slopes, and watercourses. Together they form a central core around Forbes Creek. Terrestrial corridors within this system are protected as 'medium constraint areas.' They surround and support the hydrological, vegetative and wildlife functions of the high constraint areas. They were identified in the subwatershed study as ecologically sensitive ('sensitivity" is defined in terms of imperfect drainage, and moderate slope) and as components in the core habitat of breeding populations of migratory amphibians and terrestrial species, such as white-tailed deer. These areas were designated as locally significant natural areas, enhancement areas, or complementary land uses. Together, the high and medium constraint areas constitute a 250-300 metre wide corridor through the area of the subwatershed slated for intensive urban development. Hedgerows, small woodlots, and utility corridors within the areas slated for residential and commercial land uses (constraint level three areas) are also designated as constraint level two areas. Policies require a site EIS with development proposals within and adjacent to the ESPA, LSNAs, and Enhancement areas, (including, in some cases, complementary land uses) (Planning & Engineering Initiatives Ltd. 2002, p. E-2 to E-6).

The subwatershed study assessed the ecological function of all lands adjacent to natural areas serving ecological functions at the scale of the Subwatershed (Planning & Engineering Initiatives Ltd. 2002, p. C-1). Lands adjacent to provincial and regional hydrological features may consist of buffers, LSNAs, enhanced habitat and/or complementary land use areas. Development within these areas is subject to additional EIS studies that require an assessment of their ecological functions (Planning & Engineering Initiatives Ltd. 2002, p. E-3 to E-5).

Areas that are immediately adjacent to the most significant natural areas are recognized for their significant ecological functions as part of the terrestrial habitat within the central corridor, and more importantly, as buffers to the more significant natural areas within the central portions of the corridor. These areas are designated as 'complementary land uses.' The plan suggests that these areas function as transition areas between high impact urban development and low impact significant natural system components. They help to ensure that the negative impacts of human proximity, such as direct residential encroachment, and indirect impacts such as chemical use, light, noise, pets and human presence, do not prevent interior habitat conditions from developing that support subwatershed scaled native species biodiversity, or the hydrological functions of the corridor (Planning & Engineering Initiatives Ltd. 2002, p. E-3)

Areas designated as 'enhanced areas' may be developed according to complementary land use policies. These policies require land uses and land use patterns that minimize negative hydrological and wildlife impacts. These are assumed to be: parkland, seasonally-used playing fields, institutional land uses associated with relatively large open spaces such as churches, community centres or cemeteries, and under certain conditions, storm water management facilities and single loaded streets that are used only infrequently (Planning & Engineering Initiatives Ltd. 2002, p. E-5)

All privately owned areas outside these complementary land uses are still assumed an integral part of the subwatershed/watershed ecosystem. These areas are designated as 'Low constraint areas' (Planning &

Engineering Initiatives Ltd. 2002, p. E-4). Development proposals within them are subject to 'best management practices' (BMPs). These practices include not only those meant to reduce the impacts of construction, such as storm water management and tree conservation practices, but also the future impacts of residents on adjacent natural areas. Recommended BMPS include reduced use of lawn pesticides, the proper disposal of pet waste, and fencing (Planning & Engineering Initiatives Ltd. 2002, p. E-26). See Table D.3 for a summary of basic policies for preserving and protecting hydrological Functions

Table D.3 Cambridge Basic Policies: Hydrological Functions

Provincial Policy	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Watershed planning	√	√	√	√
Prohibition of development unless (certain types of development in flood fringe of two zone or special policy area with appropriate flood-proofing))				
Floodplains	√		√	√
No Development and Site Alteration within, no development and site alteration adjacent unless it has been demonstrated there will be no negative impacts on features/functions and adjacent land use ecological functions evaluated				
Provincially significant wetlands	√	Partial	√	√
No development and site alteration unless it has been demonstrated there will be no negative impacts on features/functions and adjacent land use ecological functions evaluated				
Fish habitat	√	√	√	√
Significant valley lands			√	√
Development and site alteration shall be restricted within and adjacent to these areas such that these features and their hydrologic functions will be protected, improved or restored				
Municipal drinking supplies and designated vulnerable areas	partial		√	√
Vulnerable surface and ground water; sensitive surface and ground water features and their hydrologic functions	partial		√	√
Maintain linkages and related functions between				
Surface water features, ground water features, hydrologic functions and Natural Heritage Features and Areas	partial		√	√
Promote efficient and sustainable use of water resources			N.A.	partial
Ensure storm water management practices minimize storm water volumes, contaminant loads, maintain or increase extent of vegetation and pervious surfaces			√	√
Regional Policies				
No development and site alteration unless EIS demonstrates no 'serious adverse impact' upon the features and functions				
ESPAs (with hydrological function)	√	√	√	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

City of Cambridge Official Plan

An EIS is required for development (not site alteration) proposals within and adjacent to locally significant areas that 'perform a vital ecological function,' or provide connections to other natural areas, only if they 'may impact' upon these areas or their functions (City of Cambridge OP, Pol. 6.1.4.2).

Forbes Creek Subwatershed Plan

The policy suggestions of the Forbes Creek Subwatershed Plan include the City of Cambridge Official Plan enhanced policies. Locally significant areas are designated which support the maintenance of hydrological corridors (Planning & Engineering Initiatives Ltd. 2002, p. C-2). In addition, 'Enhancement areas' are designated to restore areas vital to aquatic and semi-aquatic habitat, and hydrological functions. Slope, drainage and overhanging tree cover identify these areas. Limited development may be considered for these areas subject to a site EIS. (Planning & Engineering Initiatives Ltd. 2002, p. E-5). This plan also specifies the restoration of specific areas of the stream course (Planning & Engineering Initiatives Ltd. 2002, p.C-33).

Pathfinder Policies

City of Cambridge Official Plan

An EIS is required for development proposals (not site alteration) within and adjacent to local wetlands and areas that ‘perform vital ecological functions,’ or act as buffers to other natural areas, but only if they ‘may impact’ upon these areas or their functions (City of Cambridge OP, Pol. 6.1.4.7, 6.1.4.8). In addition, specific mitigation measures are required for development adjacent to stream corridors: a minimum ‘vegetative buffer’ of 30 metres is required for cold-water streams, and 15 metres for warm water streams (City of Cambridge OP, Pol. 6.3.3).

Forbes Creek Subwatershed Plan

The Forbes creek subwatershed plan provides the same protection to fish habitat, ESPAs (if approved by the region of Waterloo) and LSNAs as the Official Plan of Cambridge. A policy recommendation prohibits development within these areas, although it is unclear whether this policy includes site alteration (given the definition of ‘development’ within the Cambridge Official Plan) (Planning & Engineering Initiatives Ltd. 2002, p.E-3).

Specific mitigation measures are recommended including 50 metre buffers adjacent to provincially significant wetlands, ESPA, LSNA, regulatory floodplain areas (or within the limit of the regional flood line, whichever is greater), and regionally environmentally significant discharge areas (Planning & Engineering Initiatives Ltd. 2002, p.E-6). The width exceeds the buffer widths, recommended for similar areas, by the Province of Ontario, the Region of Waterloo, the Municipality of Cambridge and the Grand River Conservation Authority (Planning & Engineering Initiatives Ltd. 2002, p.E-6). The wider width supports wetlands and water quality after urban development occurs where there are sensitive shallow hydrogeological regimes. Buffers may be reduced to 30 metres with support from a site EIS. An EIS is not required for development within land adjacent to the 50 metre buffer unless it is within the lower area of the creek where enhancement areas are recommended (Planning & Engineering Initiatives Ltd. 2002, p.E-5). It is recommended that buffers be publicly owned because this is considered the best way to ensure their ‘retention and proper management’ (Planning & Engineering Initiatives Ltd. 2002, p.E-6). Other specific mitigation measures include restrictions on lot coverage by structures within Enhancement areas that are developed with complementary land uses, and within constraint level three areas. This lower lot coverage is required to control the infiltration properties within the urbanizing part of the watershed (Planning & Engineering Initiatives Ltd. 2002, p.E-5, C-3).

A management policy recommends that buffers adjacent to streams be maintained as ‘meadow or early shrub succession’ to sustain their filtration functions over time (Planning & Engineering Initiatives Ltd. 2002, p.E-26). See Table D.4 for a summary of enhanced and pathfinder policies for preserving and protecting hydrological functions.

Table D.4 Cambridge Enhanced and Pathfinder Policies: Hydrological Functions

Enhancement Policies	OP-W	OP-A	SP-W	SP-A
Provincially-recommended policies				
Restoring hydrological features and their connectivity				
Areas of potential natural habitat are protected or restored			√	
Other hydrological corridors protected (beyond those designated by province or region)	√	√	√	√
Monitoring of hydrologic parameters			√	
Regionally-recommended Policies				
A requirement that site EIS occur in conjunction with subwatershed/watershed studies				
A course of action should an ESPA or provincially significant area be threatened by a development proposal	√		√	
Standardized management regimes				
Encouraging use of native plants	√	√	√	√
Discouraging use of invasive exotic plants	√	√	√	√
Stewardship and education policies				
Privately-owned natural areas	√		√	
Publicly-owned natural areas	√	√	√	√
Pathfinder Policies				
Increased level of preservation for designated areas			√	√
Other hydrological areas protected (beyond those designated by province or region)	√	√	√	√
Rigorous assessment criteria for demonstrating no negative impacts on features and functions	partial	partial	√	√
Specific mitigation measures	√		√	√
Buffers (prov. wetlands, ESPAs, LSNAs, Floodplain)		√		√
Restrictions on lot coverage for structures (enhancement areas)				
Mitigation of future impacts of adjacent residents				
Fences				√
Designation specific management regimes			√	
Riparian buffers maintained as meadow or early shrub succession			√	
A course of action should a locally significant area be threatened by a development proposal	√		√	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.2 Municipality of Kitchener

The Municipality of Kitchener is a lower-tier municipality within the Regional Municipality of Waterloo. The Region of Waterloo initially approved Kitchener’s Official Plan (2005) in 1995. It had to be consistent with the PPS of 1995 when first approved (C. Gosselin, Region of Waterloo, personal Communication, Nov. 16, 2006). Although Kitchener’s Official Plan was dated the same year as that of the Region (1995), Kitchener and the region worked together during its preparation to ensure consistency between the two plans (C. Gosselin, Region of Waterloo, personal Communication, Nov. 16, 2006).

Doon South Community Plan was reviewed for secondary plan policies. Doon South is a 730-hectare community that lies in the southern most part of the Municipality. It covers three subwatersheds, one of which is Doon South Creek. A subwatershed study was conducted in 1994, providing a general management plan for the area. Subsequently, a greenspace management plan, together with a community plan, was developed in 1997. The area contains three creek corridors, several provincially significant wetlands, three ESPAs, and a number of locally significant woodlands that lie adjacent to the ESPAs or provincially significant wetlands.

Kitchener's Official Plan goal for protecting its natural environment is 'to ensure the continued protection and wise management of the City's natural and environmental resources' (Kitchener OP, p. 7-1). There are 10 objectives for achieving this goal in terms of Kitchener's significant natural areas:

1. To identify, and evaluate the significant natural areas through subwatershed plans, or comprehensive environmental impact studies, prior to or concurrent with the land use planning process (City of Kitchener OP, Pol. 7.1.1.2)
2. To prevent or minimize the 'environmental impacts' of new development and municipal infrastructure projects (City of Kitchener OP, Pol. 7.2)
3. To 'restore, protect and enhance ecological, historic, cultural, recreational and visual amenities' (City of Kitchener OP, Pol. 7.3i)
4. To protect water quality and quantity (City of Kitchener, Pol. 7.3v)
5. To maintain the 'ecological diversity' of existing wetlands by protecting their 'essential hydrological functions,' maintaining their linkages to other natural areas, buffering them from adjacent land use impacts, and restricting public access (City of Kitchener OP, Pol. 7.5ii)
6. To create new wetlands where appropriate (City of Kitchener OP, Pol. 7.5v)
7. To protect and preserve significant natural areas for the long term (City of Kitchener OP, Pol.7.6i);
8. To maintain the 'ecological diversity' of, and linkages (for wildlife movement) between existing forested areas; to encourage the preservation and wise management of forested areas; and to increase tree cover in the municipality (City of Kitchener OP, Pol. 7.7i, ii, iii);
9. To achieve a 'net gain of the productive capacity of fish habitats (City of Kitchener OP, Pol.7.8i);
10. To maintain and enhance wildlife and wildlife habitat (City of Kitchener OP, Pol. 7.8ii);
11. To allow for wildlife movement between habitat areas by 'ensuring' 'a continuous linear open space system' (City of Kitchener OP 2005, 7.8iii).

D.2.1 Natural Heritage Area Policies

Basic Policies

City of Kitchener Official Plan and Doon South Secondary Plan

All basic policy requirements have been met for development within provincially designated areas (City of Kitchener OP, Pol. 7.4, 7.6, 7.8; City of Kitchener Doon South Community Plan, Pol. 5.21). Kitchener has a policy that meets the provincial requirements for restrictions on developments within 'Significant woodlands,' (City of Kitchener OP, Pol. 7.7.1.8); however Kitchener has not yet defined criteria for designating 'Significant woodlands'(City of Kitchener, 2003a). Significant woodlands were not defined within the Doon South Community Plan (City of Kitchener, 2003. Doon South Community Plan). Kitchener does not have a 'Significant wildlife habitat' natural area designation (City of Kitchener OP, Pol. 7.8.2).

Adjacent land use policies are consistent with those of the region (City of Kitchener OP, Pol. 7.6; City of Kitchener Doon South Community Plan, Pol. 5.21). Policy requirements for proposals on lands adjacent to provincially significant areas (ANSIs, and significant habitat of endangered species or threatened species) are not met in the official plan because they do not require the assessment of the ecological function of these lands (City of Kitchener OP, Pol. 7.6, 7.8). These areas were not identified with the Doon south community planning area. See Table D.5 for a summary of basic policies for protecting natural heritage areas.

Table D.5 Kitchener Basic Policies: Natural Heritage Areas

PPS 2005 Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Development may be permitted if risk to public safety minor/mitigated according to provincial standards				
Hazardous sites (steep slopes, erosion prone, unstable soils)	√	N.A.	√	N.A.
Prohibition of development and site alteration within and no development or site alteration adjacent lands to unless demonstrates 'no negative impacts' on features and functions and ecological function of adjacent lands evaluated				
Provincially designated portions of habitat of endangered or threatened species	√	partial	*	*
No development or Site Alteration unless demonstrates 'no negative impacts' on features/functions and ecological function of adjacent lands evaluated				
Provincial ANSIs	√	partial	*	*
Significant woodlands	√	partial	*	*
Significant wildlife habitat				
Region of Waterloo Policies				
No development or site alteration unless demonstrates no' serious adverse impacts' on features/functions				
ESPAs	√	√	√	√
Encouraging the use of natives/discouraging invasive exotic plants within ESPAs			√	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

<u>Enhanced Policies</u>

City of Kitchener Official Plan

Kitchener has a policy to restore forested habitat within publicly owned parks, open spaces and storm water management areas and to re-create or strengthen linkages between designated natural areas to enhance wildlife movement and create recreational corridors (City of Kitchener OP, Pol. 7.7.1.4). Toward this end the city has a policy that they 'may require' developers to preserve areas of wildlife habitat that lie outside of the currently designated provincial, regional and locally significant areas to provide natural corridors, linkages and hedgerows between designated areas to allow for wildlife movement (City of Kitchener OP, Pol. 7.8.2.2). These 'linkages' are to be identified through the subwatershed planning process (City of Kitchener OP, Pol. 7.3.2.5).

Kitchener does not have an objective within their official plan of conserving biodiversity (City of Kitchener OP 1885, amendments to 2005). However, the Province of Ontario, the Region of Waterloo and the Municipality of Kitchener have developed policies to preserve natural areas that are, or could be, important habitats for species susceptible to extirpation. In terms of locally significant areas, Kitchener has policies for the maintenance of the current 'diversity' of forest ecosystems, the preservation of 'significant forested areas,' the maintenance and development of 'linkages' between natural area designations, and for increasing municipal forest cover (City of Kitchener OP, Pol. 7.7 and 7.8).

Doon South Secondary Plan

Within the Doon South Secondary Plan, connectivity between natural areas is promoted through the protection of two types of corridors. Those within the more intensively development area are planned to function as 'visual amenities,' recreational systems and 'small wildlife' habitat and migration corridors. These corridors are to include areas within designated upland woodlands, storm water management facilities, hedgerows, and areas within and adjacent to the 'scenic road community trail network' (City of Kitchener Doon South Community Plan, Pol. 5.5). The second type of corridor is planned for the area to the south of the intensively planned area, which is still primarily agricultural. A 300-metre wide corridor, centred on a stream, connects a large provincially significant wetland and ESPA to the south with a large upland ESPA to the north. The corridor is designed to accommodate large mammals, such as deer (City of Kitchener, 2003b).

While this plan does not have the objective of conserving municipal or regional biodiversity, it does designate areas, such as the wide corridor described, that contribute to the conservation of biodiversity within the municipality (City of Kitchener, 2003b).

A subwatershed monitoring program is suggested within the management plan. It recommends that the developer monitor prior to, during and post development up to two years following construction. The proponent is to recommend a long-term monitoring program, however the municipality is responsible for implementing it. Based on the list of parameters to be measured, monitoring appears to be largely focused on hydrological functions, and impacts related to construction (City of Kitchener, 2003b).

Pathfinder Policies

City of Kitchener Official Plan

The City of Kitchener Official Plan has policies for regulating development within locally significant woodlands, however these areas have yet to be identified (City of Kitchener OP, Pol. 7.7). An EIS is required with a development proposal both within and adjacent to these areas (City of Kitchener OP, Pol. 7.7.1.8). There is no definition of adjacent land use within the official plan (City of Kitchener OP 1885, amendments to 2005). This means that the City of Kitchener will have to justify its request for an EIS for each adjacent land development proposal. This may be difficult if the City has not performed its own natural area-specific studies of the potential impacts of adjacent land use development. EIS for locally designated areas are required to describe mitigation, enhancement and rehabilitation measures, rather than demonstrate no negative impact on features and functions (City of Kitchener OP, Pol. 7.7.1.8iii). Significant woodlands within rural areas of the municipality do not receive the same level of protection as those within urban areas, but are subject to the region of Waterloo's tree cutting by-law (City of Kitchener OP, Pol. 7.7.2.1). The EIS policies specify assessment criteria for determining the compatibility of the development with natural area features and functions (City of Kitchener OP, Pol. 7.7.1.8ii, iii).

Specific mitigation measures in the form of buffers, setbacks, or supplemental plantings 'may be required' adjacent to designated natural areas that serve as 'significant or sensitive wildlife habitat' (City of Kitchener OP, Pol. 7.8.2.1). In addition, the municipality has a policy outlining a possible course of action, including acquisition and land use regulations, should a natural area be threatened with development (City of Kitchener OP, Pol. 3.1.2.1).

Doon South Secondary Plan

Within the Doon South Secondary Plan, there are specific mitigation measures required for development proposals within and adjacent to ESPAs and significant woodlands. These include buffers, additional plantings of native vegetation in buffers, vegetation or edge protection, restoration measures, and erosion control measures (City of Kitchener, 2003b). A comprehensive environmental assessment of these features was conducted by the city through the watershed plan to determine the area of 'adjacent land' in which to consider adjacent land use impacts. This assessment concluded that development proposals within 15 metres of these features could potentially lead to negative impacts and require an Environmental Implementation Report (EIR) to determine mitigation measures (see below under hydrological pathfinder policies for description of EIR requirements). Specific mitigation measures are also required for proposals within or adjacent to terrestrial corridors and rehabilitation areas. EIS are required to specify enhancement plantings for their edges and adhere to tree management and erosion control policies (City of Kitchener, 2003b)sec. 3). A further pathfinder policy of this plan requires EIR to describe how future demand for development generated by the proposal may affect the natural area's features and its functions (City of Kitchener, 2003b) sec 3). See Table D.6 for a summary of enhanced and pathfinder policies for preserving and protecting natural heritage areas.

Table D.6 Kitchener Enhanced and Pathfinder Policies: Natural Heritage Areas

Enhanced Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Provincially-recommended policies				
Policies that restore natural heritage areas and their connectivity				
Areas of potential natural habitat are protected or restored	√		√	
Other terrestrial corridors or linkages protected	√	√	√	√
Policies that conserve biodiversity as a goal in planning				
Supporting the function of Biodiversity or native biodiversity is one of the goals of environmental policies				
Policies that support areas and/or corridors specifically planned to support a biodiversity goal, specialized or area sensitive wildlife	√		√	
Monitoring (either by municipality or proponent)			√	
Regionally-recommended policies				
Site EIS occur in conjunction with subwatershed planning			√	√
Encouraging stewardship and education within public and private areas				
Standardized management policies (natives/invasive exotics)	√	√	√	√
Natural area specific management policies (management plans)				
Pathfinder Policies				
Increased level of preservation for designated areas				
Other natural features or areas protected (beyond those designated by Province or Region)	√	√	√	√
Rigorous assessment criteria for demonstrating development impacts compatible with features and functions	√	√	√	√
Specific mitigation measures required (ESPA; significant woodlots)				
Buffer			√	√
Enhancement planting			√	√
Tree preservation	√	√	√	√
Storm water management (including erosion/siltation controls)		√		√

EIS are required to consider cumulative effects of development			√	
Course of action should a locally-significant area be threatened with development	√			

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.2.2 Hydrological Function Policies

Basic Policies

Official Plan and Doon South Secondary Plan

Region of Waterloo policy requirements have been met and requirements for provincial policy have been partially met within both the City of Kitchener Official Plan and the Doon South Secondary Plan. In concert with the Region of Waterloo, the Grand River Conservation Authority, and other agencies, Kitchener conducts subwatershed planning, and in some cases prepares master drainage plans, along side the development of secondary plans within ‘sensitive areas,’ or those areas that will be developed in the near future. Through this process Kitchener sets water quality and quantity standards, identifies key resources and determines protection policies within the subwatersheds studied (City of Kitchener OP, Pol. 7.3). Kitchener prepared plans the three subwatersheds that encompass the Doon south creek planning area prior to the preparation of the secondary plan.

Provincial wetland policy requirements are met (City of Kitchener OP, Pol. 7.5.2). The wetland complexes associated with the three creek systems within the Doon south planning area received a comprehensive environmental assessment during the preparation of the subwatershed plan (City of Kitchener, 2003b), sec. 3). The assessment concluded that EIS are required within 120, 30 and 15 metres of ‘high, medium and low constraint’ wetland edges, respectively (City of Kitchener, 2003b) Sec. 3).

The City of Kitchener has a policy to protect significant valley lands from development (City of Kitchener OP, Pol. 7.3.2.5; 7.8.1.8). A policy specifies that the subwatershed master plan for an area will identify EIS requirements for lands adjacent to significant valley lands (City of Kitchener OP, Pol. 7.8.1.8). The Kitchener Official Plan partially meets provincial policy requirements for proposals within areas adjacent to provincial wetlands and significant valley lands. It does not require the evaluation of adjacent area ecological function (City of Kitchener OP, Pol. 7.5.2). No significant valley lands were identified within the Doon south planning area.

The policies of the two plans partially meet provincial policy requirements to protect sensitive surface and ground water areas, their features and functions. Provincial policy requires the ‘necessary restrictions’ to be placed on land uses within and adjacent to these areas (Ontario PPS 2005, Pol. 2.2.1d.). Kitchener follows regional policies with regard to sensitive groundwater areas (City of Kitchener OP, Pol. 7.3.1.6). However, Regional policies appear to be missing that regulate land use developments within areas adjacent to sensitive ground water and surface water features (Region of Waterloo OP 1995 with amendments to 1998, Pol. 5.2). This is now a provincial policy requirement according to PPS 2005, Pol. 2.2.2. Sensitive surface water features and functions may be protected through Kitchener’s policies for protecting significant valley lands. This policy appears to protect other elements, such as less significant streams, that are ‘critical to the ecological strength or viability of the significant valley land' (City of Kitchener OP, Pol. 7.3.2.5). The linkages between surface water and terrestrial areas may also be enhanced through this policy if an argument can be made that terrestrial natural areas are critical to the ecological function of the associated significant valley land.

There is no mention of groundwater features with the Doon Valley South Secondary Plan; however, the surface water features, and the three creeks, are protected from development. In addition, the rehabilitation of their watercourses and riparian vegetation is recommended to enhance their hydrological functions. Developers are required to determine buffer widths, and other measures to protect these features from adjacent development. These measures may or may not be sufficient to protect these features from adjacent development according to provincial policy. Linkages between these surface water and their adjacent terrestrial areas are maintained or enhanced within this plan, but the function of these linkages in terms of hydrology, is not clear (City of Kitchener, 2003, sec. 7.1, 7.2).

Policies in the Kitchener Official Plan regarding master drainage plans and storm water management plans seek to control storm water volumes and contaminant load (City of Kitchener OP, Pol. 7.3.3.3 and 7.3.4.2). Storm water management in the Doon south community is to occur according to guidelines prepared by the Ontario Ministry of the Environment, and the City of Kitchener. It is to be guided by the Doon South Creek Subwatershed Management Plan, and the Strasburg Creek Master Watershed Study (City of Kitchener, 2003a). The provincial policy requirement of maintaining or increasing vegetation and porous surfaces (PPS 2005, Pol. 2.2.1g.) is not specifically mentioned in either the Official or Secondary Plans (City of Kitchener OP, Pol. 7.3.3.3 and 7.3.4.2).

There is a policy related to sensitive ground water resources that states that the region, in conjunction with Kitchener and other agencies, will 'inform and consult the public about water resource protection issues' (Region of Waterloo OP 1995, Pol. 5.2.1.1c). However, the Kitchener Official Plan and the Doon South Community Plan do not have policies that promote water conservation, or practices that sustain water quality.

Within both plans, ESPAs with hydrological functions are protected according to regional policy. In addition, in the Doon South Community Plan, only Region of Waterloo approved plant species are to be planted within buffer areas, hedgerows and other areas left to naturalize within the planning area. This complies with the region's policy for plantings in and adjacent to ESPAs process (Region of Waterloo, 1992). See Table D.7 for a summary of basic policies for preserving and protecting hydrological functions.

Table D.7 Kitchener Basic Policies: Hydrological Functions

Provincial Policy	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Watershed and subwatershed planning	√	√	√	√
Prohibition of development unless (certain types of development in flood fringe of two zone or special policy area with appropriate flood-proofing))				
Floodplains	√	N.A.	√	N.A.
No Development and site alteration (or within adjacent lands unless no negative impacts to features and functions)				
Provincially significant wetlands	√	partial	√	partial
No development and site alteration unless it has been demonstrated there will be no negative impacts on features/functions (except agricultural uses)				
Fish habitat	√	N.A.	√	N.A.
Significant valley lands	√	partial	*	*
Development and site alteration shall be restricted within and adjacent to these areas such that these features and their hydrologic functions will be protected, improved or restored				

Municipal drinking supplies and designated vulnerable areas	√		*	
Vulnerable surface and ground water; sensitive surface and ground water features and their hydrologic functions	partial	partial	partial	partial
Maintain linkages and related functions between				
Surface water features, ground water features, hydrologic functions and natural heritage features and areas	partial	N.A.	partial	N.A.
Promote efficient and sustainable use of water resources		partial		partial
Ensure storm water management practices minimize storm water volumes, contaminant loads, maintain or increase extent of vegetation and pervious surfaces		partial		partial
Regional Policies				
No development and site alteration unless EIS demonstrates no 'serious adverse impact' upon the features and functions				
ESPAs (with hydrological function)	√	√	√	√
Encouraging the use of natives/discouraging invasive exotic plants within ESPAs	N.A.	N.A.	√	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
*areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

<u>Enhanced Policies</u>

Official Plan

Connectivity within the hydrological system (over and above that required by provincial and regional policy) is achieved through policies that preserve and protect areas associated with significant valley lands, and fisheries (City of Kitchener OP, Pol. 7.3.2.5 and 7.8.1.2). Development may be permitted within and adjacent to areas included in significant valley lands subject to a site EIS (City of Kitchener OP, Pol. 7.3.2.6). Together, these corridors are to contribute toward the creation of a 'continuous linear open space system' in Kitchener (City of Kitchener OP, Pol. 7.3.2.5).

In terms of restoration policies, restoration of riparian areas may be achieved through Kitchener's policy to naturalize some of its parks and open space (City of Kitchener OP, Pol. 7.7.1.4, 7.8.2). Private landowners may be assisted in their efforts to reforest or restored forests associated with wetland areas (City of Kitchener OP, Pol. 7.7.1.5).

Doon South Secondary Plan

This community plan includes all the enhanced policies within the Kitchener Official Plan. Extensive stream and riparian habitat restoration policies are established through this plan, in addition to the restoration of corridors between wetlands and their associated upland habitats (City of Kitchener, 2003a; City of Kitchener, 2003b).

<u>Pathfinder Policies</u>

City of Kitchener Official Plan

Development is prohibited in locally significant wetlands (> 2ha in area), except for major municipal infrastructure, which can make 'minor intrusions' subject to an EIS and mitigation measures (City of Kitchener OP, Pol. 7.5.3.4). Development is prohibited within local wetlands < 2ha 'where feasible,' and 'major intrusions' will be permitted, if an EIS states that the wetland has no 'significant' ecological or hydrologic functions (City of Kitchener OP, Pol. 7.5.3.5).

Specific mitigation measures are required for development adjacent to all wetlands. Developers are required to make recommendations on the need for, width of, and compatible land uses within, vegetated buffers, and building setbacks (City of Kitchener OP, Pol. 7.5.1). Buffers and setbacks to local wetlands of 'up to' 30 metres in width are required; however, there are no minimum width provisions (City of Kitchener OP, Pol. 7.5.3.7). Buffers are to be dedicated to the City (in addition to land required for the parkland dedication) (City of Kitchener OP, Pol. 7.5.3.8). For development proposals on lands adjacent to local wetlands (defined as 120 metres from wetland edge), an EIS is required to determine if development can occur without 'adversely affecting' the wetland (City of Kitchener OP, Pol. 7.5.3.7) The term 'adversely affecting' is not defined. A minimum 30-metre buffer is also required adjacent to existing, or potential, fish habitat within warm water streams (City of Kitchener OP, Pol. 7.8.1.2). Specific storm water management practices may be required in areas of the municipality where a master drainage plan has not been prepared (City of Kitchener OP, Pol. 7.3.4.2). The purpose of these practices is to minimize the impacts on adjacent surface, groundwater and terrestrial natural areas from alterations in hydrological regimes due to adjacent development (City of Kitchener OP, Pol. 7.3.4.2, 7.3.4.2).

Doon South Secondary Plan

Although the wetlands are considered interconnected within the Doon South Secondary Plan, and could all be subject to provincial wetland policy, the comprehensive environmental assessment differentiated the different components of the wetland complexes according to 'edge sensitivity.'(See Basic hydrological policies for description of policies). However, all these wetland components require proponents to prepare EIS and Environmental Implementation Report (EIR) for development within a certain distance of the wetland edge. This latter report is to demonstrate: 1) there will be no loss of wetland area or function, 2) how 'vital' terrestrial 'linkages and connections' will be maintained, and 3) specify other measures necessary to mitigate the anticipated negative impacts of development (City of Kitchener, 2003a Pol. 5.11, 5.12, 5.13; City of Kitchener, 2003b), Sec. 3).

Specific mitigation measures include supplemental native vegetation within buffers, tree management policies, allowing regeneration in riparian areas (and very little subsequent management or agricultural land use). The purpose of plantings within the buffer is to 'establish native species, assist natural succession, and to provide additional linkage opportunities for movement of wildlife' (City of Kitchener, 2003b), Sec. 8). Fences and signage permanently demarcate buffers once construction is complete (City of Kitchener, 2003b), Sec. 8(1)). However, the policy does not specify the purpose of this demarcation. It must be assumed to protect the adjacent natural area from adjacent resident impacts.

A policy to protect wildlife habitat from recreation-related disturbances is also included in this plan. In some areas adjacent to storm water management facilities, wetlands and stream corridors, trails are to be design on the outside of buffers, or the STM facilities (that lie immediately adjacent to these features), to reduce recreation-related impacts on wetlands and stream corridors (City of Kitchener, 2003b, Sec. 8 (5). See Table D.8 for a summary of enhanced and pathfinder policies for preserving and protecting hydrological functions.

Table D.8 Kitchener Enhanced and Pathfinder Policies: Hydrological Functions

Enhancement Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Provincially-recommended policies				
Restoring hydrological features and their connectivity				
Areas of potential natural habitat/function are protected or restored	partial	√	√	√
Other hydrological corridors protected (beyond those designated by province or region)	√	√	√	√
Monitoring			√	
Regionally-recommended policies				
EIS occurs in conjunction with subwatershed planning	√	√	√	√
Encouraging stewardship and education				
Standardized management regimes				
Natives only /discouraging invasive exotic plants	√	√	√	√
Natural area-specific management regimes				
Management plans				
Pathfinder Policies				
Other hydrological areas protected (beyond those designated by province or region)	√	√	N.A.	N.A.
Assessment criteria for demonstrating no negative impacts on features and functions from development (construction)	√	√	√	√
Specific mitigation measures are required (wetlands)	√	√	√	√
Buffers	√		√	
Supplemental plantings			√	
Tree management	√		√	
Storm water management (including erosion control)		√		√
Mitigation of future impacts of adjacent residents (wetlands/some stream corridors)				
Fences			√	
Signage			√	
Mitigation of future impacts of recreation				
Position trails away from 'sensitive areas' (wetlands/stream corridors)			√	
Mitigation of incremental impacts of development (wetlands)			√	
Designation-specific management regimes (wetlands/stream corridors)			√	
'passive management' or naturalization			√	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.3 Municipality of Waterloo

The municipality of Waterloo is a lower-tier municipality within the Regional Municipality of Waterloo. At the time of approval, the Official Plan of the City of Waterloo (1990, amended in 2004) had to be consistent with the policies of the 1990 Planning Act, and the Floodplain policy statement (1988). The comprehensive provincial policy statement was not yet in force. The current OP of the Region of Waterloo (1995, amended in 1998) post-dated that of the City of Waterloo. At the time of approval, compliance with the Region of Waterloo's 1985 OP would have been required. This regional OP was similar to the current one in terms of the policies regulating development within and adjacent to regionally significant areas. However, the 1995 Official Plan of the Region of Waterloo included rigorous criteria for designating regionally significant areas, in addition to a definition of 'adverse environmental impacts.' This helped local municipalities and the Region of Waterloo, negotiate stronger controls on development during the subdivision approval process (C. Gosselin, Region of Waterloo, Personal Communication, Nov. 15, 2006).

The natural systems policies developed for some of the Westside lands of the City of Waterloo in the mid 1990s were significantly different from those approved in the OP prior to this time. Within the Region of Waterloo OP (1995, amended in 1998), the West side lands of the City of Waterloo are identified, 'symbolically', as an ‘environmentally significant landscape,’ in part due to the existence of four regional ESPAs, and a provincially significant wetland complex in close proximity. In its OP, the Region of Waterloo required the municipality to conduct a ‘comprehensive study’ to assess these agricultural lands, along with the functions and interrelationships of their natural areas, prior to local policy development. In particular, the City of Waterloo was to develop ‘specific targets or restrictions’ on land uses within this area that would protect its features and functions (Regional Municipality of Waterloo, 1998), Pol. 4.6.1. The City of Waterloo engaged in a comprehensive subwatershed planning process for this area of the Laurel Creek Watershed in the early 1990s, involving many community groups, including developers, other planning jurisdictions and the public (Cox, Hendrickson, Skelton, & Suffling, 1996). The resulting policies for this area of Waterloo were incorporated into the Official Plan of Waterloo (City of Waterloo, 2004). The policies for the Laurel wood Secondary Plan (an area within the West side lands), developed in approximately 1993, will be described as an example of these policies.

The City of Waterloo’s primary environmental goal is: ‘to protect, conserve, manage and enhance its natural resources including land, surface water and groundwater quantity and quality, forest and wildlife’ (City of Waterloo, 2004), Pol. 1.7.2.3). To achieve this goal in terms of its natural areas, the City of Waterloo’s Official Plan has six objectives:

1. To control runoff from development;
2. To prevent steam bed disturbance, sheet and stream bank erosion during and post development, and restore stream banks to a natural or stable condition (where practical);
3. To ensure water quality and preserve aquatic resources;
4. To protect and enhance the fishery habitat;
5. To protect surface discharge and water supply aquifer;
6. To identify and protect significant natural areas and other ‘environmentally-important resources’ from the ‘negative impacts of proposed development’ so that ecological processes and genetic diversity are maintained
   (City of Waterloo, 2004, Pol. 1.7.3.6, 1.7.3.7, 1.7.3.8, 1.7.8.9, 1.7.3.10, 1.7.3.12).

D.3.1 Natural Heritage Area Policies

<u>Basic Policies</u>

City of Waterloo Official Plan

The Official Plan for the City of Waterloo partially meets the policy requirements of the PPS 2005 and the Regional Official Plan in terms of its policies for protecting natural heritage areas. No policies address the significant habitat of endangered species or threatened species. Provincial ANSIs, significant woodlands, and significant wildlife habitat are protected as regional ESPAs, and development proposals within these areas require an EIS , and within other ESPAs (City of Waterloo, 2004, Pol. 2.3.13.1, 2.3.13.4, 2.3.23.5). However, it is unclear whether an EIS is required for both development (structures) and site alteration, as no definitions are provided for these terms.

There is no requirement for an EIS to demonstrate ‘no negative impacts’ to the features and functions of ANSIs (as required by the PPS 2005, Pol. 2.1.4e.), or for it demonstrate ‘no serious adverse impacts’ on the features and functions of ESPAs (as required by the Regional of Waterloo OP, Pol. 4.3.14). Rather, an EIS is required to outline mitigating measures necessary to reduce or eliminate the expected impacts (City of Waterloo, 2004, Pol. 2.3.13.5.3, 2.3.13.5.4). In addition, there are no policies requiring an EIS for development proposals within land uses adjacent to provincially significant areas, or that require the assessment of the ecological functions of adjacent lands (PPS 2005, Pol. 2.1.6).

Laurelwood Secondary Plan

Basic policy compliance is similar to that of the Official Plan except that an EIS is now required for developments within lands adjacent to an ANSI, and other ESPAs. While the subwatershed study indicates that adjacent lands (designated Constraint level 3) fulfill ecological functions within the subwatershed, there is no assessment of their functions, and a developer is not required to assess site-scaled functions within an EIS. These areas are subject to ‘best management practices’ to reduce the impacts of development on the subwatershed; however these practices are largely limited to storm water management practices and do not recognize, or support, the ecological functions of these areas. See Table D.9 for a summary of basic policies for preserving and protecting natural heritage features.

Table D.9 Municipality of Waterloo Basic Policies: Natural Heritage Areas

PPS 2005 Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Development may be permitted if risk to public safety minor/mitigated according to provincial standards				
Hazardous sites (steep slopes, erosion prone, unstable soils)	√	**N.A.**	√	**N.A.**
Prohibition of development and site alteration within and no development or site alteration adjacent lands to unless demonstrates ‘no negative impacts’ on features and functions and ecological function of adjacent lands evaluated				
Provincially designated portions of habitat of endangered or threatened species				
No development or Site Alteration unless demonstrates ‘no negative impacts’ on features/functions and ecological function of adjacent lands evaluated				
Provincial ANSIs	partial		partial	partial
Significant woodlands	partial		partial	partial
Significant wildlife habitat	partial		partial	partial
Region of Waterloo Policies				
No development or site alteration unless demonstrates no’ serious adverse impacts’ on features/functions				
ESPAs	partial		partial	partial

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

City of Waterloo Official Plan

The City of Waterloo Official Plan has established a provincially recommended policy of restoring areas with degraded habitat (PPS 2005, Pol. 2.1.2). It has a policy to assist in the ‘reforestation and improvement’ of privately owned woodlands (City of Waterloo, 2004, Pol. 2.3.12.4). Stewardship is encouraged within privately owned natural areas by encouraging landowners to seek the management assistance of the Ontario Ministry of Natural Resources or the Grand River Conservation Authority (City of Waterloo, 2004, Pol. 2.3.12.5).

Laurelwood Secondary Plan

The policies of the Laurelwood Secondary Plan recognize the value of areas that are degraded but have the potential to be 'significant' natural areas. An EIS is required for development within local areas that do not meet the criteria for locally significant areas because they are degraded. These include areas of lower quality vegetation with higher levels of disturbance; lower quality vegetation adjacent to, or connecting, other natural area designations; degraded vegetation that has the potential to function as important connectors, and urban green space (including active parkland). A number of these areas are also recognized for their function as linkages between natural areas.

The secondary plan also includes the objective of maintaining genetic diversity. Proponents are required to demonstrate through an EIS, and a buffer study, that they will maintain and enhance biological diversity within the designated natural areas and systems. Areas that may be particularly important for maintaining diversity have also been designated within the Laurel Creek area, including ESPAs, areas with mature vegetation >4ha, and areas that link significant natural areas. In addition, monitoring is required for some of these areas according to the performance criteria within the Laurel Creek sub-watershed plan.

In terms of regionally suggested policies, an EIS must be prepared in conjunction with the sub-watershed plan for proposals within adjacent areas to locally significant natural areas.

Pathfinder Policies

City of Waterloo Official Plan

Locally significant areas are designated, with an EIS required for development proposals within and adjacent to both locally significant areas (ESAs) and locally significant woodlots (City of Waterloo, 2004, Pol. 2.3.14.3). EIS must demonstrate the compatibility of the 'development' with the ESA (City of Waterloo, 2004, Pol. 2.3.14.4.5). The criteria used to identify ESAs are not included within the official plan (City of Waterloo, 2004, Pol. 2.3.14.1). While the EIS is not required to demonstrate 'no negative impacts on features and functions', they may be reviewed by the Regional Ecological and Environmental Advisory Committee (EEAC) (City of Waterloo, 2004, Pol. 2.3.14.6).

In addition, the City of Waterloo has a policy that states that if an ESPA is degraded to a level where it no longer meets ESPA requirements, its designation will be changed to an ESA (City of Waterloo, 2004, Pol. 2.3.13.6). The City of Waterloo also has a policy that describes a course of action, including possible acquisition, should an EIS indicate that a development proposal will lead to unacceptable negative impacts on a significant natural area, including a locally-significant area (City of Waterloo, 2004, Pol. 2.3.6).

Laurelwood Secondary Plan

In addition to the Pathfinder policies listed for the City of Waterloo Official Plan, those in the secondary plan for the Laurelwood lands include an increased level of preservation for both provincial ANSIs and other regional ESPAs. 'No development or encroachment' is permitted within these areas. Locally significant areas have also been designated. No development or encroachment is permitted within areas of 'mature vegetation over 4 ha and which exhibit low levels of human disturbance;' and areas of 'high quality' vegetation which lie adjacent to or connect other designated natural areas. Development proposals within areas adjacent to ANSIs, ESPAs and these locally significant areas require an EIS.

In addition, specific mitigation measures are required for developments within adjacent lands to ANSIs, ESPAs, and the more significant local natural areas. They consist of a minimum buffer of 15-30 metres to be determined by a buffer study. Development within adjacent lands to less significant local natural areas may also require a buffer or may be subject to a buffer study if they are wooded. See Table D.10 for a summary of enhanced and pathfinder policies for preserving and protecting natural heritage features.

Table D.10 Waterloo Enhanced and Pathfinder Policies: Natural Heritage Areas

Enhanced Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Provincially-recommended policies				
Restoring natural heritage areas and their connectivity				
Areas of potential natural habitat are protected or restored	√		√	
Other terrestrial corridors or linkages protected (beyond significant valley lands)			√	√
Conserving biodiversity is a goal in planning	√		√	√
Areas/corridors designated for their role in support of biodiversity			√	
Monitoring required (either by municipality or proponent)			√	
Regionally-recommended policies				
Site EIS required in conjunction with subwatershed planning			√	
Standardized management policies				
Encouraging natives/discouraging exotic invasives				
Natural area-specific management policies				
Management plans				
Encouragement of stewardship or management agreements				
Private natural areas	√		√	
Public natural areas				
Pathfinder Policies				
Increased level of preservation for designated areas			√	
Other natural areas protected (beyond those designated by the Province or Region)	√	√	√	√
Assessment criteria for demonstrating development compatible with features and functions	√	√	√	√
Specific mitigation methods required				
Buffers			√	√
Tree preservation			√	√
Mitigation of Recreation impacts or future impacts				
Low impact trail design			√	
Course of action should a private natural area be threatened with development (including acquisition)	√		√	
Course of action should a regionally designated area be degraded to a point where it no longer meets ESPA criteria	√		√	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.3.2 Hydrological Function Policies

<u>Basic Policies</u>

City of Waterloo Official Plan

The Official Plan has partially met the policy requirements of the provincial and regional governments. It has a policy that will incorporate watershed goals, objectives and policies to guide future development; however, it is unclear whether this policy is restricted to the Laurel creek watershed planning area, or applies to the entire municipality (City of Waterloo, 2004, Pol. 1.6.2.12).

Policies for development proposals within ANSIs and regional ESPAs (with a hydrological function) do not require that an EIS demonstrate no ‘serious adverse impacts’ on features and functions (City of Waterloo, 2004, Pol. 2.3.13.4). Policies are missing for significant valley lands and fish habitat, although there are policies that support the protection of the Grand River and its tributaries. Policies state that the City of Waterloo will support the Region of Waterloo, the GRCA, and other agencies to acquire, protect and develop corridors associated with these hydrological features in order to create ‘open space’ and recreation facilities (City of Waterloo, 2004, Pol. 3.7.3.9) Policies partially meet requirements for development within areas adjacent to the above areas. There are no policies that require an EIS for development proposals within lands adjacent to ANSIs (or any other ESPA) that may have a hydrological function. Similarly, there are no policies that specify that the ecological functions of the adjacent lands will be assessed. However, there is a policy that requires building setbacks from the Grand River and its tributaries (City of Waterloo, 2004, Pol. 3.7.3.9.2).

There are no policies that specifically reference regionally designated sensitive groundwater areas, or regionally or locally designated environmentally significant discharge areas, or maintaining linkages between terrestrial, ground water and surface water features (as required by PPS 2005, Pol. 2.2.1). There is a policy that promotes the maintenance of surface water linkages along the Grand River, its tributaries, and the ‘open space corridor’ surrounding the Laurel Creek Conservation Area (City of Waterloo, 2004, Pol. 3.7.3.9, 3.7.3.10)

The City of Waterloo has met the requirement for having a policy that promotes water conservation (PPS 2005, Pol. 2.2.1f). Its policy states that it will assist the Region of Waterloo in its efforts to implement water conservation measures (City of Waterloo, 2004, Pol. 2.4.3). In addition, it has policies that require storm water management practices the ensure the negative development impacts on the watershed, including its hydrological features, are minimized (City of Waterloo, 2004, Pol. 2.4.6). However, this OP does not specifically mention minimizing storm water volumes, contaminant loads, or maintaining or increasing vegetation or pervious surfaces as is required in the PPS 2005, policy 2.2.1 g.

Laurelwood Secondary Plan

Laurelwood Secondary Plan policies are in full compliance with Regional Official Plan policies, but are partially compliant to provincial policies. Provincial policy requires that land use restrictions protect, restore and improve municipal drinking supplies, and vulnerable and sensitive surface and ground water features. Although many hydrological features and corridors have been protected through municipal policies, it is difficult to determine the degree these independent policies addresses water quality and quantity as a hydrological system.

Provincial policy also requires that linkages be maintained between surface water, ground water and terrestrial natural areas and features. Although the Secondary Plan maintains many surface and terrestrial natural areas and feature linkages, there is no explicit reference to groundwater systems, or the interaction with surface water and terrestrial systems in support of water quality and quantity.

Policies for lands adjacent to ESPAs with a hydrological function require an EIS and comply with regional requirements. Some provincial policy requirements are also met. Areas adjacent to provincial wetlands require an EIS; however, there is no requirement for proponents to assess their ecological functions. The Secondary Plan also meets the required storm water management objectives. All adjacent lands (even those not immediately adjacent to natural areas) are subject to 'best management practices,' which include 'storm water infiltration trenches, extended detention and wetland creation.' In addition, this plan specifies that storm water management designs meet specific water quantity and quality targets specified in the sub-watershed plan.

Other adjacent land use policies are more difficult to evaluate in terms of their provincial compliance. A provincial requirement specifies that development and site alteration 'be restricted near sensitive surface features and sensitive ground water features such that these features and their related hydrological functions will be protected, improved or restored.' However, within the Waterloo Official Plan there are no requirements for land use restrictions adjacent to groundwater recharge areas or local wetlands. This may, or may not, reduce the extent to which these functions are protected. There are also no policies that address the provincial policy requirement that efficient and sustainable use of water resources be promoted, including the promotion of practices that conserve water and sustain water quality. See Table D.11 for a summary of basic policies for preserving and protecting hydrological functions.

Table D.11 Waterloo basic policies: Hydrological functions

Provincial Policy	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Watershed planning	√	√	√	√
Prohibition of development unless (certain types of development in flood fringe of two zone or special policy area with appropriate flood-proofing))				
Floodplains	√	N.A.	√	N.A.
No development and site alteration within, and none on adjacent land unless it has been demonstrated there will be no negative impacts on features/functions and ecological functions of adjacent lands evaluated				
Provincially significant wetlands	√	partial	√	partial
No development and site alteration within or on adjacent land unless it has been demonstrated there will be no negative impacts on features/functions and ecological functions of adjacent lands evaluated				
Fish habitat				
Significant valley lands				
Development and site alteration shall be restricted within and adjacent to these areas such that these features and their hydrologic functions will be protected, improved or restored				
Municipal drinking supplies and designated vulnerable areas			partial	
Vulnerable surface and ground water; sensitive surface and ground water features and their hydrologic functions			partial	
Maintain linkages and related functions between				
Surface water features, ground water features, hydrologic functions and natural heritage features and areas	partial		partial	
Promote efficient and sustainable use of water resources	√	√		
Ensure storm water management practices minimize storm water volumes, contaminant loads, maintain or increase extent of vegetation and pervious surfaces	partial	partial	partial	partial
Regional Policies				
No development and site alteration unless EIS demonstrates no 'serious adverse impact' upon the features and functions				
ESPAs (with hydrological function)	partial		√	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

City of Waterloo Official Plan

Enhanced policies within the City of Waterloo Official Plan include the requirement for an EIS for lands adjacent to locally significant wetlands, and stream valley corridors (City of Waterloo, 2004, Pol. 2.3.14.1). It does not have a criterion for designating these areas within its Official Plan (City of Waterloo, 2004, Pol. 2.3.14.1).

Laurelwood Secondary Plan

The Laurelwood Secondary Plan has policies that protect locally significant hydrological corridors. Development is prohibited within 30 metres of a perennial stream, 15 metres of an intermittent stream, and high quality vegetation adjacent to or linking, ESPAs and locally significant vegetation >=4 ha. Proposals within 15 metres of an intermittent stream and lower quality vegetation adjacent to or linking, ESPAs, locally significant, and rehabilitation areas require EIS. There are also policies that encourage rehabilitation and naturalization within the buffer areas of stream corridors.

All EIS must be carried out in conjunction with the subwatershed study and all adjacent areas are to be developed and monitored according to the performance criteria within the Laurel Creek Watershed Subwatershed Plans.

Pathfinder Policies

City of Waterloo Official Plan

A pathfinder policy within the City of Waterloo Official Plan addresses the future management implications of development adjacent to stream corridors. Where the City of Waterloo is accepting land adjacent to an open water course as part of the dedication for park purposes, the proponent is required to provide sufficient space to allow for the maintenance of the watercourse (City of Waterloo, 2004, Pol. 2.3.9).

Specific mitigation measures are also required adjacent to riverbanks, and hazard lands, in the form of setbacks (City of Waterloo, 2004, Pol. 2.3.10.7, 3.7.3.9.2). Adjacent to hazard lands these setbacks protect residents and their property from erosion or flooding hazard. The characteristics of these hazards determine the width of the setback. Setbacks from riverbanks that are not hazard lands are designed to 'protect the scenic quality' of the river (City of Waterloo, 2004, Pol. 3.7.3.9.2).

Laurelwood Secondary Plan

The Laurelwood Secondary Plan provides an increased level of protection for both provincial ANSIs and other regional ESPAs. 'No development or encroachment' is permitted within these areas; however, these terms are not defined. Protective policies have been developed for locally significant hydrological features. A proposal within a locally significant wetland or groundwater recharge area requires an EIS.

Negative impacts on floodplains and stream corridors are mitigated through a boundary definition that includes the area required to filter and absorb storm water, rather than through a buffer requirement. The boundaries of floodplains are 15 metres from top of bank (or the regulatory flood plain, whichever is greater), and perennial and intermittent streams are defined to include 30 and 15 metres of riparian habitat, respectively. However, minimum buffers of 15-30 metres (depending on a buffer study to be prepared by the proponent) are also required as specific mitigation measures adjacent to ESPAs, locally significant vegetation >= 4ha, and high quality vegetation adjacent to or linking an ESPA, or linking locally significant vegetation >= 4ha. Buffers may also be required (according to a buffer study) adjacent to intermittent streams, lower quality vegetation adjacent to, or linking, ESPAs, locally significant areas, and rehabilitation areas; locally significant wetlands and groundwater recharge areas, if any of these areas are wooded.

Although no specific policy requirements are established, resident access to stream corridor buffers is to be controlled through fencing, signage and/or controlled access points. In addition, pedestrian trails may be placed within these buffers, but only those that do not lead to high construction impacts (not highly 'engineered surfaces') on the buffer and its adjacent natural area. See Table D.12 for a summary of enhanced and pathfinder policies for preserving and protecting hydrological functions.

Table D.12 Waterloo Enhanced and Pathfinder Policies: Hydrological Functions

Enhancement Policies	**OP-W**	**OP-A**	**SP-W**	**SP-A**
Provincially-recommended policies				
Restoring hydrological features and their connectivity				
Areas of potential natural habitat are protected or restored			√	
Other hydrological corridors protected (beyond those designated by province or region)		√	√	√
Monitoring			√	
Regionally-recommended policies				
Watershed/subwatershed planning prior to/in conjunction with EIS			√	
Standardized management regimes				
Naturalization			√	
Pathfinder Policies				
Increased level of preservation for designated regionally or provincially designated areas			√	
Other hydrological features/areas protected (beyond those designated by province or region)	√	√	√	√
Assessment criteria for demonstrating compatibility of development with natural area features and functions	√	√	√	√
Specific mitigation measures				
Buffers				√
Setbacks		√		
Tree preservation			√	√
Storm water management (including erosion/ siltation controls)	√	√	√	√
EIS must evaluate and provide for the future impacts on management development on the management of the hydrological feature/function				
Sufficient space for management		√		√
Mitigation of future impacts of adjacent residents (stream corridor buffers)			√	
Fencing, signage and/or controlled access points			√	√
Mitigation of recreation impacts or future impacts				
Low impact trail design			√	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.4 Municipality of Guelph

The City of Guelph is an upper-tier municipality. When first approved by the province of Ontario, the Official Plan of Guelph (1994, with amendments to 2004) had to be consistent with the policies of the 1995 PPS. Guelph's goal for the protection of its natural environment is 'to respect and encourage the protection and enhancement of the natural environment, other distinctive features of the landscape and the associated ecological functions to support a healthy and diverse ecosystem both within and beyond the city limits (Guelph OP 2001, p. 5).

Guelph has four objectives to achieve these goals in terms of its natural systems:

1. To identify, preserve, protect and enhance significant natural areas and functions;
2. To interconnect significant natural areas with terrestrial and surface water corridors;
3. To protect significant natural areas and functions from adjacent development (structures and site alteration), and
4. To provide 'ecologically-appropriate' recreational and educational opportunities within the natural areas.

D.4.1 Natural Heritage Area Policies

Basic Policies

The City of Guelph's Official Plan meets many of the basic policy requirements of the PPS of 2005. Significant woodlands, and significant wildlife habitats have been defined and a site EIS is required for development within and adjacent to these areas. Adjacent lands are defined as 50 metres (or that defined in a comprehensive EIS) for significant portions of the habitat of endangered species and threatened species, provincial ANSIs, significant woodlands, and significant wildlife habitat. However, for ANSIs, significant woodlands and wildlife habitat there are no policies that specify that no development or site alteration will occur if the EIS demonstrates that there will be a negative impact on their features or functions. In addition, the assessments of the ecological functions of adjacent land uses are not a requirement of site EIS. See Table D.13 for a summary of basic policies for preserving and protecting natural heritage areas.

Table D.13 Guelph Basic Policies: Natural Heritage Areas

PPS 2005 Policies	OP-W	OP-A
Development may be permitted if risk to public safety minor/mitigated according to provincial standards		
Hazardous sites (steep slopes, erosion prone, unstable soils)	√	N.A.
Prohibition of development and site alteration within and no development or site alteration adjacent lands to unless demonstrates 'no negative impacts' on features and functions and ecological function of adjacent lands evaluated		
Provincially designated portions of habitat of endangered or threatened species	√	partial
No development or site alteration unless demonstrates 'no negative impacts' on features/functions and ecological function of adjacent lands evaluated		
Provincial ANSIs	√	partial
Significant woodlands	partial	partial
Significant wildlife habitat		

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

The City of Guelph has policies to restore habitat within designated natural areas and open space areas outside the natural area network. Proponents may be required to enhance significant portions of endangered or threatened species, ANSIs, and other locally designated areas, 'where appropriate and reasonable' as part of the EIS requirement for these areas. The City of Guelph also has a policy to naturalize other 'open space' areas outside the network, such as storm water management areas or portions of active parks, 'where appropriate.'

In terms of enhancing connectivity between natural heritage areas, Guelph has a policy requiring EIS for proposals within and adjacent to terrestrial corridors that connect provincially significant wetlands and the major river corridors. Ecological linkages between remnant natural areas are restored through the naturalization of its other types of 'open space.' Tree management policies regulate development within and adjacent to non-significant wooded areas, hedgerows and individual trees.

Guelph states that one of the objectives of its open space system is to 'encourage indigenous biological diversity in appropriate open space areas' (Official Plan of Guelph 1994 amended in 2004, p. 126). The Plan does not specify which open space areas are 'appropriate' for encouraging indigenous biological diversity. The municipality has policies to support wildlife areas that include habitats for rare or specialized and vulnerable species. Biodiversity is supported through the connection of Guelph's open spaces into a linked system.

Guelph has a comprehensive monitoring program for both natural heritage areas and hydrological functions. Within development proposals, developers must prepare, but not implement, a short and long-term monitoring program. This program evaluates the site scaled impacts of development. Guelph also has a policy to establish a monitoring program (with other agencies) to assess long-term impacts at the scale of the watershed/subwatershed. In addition, it has a policy to conduct comprehensive EIS to establish baseline data points relative to which impacts can be assessed.

Guelph also has enhanced policies that have been recommended by some of the regional governments of the other local municipalities. It has policies to encourage stewardship and education. It requires developers to prepare brochures, signage or other means to 'explain the ecosystem approach used to protect the city's natural heritage system' to initial homeowners. The definition of the City's goals for its natural heritage system or its 'ecosystem approach' is unclear and therefore it is difficult to determine the purpose of these stewardship programs. The City also has a policy to conduct other types of programs including meetings, newsletters, signage, information reports and its own brochures to educate and encourage all residents to steward public natural areas and the environment. However, the educational message or stewardship activities to be adopted by residents are not stated. In addition to these programs, Guelph has an urban design policy that promotes design that encourages informal surveillance of public parks. It is not clear whether this policy is related to its policy to promote stewardship among residents, or the extent to which it refers to the design of boundary areas between natural areas and adjacent residents.

Pathfinder Policies

Provincial ANSIs receive an increased level of protection within the Guelph Official Plan. A policy prohibits all development (structures and site alteration) within these areas. In addition, within and adjacent to most designations, rigorous assessment criteria are required within EIS. However, EIS for significant woodlands and wildlife habitat appear to be less rigorous than for other natural area designations. In some cases, proponents are required to prepare an environmental implementation report (EIR) that outlines how the proposal meets the conditions of development. Guelph's ecological advisory committee reviews both EIR and EIS. The City of Guelph also has a course of action should a privately owned natural heritage feature be threatened with development.

Specific mitigation measures include tree preservation, erosion/siltation, and storm water 'best management practices.' These latter practices minimize the impacts of development within and adjacent to natural areas, and the future maintenance of these facilities.

Guelph also has a policy that it may refuse a development proposal in instances where the development is predicted, through an EIS, to have a 'substantial negative impact' (feature or functions are lost or severely degraded) on a natural area See Table D.14 for a summary of enhanced and pathfinder policies for preserving and protecting natural heritage areas.

Table D.14 Guelph Enhanced and Pathfinder Policies: Natural Heritage Areas

Enhanced Policies	**OP-W**	**OP-A**
Provincially-recommended policies		
Restoration of habitat, or potential habitat within designated areas and certain open spaces, 'where appropriate'	√	
Other terrestrial corridors or linkages protected	√	√
Supporting the function of biodiversity or native biodiversity is one of the goals of environmental policies	√	
Policies that support areas and/or corridors specifically planned to support a biodiversity goal, specialized or area sensitive wildlife	√	
Monitoring	√	
Policies suggested by some regions		
Subwatershed/watershed studies prior to or in conjunction with site EIS, where appropriate	√	√
Stewardship and education policies		
Stewardship of private natural areas	√	
Resident education or stewardship of public natural areas	√	√
Subdivision and recreation system design that encourages 'informal surveillance' by residents	partial	partial
Pathfinder Policies		
Increased level of preservation for designated areas	√	
Rigorous assessment criteria for demonstrating development impacts compatible with features and functions	√	√
Other natural features or areas protected (beyond those designated by the Province)	*	*
Specific mitigation measures		
Tree preservation	√	
Storm water management (including erosion and siltation controls and ease of maintenance)		√
Course of action should a privately owned natural area be threatened by a development proposal (including acquisition and management agreements with owners)	√	
Protection of natural areas from impacts related to development of recreation facilities		
Protection of natural areas from construction impacts related to trail development	√	
Standardized management regime		
Naturalization policies (within open space areas outside the natural heritage system)		√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
*areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.4.2 Hydrological Function Policies

Basic Policies

Within the City of Guelph Official Plan, basic policy requirements have been met for development proposals within provincially designated natural heritage features related to hydrology. Policy requirements are partially met for proposals on lands adjacent to these features. EIS for Provincially significant wetlands must demonstrate that the proposal will not result in 'a loss of the wetland's function' rather that no negative impact on the wetland's features and functions, as is required by provincial policy. In addition, there is no policy that specifies that the ecological functions of adjacent areas must be assessed.

This Official Plan indicates that Guelph is still in the process of identifying some of the surface water, ground water, hydrological functions and natural heritage areas that are key to protecting, improving and restoring water quality and quantity. Specific policies that govern development within and adjacent to all drinking supplies and vulnerable surface and ground water features and functions are not established as policies within this Official Plan.

Guelph partially fulfills the requirement to maintain linkages and related functions between water features, ground water features, hydrologic functions and natural heritage areas. It has policies that protect significant, and not significant, 'Environmental corridors' (valleylands/water courses), and 'ecological linkages' (or terrestrial corridors). The purpose of these latter areas is to link not only terrestrial natural heritage features and areas, but also wetlands and valley lands.

Guelph has policies to ensure that stormwater management practices regulate stormwater management volumes and minimize contaminant load. Maintaining (but not increasing) existing vegetation in association with major watercourses is mentioned as desirable, however there is no specific mention of maintaining or increasing the amount of pervious surfaces. While the official plan contains a goal to promote the sustainable use of resources, it does not have any specific policies that relate to promoting the efficient and sustainable use of water resources. See Table D.15 for a summary of basic policies for protecting hydrological functions.

Table D.15 Guelph Basic Policies: Hydrological Functions

Provincial Policy	**OP-W**	**OP-A**
Watershed and subwatershed planning	√	√
Prohibition of development unless (certain types of development in flood fringe of two zone or special policy area with appropriate flood-proofing))		
Floodplains	√	N.A.
No development and site alteration within, and none within adjacent lands unless no negative impacts to features and functions and ecological functions of adjacent land uses are evaluated		
Provincially significant wetlands	√	partial
No development and Site Alteration within and adjacent to feature unless it has been demonstrated there will be no negative impacts on features/functions and ecological functions of adjacent land uses are evaluated		
Fish habitat	√	partial
Significant valleylands		
Development and site alteration shall be restricted within and adjacent to these areas such that these features and their hydrologic functions will be protected, improved or restored		
Municipal drinking supplies and designated vulnerable areas	partial	partial
Vulnerable surface and ground water; sensitive surface and ground water features and their hydrologic functions	partial	partial
Maintain linkages and related functions between		
Surface water features, ground water features, hydrologic functions and natural heritage features and areas	partial	partial
Promote efficient and sustainable use of water resources		
Ensure stormwater management practices minimize stormwater volumes, contaminant loads, maintain or increase extent of vegetation and pervious surfaces	partial	partial

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

Guelph has a policy that it 'may require' proponents of development within lands adjacent to provincially significant wetlands, natural hazard lands and floodways to enhance these natural areas as part of the EIS. Riparian vegetation is also to be established within at least the first 15 metres of environmental corridors (from the top of bank). An EIS is required to describe measures to enhance ('where appropriate') a natural heritage feature and its functions. Guelph also has a policy that it 'will consider' performing restoration activities that enhance fish habitat, remove structural barriers within the major rivers, enhance municipal tree cover, and restore riparian vegetation adjacent to environmental corridors.

Guelph has established policies to protect 'environmental corridors' which are defined as 'linear biophysical features usually associated with rivers, streams and creeks valley lands that provide essential links for plant and animal species and often serve as buffers to riverine ecosystems' (Guelph Official Plan 2001, p.79). Significant environmental corridors are made up of Guelph's two major river corridors and their tributaries. An EIS is required for proposals within and adjacent to these features. Adjacent lands consist of the first 50 metres from the environmental corridor boundaries. There is no requirement that an EIS demonstrate 'no negative impacts' on their features or functions. All other streams or creek corridors, that are not significant environmental corridors should, where possible, be protected, however there are no policies regulating development within or adjacent to these areas, apart from tree preservation policies.

Pathfinder Policies

The Guelph Official Plan designates locally significant wetlands. An EIS is required for proposals within and adjacent to these features. Adjacent lands consist of those within 30m of local wetlands. There is no requirement that an EIS associated with these areas demonstrate 'no negative impacts' on their features or functions. EIS for development proposals within local wetlands must demonstrate that the development (and site alteration) will not lead to future demand for development that will result in a negative impact on the wetland. In addition, the EIS requires that the development (and site alteration) will not 'conflict' with existing wetland management practices.

Specific mitigation measures are required for developments and site alterations adjacent to environmental corridors. A setback of a minimum of 30 metres from the rivers edge or, where the slope is steep, 15 metres from the top of slope, is required. In environmental corridors that are not deemed significant, minimum setbacks of 10 metres from top of bank, or 30 metres from the stream edge (whichever is greater) are required. The establishment of naturalized riparian vegetation will be 'encouraged' in these areas. The riparian areas are to perform these hydrological functions: improve river water quality and fish habitat, prevent erosion of riverbanks and steep slopes, and allow the infiltration of storm water run-off.

Guelph also has a policy to promote the 'naturalization and enhancement' of riparian areas adjacent to its significant environmental corridors. See Table D.15 for a summary of enhanced and pathfinder policies for preserving and protecting hydrological functions.

Table D.15 Guelph Enhanced and Pathfinder Policies: Hydrological Functions

Enhancement Policies	OP-W	OP-A
Provincially-recommended policies		
Restoration of hydrological features and their connectivity		
Areas of potential natural habitat/hydrological function are protected or restored	√	√
Other hydrological corridors protected (beyond those designated by province)	*	*
Rigorous assessment criteria for demonstrating no negative impacts on features and functions, or conservation of features and functions	√	√
Monitoring	√	
Policies suggested by some regions		
Subwatershed/watershed planning prior to/in conjunction with EIS (where appropriate)	√	√
Stewardship and education policies		
Stewardship of private natural areas	√	
Resident education or stewardship of public natural areas	√	√
Subdivision and recreation system design that encourages 'informal surveillance' by residents	partial	partial
Pathfinder Policies		
Rigorous assessment criteria for demonstrating development compatible with features/functions of natural area		
Other hydrological areas protected (beyond those designated by province)	√	√
Specific mitigation measures required		√
Buffers (referred to by Guelph as 'setbacks')		√
EIS must consider the *impacts of development on the future management* of a local wetland	√	√
EIS must consider negative *impacts on local wetlands of subsequent demand for development* as a result of their development	√	√
Designation-specific management regimes		
Naturalization of riparian buffers adjacent to streams	√	
Protection of natural areas from impacts related to development of recreation facilities		
Protection of natural areas from construction impacts related to trail development	√	
Course of action should a designated natural area be threatened with development		

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.5 Municipality of Mississauga

The City of Mississauga is a lower-tier municipality within the Regional Municipality of Peel. The current Official Plan of Mississauga was approved by the Region of Peel in 2003 and includes amendments up to 2005. It post-dates the Official Plan of Peel that was approved by the province in 1996 with amendments up to 2005. Mississauga's Official Plan reflects their most recently developed environmental policies (EP5).

Mississauga's primary goals regarding its natural environment are to 'protect and maintain significant natural heritage systems, to promote pollution prevention and reduction, to ensure land use compatibility, to protect people and property from hazards and to promote, and be proactive, in the management and protection of natural areas and features' (Mississauga OP 2003, Sec. 2, p. 4). In terms of natural area systems, Mississauga has five objectives to achieve these goals:

1. To identify the 'natural areas system;'
2. To promote the preservation, enhancement and remediation of the 'natural areas system;'
3. To promote community stewardship;
4. To ensure that development proposals 'recognize' and enhance the 'viability' of natural areas;
5. To mitigate the negative impacts of urban drainage systems (Mississauga OP, Sec. 2, p.4).

D.5.1 Natural Heritage Area Policies

Basic Policies

The Official Plan of Mississauga meets the provincial policy requirements for regulating development proposals within provincially significant natural areas. However, Mississauga's policy requires that a proponent 'demonstrate that the ecological functions are being maintained or enhanced,' rather than 'No negative impact' on features and functions. Mississauga partially meets the provincial policy requirements for development adjacent to these areas. Watershed, sub-watershed and EIS do not require an evaluation of the ecological functions of the adjacent lands.

The City of Mississauga's Official Plan is in partial compliance with regional policies. Mississauga's policy for regionally significant areas does not specify that a proponent demonstrate that the proposal is a 'minor development or minor site alteration.' A 'minor development or minor site alteration' is defined by the Region of Peel as a development that demonstrates no 'significant incremental or cumulative impacts on regional landforms, features or ecological functions' (Official Plan of Peel Region, p.137). Nor does it specify that in the event that a regional natural area is damaged or destroyed, that the natural area be restored, rather than re-zoned for development.

The Region of Peel specifies that Mississauga establish policies within its official plan for the 'interpretation, protection, restoration, enhancement, proper management and stewardship of' provincially and regionally significant natural areas. These areas include provincially significant wetlands, woodlands >= 30 ha in area, environmentally sensitive or significant areas (areas identified by the Conservation Authorities in the Region), provincial ANSIs, habitats of vulnerable, threatened or endangered species, and specific valley and stream corridors. Mississauga has partially met these requirements. Policies that meet 'protection, restoration and enhancement requirements' include: policies that require EIS to demonstrate that 'ecological function will be maintained or enhanced' and that natural forms, ecological functions and linkages will be preserved, enhanced, restored. Policies that meet the 'proper management' requirement include:

1. The use of native materials and species within municipally owned areas;
2. The control of non-native plants in natural areas;
3. The regulation of residential encroachment;
4. The control of activities 'inconsistent with the retention of natural forms, functions and linkages;'
5. To allow the regeneration of natural areas 'to a natural state;'
6. To possibly require proponents to prepare an 'ecologically based woodland management plan' as a condition of development (It is not clear whether this management plan refers to management prior to or after conveyance of the natural area).

In terms of the 'stewardship' and 'natural area interpretation' policy requirements, Mississauga has a policy to develop a 'program of protection alternatives,' but includes no objectives for these programs, or specific implementation policies. These alternatives may include providing information/education, stewardship or management agreements, facility watch, land trusts or conservation easements. Facility watch is a program similar to 'Neighbourhood watch' that encourages residents to monitor publicly-owned lands and structures to deter and report acts of vandalism, and other forms of anti-social behaviour. In addition, Mississauga has a policy that states that urban design should apply Crime Prevention Through Environmental Design (CPTED) concepts. However, there are no policies that state that they will be applied to the design of natural area recreational systems, or to their boundaries with adjacent residential areas, to reduce residential encroachment. Mississauga is also missing a policy that meets the regional requirement for EIS to determine monitoring information requirements. See Table D.16 for a summary of basic policies for protecting natural heritage areas.

Table D.16 Mississauga Basic Policies: Natural Heritage Areas

PPS 2005 Policies	**OP-W**	**OP-A**
Development may be permitted if risk to public safety minor/mitigated according to provincial standards		
Hazardous sites (steep slopes, erosion prone, unstable soils)	√	
Prohibition of development and site alteration within and no development or site alteration adjacent lands to unless demonstrates 'no negative impacts' on features and functions and ecological function of adjacent lands evaluated		
Provincially designated portions of habitat of endangered or threatened species	√	partial
No development or site alteration unless demonstrates 'no negative impacts' on features/functions and ecological function of adjacent lands evaluated		
Provincial ANSIs	partial	partial
Significant woodlands	N.A.	N.A.
Significant wildlife habitat	N.A.	N.A.
Region of Peel Policies (1996)		
Proponent must demonstrate no significant incremental or cumulative impacts on the landform features or ecological functions of the regional natural heritage system		
Environmentally sensitive or significant areas (identified by the conservation authorities) ESAs	√	√
Include objectives and policies in OP for their protection, restoration, enhancement, and proper management/ require an EIS on lands adjacent to woodlands > = 30 ha;		
All of the above natural area designations	√	above
Woodlands >= 30 ha	√	√
Woodlands >=3ha < 30ha	√	N.A.
Woodlands < 3ha (potential natural area)	√	N.A.
Earth Science ANSIs (potential natural area)	√	N.A.
Include objectives and policies in OP for their interpretation and stewardship		
All of the above natural area designations	partial	partial
Woodlands >= 30 ha	partial	partial
Woodlands >=3ha < 30ha	partial	partial
Woodlands < 3ha (potential natural area)	partial	partial
Earth Science ANSIs (potential natural area)	partial	partial
Monitoring requirements for provincial and regional natural areas to be determined within EIS		

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* these areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

Mississauga has policies to preserve degraded natural areas that are potentially significant, including woodlands with potential interior habitat conditions, and areas adjacent to provincially, regionally or locally significant natural areas that have the potential to be restored. Development within and adjacent to these areas (and the locally significant natural areas below) require an EIS, according to rigorous assessment criteria, to determine if ecological functions are being maintained or enhanced. In addition, all Mississauga's designated areas are subject to the management and stewardship. Mississauga also has a policy to promote the restoration of habitat within some open space areas, such as active parks or cemeteries, to expand an adjacent natural area or increase connectivity between natural areas. Open space areas that are adjacent to or contain natural areas are subject to the same management and stewardship policies as designated natural areas.

Mississauga also has policies protecting features and corridors that serve to link any provincially, regionally or locally designated natural area together, including open spaces (parkland, erosion-prone areas, and cemeteries); rights-of-way and ‘green space’ along roadways (where there is a barrier between the two). These areas are subject to the same policies as degraded and significant locally- significant areas.

Maintaining biodiversity (‘compatible’ with ‘indigenous natural systems’) is a goal of Mississauga’s environmental policies, and it has designated areas that support a relatively high diversity of plants, or plant species or vegetation associations that are ‘uncommon’ within the municipality.

Pathfinder Policies

The city of Mississauga has established policies for protecting locally-significant areas, including areas with a ‘diversity of vegetation species’, woodlands with ‘old growth trees’, woodlands <3ha, woodlands with ‘uncommon canopy or vegetation associations’, areas with regionally rare or significant plant species, and areas that include natural (not engineered) features.

A policy addresses the impacts of construction encroachment (and possibly the impacts of previous land uses) on adjacent natural areas. Construction encroachment is defined here as construction activities or products that cross the limit of development and affect the adjacent natural area during the construction period. The policy states that developers are required to convey natural areas to the municipality in a satisfactory condition. The policy does not specify what constitutes a ‘satisfactory condition,’ or the impacts of concern.

Mississauga also has a policy that it will control activities that are ‘inconsistent with maintaining the features and functions of natural areas’, however it is not clear what activities are ‘inconsistent’, or whether they occur within or adjacent to the natural area. They also have a policy that formal pathways will be used as a means of lessening the impact of recreational activities within some natural areas, and a policy that they will regulate "public encroachment." However, they do not define the term ‘encroachment,’ or specify how they will address encroachment.

Mississauga has policies to incorporate ‘significant treed areas’ into its open space system, and that tree canopies ‘should be retained in residential areas with mature trees. While it does not have any specific stormwater management policies in its official plan, it does have a policy that states that certain measures will be required ‘where appropriate.’

Although Mississauga does not have a specific policy regarding a course of action should a privately owned natural area be threatened with development, or site alteration, there is a policy that states that acquisition of these areas will be considered

Some privately owned land uses are recognized as parts of the natural heritage system. These include privately owned designated natural areas and residential areas with large lots and canopy trees. These areas are assumed to function as habitat for ‘tolerant’ canopy birds, ground water recharge areas due to the high proportion of permeable ground cover. The tree canopy within these areas is to be maintained where possible; however, no specific tree conservation policies are mentioned. See Table D.17 for a summary of enhanced and pathfinder policies for protecting natural heritage areas.

Table D.17 Mississauga Enhanced and Pathfinder Policies: Natural Heritage Areas

Enhanced Policies	**OP-W**	**OP-A**
Provincially-recommended policies		
Restoration of habitat and connectivity		
Areas of potential natural habitat protected or restored	√	√
Other terrestrial corridors or linkages protected (other than designated by Province/Region)	√	√
Conserving biodiversity		
Supporting the function of biodiversity or native biodiversity is one of the goals of environmental policies	√	
Policies that support areas and/or corridors specifically planned to support a biodiversity goal, specialized or area sensitive wildlife	√	
Regionally-recommended policies		
Standardized management policies (see under Basic policies)		
Passive management or naturalization	√	
Natives only planted in municipal land	√	
Controlling non-natives in natural areas	√	
Individualized management policies		
Management plans	√	
Stewardship and education policies (see under basic policies)		
Public natural areas	partial	partial
Private natural areas	partial	partial
Pathfinder Policies		
EIS with rigorous assessment criteria for demonstrating development compatible with features and functions	√	√
Other natural features or areas protected (beyond those designated by province/ region)		
EIS are required to consider cumulative effects of development		
A course of action should a regionally designated area be degraded to a point where it no longer meets designation criteria		
Specific mitigation measures required		
Tree preservation	partial	partial
Storm water management (including grading/drainage and erosion/siltation controls)		partial
Mitigation of construction encroachment impacts		
Natural area clean-up or management measures prior to conveyance to municipality	√	
Mitigation of recreation impacts		
Regulating movement within natural areas using formal trails	√	
Mitigating future impacts of adjacent residents		
Regulation of residential encroachment		√
Recognizing and regulating redevelopment within adjacent lands		
Designates privately owned land with a significant ecological role (not privately owned natural areas) as elements in natural heritage systems	√	
Policies that mitigate (or encourage the mitigation of) the negative impacts of development on specific attributes	partial	
Subdivision and recreation system design that encourages 'informal surveillance' by residents of natural areas	partial	
Course of action should a privately owned natural area be threatened by development	partial	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
*areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.5.2 Hydrological Function Policies

Basic Policies

The Official Plan of Mississauga meets most of the provincial policy requirements for protecting provincially designated natural heritage features related to hydrology. The provincial requirement that a municipality demonstrate no negative impacts on the features and functions is not met (Mississauga requires that an EIS demonstrate that the 'ecological function is being maintained or enhanced'). Policy requirements for developments within adjacent lands to these areas are also partially met. They do not require that the ecological functions of these areas be assessed, or that there be no negative impacts on the features and functions of the adjacent natural areas.

Regional requirements for hydrological features are also partially met. There is no requirement that EIS demonstrate no significant cumulative impacts, or the necessity for regionally designated areas to be rehabilitated, should they be degraded and no longer meet designation requirements. There is no definition of what constitutes an adjacent area to these hydrological features, except for provincial wetlands.

Mississauga does not have any policies regarding the identification and protection of municipal drinking supply areas. However, these areas may exist outside the municipality. They have a general policy to identify and protect areas of ground water recharge and discharge through 'future studies, if necessary.' Surface water features and their associated floodplains receive protection through their designation as natural areas at both regional and local levels. Proposals within these areas are subject to an EIS and must proponents must prepare a 'drainage plan.' However, most of Mississauga has already been developed and there are few undeveloped areas left with these features.

Mississauga does not have specific provisions that require stormwater management practices to minimize storm water volumes, contaminant loads, and maintain or increase extent of vegetation and pervious surfaces. Certain surface water features within Mississauga have been identified as degraded and development within these areas are subject to the restoration, and possibly on-site storm water management practices, recommended within a rehabilitation study.

The province also requires that municipalities maintain linkages and related functions between surface water features, ground water features, hydrologic functions and natural heritage features and areas. Mississauga's EIS policies for all local and regional features and corridors require that development proposals 'preserve, enhance, restore and remediate natural forms, ecological functions and linkages.' In addition, Mississauga recognizes and applies its protective policies to areas that serve linking functions, such as stormwater management facilities, designated open spaces, rights-of-way and green space along roadways. However, there are no policies for connecting ground water areas, features with surficial or terrestrial natural heritage areas. The establishment of linked systems is likely to be significantly impeded by the high level of existing development within the municipality that did not accommodate linkages between these areas. Mississauga meets the provincial requirement for a policy that promoted the conservation and re-use of water. See Table D.18 for a summary of basic policies for protecting hydrological functions.

Table D.18 Mississauga Basic Policies: Hydrological Functions

Provincial Policy	**OP-W**	**OP-A**
Watershed and subwatershed planning		
Prohibition of development unless (certain types of development in flood fringe of two zone or special policy area with appropriate flood-proofing))		
Floodplains	√	N.A.
No development and site alteration (or within adjacent lands unless no negative impacts to features and functions)		
Provincially significant wetlands	partial	partial
No development and site alteration unless it has been demonstrated there will be no negative impacts on features/functions (except agricultural uses)		
Fish habitat	partial	partial
Significant valleylands	partial	partial
Development and site alteration shall be restricted within and adjacent to these areas such that these features and their hydrologic functions will be protected, improved or restored		
Municipal drinking supplies and designated vulnerable areas		
Vulnerable surface and ground water; sensitive surface and ground water features and their hydrologic functions	partial	

Maintain linkages and related functions between		
Surface water features, ground water features, hydrologic functions and natural heritage features and areas	partial	
Promote efficient and sustainable use of water resources	√	√
Ensure stormwater management practices minimize stormwater volumes, contaminant loads, maintain or increase extent of vegetation and pervious surfaces	partial	partial
Regional Policy		
Include objectives and policies in OP for their interpretation, protection, restoration, enhancement, proper management and stewardship/ require an EIS on ESAs (performing significant hydrological function) defined by Conservation Authorities		
ESAs that perform significant hydrological functions (defined by conservation authorities)	partial	√
Regionally significant wetlands (Class 4-7)	partial	N.A.
Unevaluated wetlands	partial	N.A.
Valley/stream corridors with < 125 ha drainage area	partial	N.A.
Shoreline & littoral zones of lakes and parts of historic shorelines	partial	N.A.

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

Development adjacent to valley lands, watercourses (engineered or not), storm water management areas, and lakes require EIS to outline how the development will enhance, restore, remediate, as well as protect these areas. However, these policies do not apply to redeveloped adjacent land uses unless they involve the creation of a new lot, a change in the land use, or the construction of buildings and structures.

Mississauga has policies to restore, or to 'consider' restoring habitats serving a hydrological function and the linkages between them, including: special management areas (areas adjacent to natural areas with a hydrological function that have the potential for restoration), linkages (areas that link natural areas with hydrological functions), the Lake Ontario waterfront, urbanized watercourses and other shorelines. Locally significant corridors are designated including natural (not engineered) landscape features. These include all watercourses (even if engineered) with some riparian vegetation (not mowed grass). All of these local hydrological features are protected under the same policies as local and regional terrestrial and hydrological features.

Pathfinder Policies

Site alteration and new utilities are prohibited within locally significant wetlands, or those > 2ha. Development adjacent to Mississauga's two lakes and stormwater management facilities including ponds and watercourses (designated as 'Linkages') require an EIS.

Specific mitigation measures such as boundary delineation, buffers and building setbacks 'may be required' for developments adjacent to natural areas required for flood and erosion control, drainage and 'conservation,' as determined by the municipality, and other agencies. Buffers 'may be' subject to dedication to the City, or to land use restrictions. The natural heritage designations included under the term 'conservation lands,' however, is not clear. See Table D.19 for a summary of enhanced and pathfinder policies for preserving and protecting hydrological functions.

Table D.19 Mississauga Enhanced and Pathfinder Policies: Hydrological Functions

Enhancement Policies	OP-W	OP-A
Provincially-recommended policies		
Restoring hydrological function and connectivity		
Areas of potential natural habitat/hydrological function protected/restored	√	√
Other hydrological corridors protected (beyond those designated by province or region)	√	√
Conserving Biodiversity as a goal (see basic policies, natural heritage areas)	√	
*Conserving areas that may be important contributors (*see basic policies, natural heritage areas)	√	
Regionally-recommended policies		
Standardized management policies (see basic policies, natural heritage areas)		
Passive management or 'naturalization'	√	
Native plants and 'materials' only in municipal land	√	
Controlling non-natives in natural areas	√	
Individualized management policies		
Management plans	√	
Stewardship and education policies (see under Basic policies for natural heritage areas) (see under Basic policies)		
Public natural areas	partial	partial
Private natural areas	partial	partial
Pathfinder Policies		
Increased level of preservation for designated areas (local wetlands)	√	
EIS include rigorous assessment criteria for demonstrating no negative impacts on features and functions, or conservation of features and functions	√	√
Policies developed for other hydrological areas (beyond those designated by province or region)	√	√
Specific mitigation measures required (hazard lands, floodplains, valley lands)		
Buffers	partial	
Structure setbacks	partial	
Tree management policies (see pathfinder policies, natural heritage areas)	partial	
Storm water management policies (see pathfinder policies, natural heritage areas)		partial
Mitigation of construction encroachment impacts after they occur (see pathfinder policies, natural heritage areas)	√	
Mitigation of recreation impacts (see pathfinder policies, natural heritage areas)	√	
Mitigation of adjacent resident impacts after they occur (see pathfinder policies, natural heritage areas)		√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
*areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.6 Municipality of Oakville

The City of Oakville is a lower tier municipality within the Regional Municipality of Halton. The Official Plan of Oakville was approved by the Region of Halton in 1983 and was amended to 2004. The Halton Regional Official Plan was approved in 1995 and amended to 2004. When Oakville's Official Plan was first approved, provincial policies were limited to the regulation of development (structures) in hazardous areas, which included both erosion, and flood-prone areas.

The Official Plan of Oakville has two general goals related to the natural environment:

1. 'To protect natural areas;' and
2. 'To implement an ecosystem approach to planning and development which minimizes the disruption of natural resources while ensuring the long-term health of the natural, social and economic systems which meets the needs of the present without compromising the needs of future generations' (Oakville OP 2004, p. 7).

In terms of its natural areas, Oakville has eight objectives to meet these goals:

1. To identify significant natural areas;
2. 'To reduce or eliminate adverse impacts to existing natural features due to day-to-day human activities where appropriate';

3. 'To rehabilitate natural areas that have become degraded by urban influence in order to sustain a diversity of native plant and wildlife species;'
4. 'To identify opportunities for the restoration of natural conditions;'
5. To identify appropriate land use controls;
6. To identify and assess the value of natural area linkages in terms of their ecological and recreational functions;
7. To develop policies for the acquisition of significant natural areas; and
8. To promote opportunities for scientific, recreational and educational use of natural features in a manner that does not diminish or impair ecological integrity' (Oakville OP 2004, p. 13).

D.6.1 Natural Heritage Area Policies

Basic Policies

The Official Plan for the City of Oakville meets the basic policy requirements of the PPS 2005 and of the Region of Halton Official Plan, in terms of policies regulating land use within natural areas. Regional adjacent land use policy requirements are met. Provincial adjacent land use policies are partially met because the City of Oakville does not require the assessment of the ecological functions of adjacent land uses. See Table D.20 for a summary of basic policies for protecting natural heritage areas.

Figure D.20 Oakville Basic Policies: Natural Heritage Areas

PPS 2005 Policies	**OP-W**	**OP-A**
Development may be permitted if risk to public safety minor/mitigated according to provincial standards		
Hazardous sites (steep slopes, erosion prone, unstable soils)	√	N.A.
Prohibition of development and site alteration within and no development or site alteration adjacent lands to unless demonstrates 'no negative impacts' on features and functions and ecological function of adjacent lands evaluated		
Provincially designated portions of habitat of endangered or threatened species	√	partial
No development or site alteration unless demonstrates 'no negative impacts' on features/functions and ecological function of adjacent lands evaluated		
Provincial ANSIs	√	partial
Significant woodlands	*	*
Significant wildlife habitat	*	*
Region of Halton Policies		
*No development of site alteration unless EIS (no policy that it must demonstrates no negative impacts on features/functions***)**		
Other regional environmentally sensitive areas (includes a wide variety of natural areas in addition to regional ANSIs, and habitat of endangered or threatened species)	√	√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Enhanced Policies

Oakville has a policy that requires subwatershed plans to be the most important mechanism for identifying, and establishing protection policies for the municipality's natural areas. These studies are supplemented at a finer scale by natural area-specific studies (see below under pathfinder policies), and they are to take the place of an EIS where possible. This approach allows the municipality more control over the establishment and negotiation of protective policies.

Oakville has a policy to restore newly and already identified natural features, where appropriate, and to extend and enhance natural areas through acquisition, landowner agreements, or another land use planning measure. City of Oakville natural area studies are to identify measures for restoring natural areas (outlined below under Pathfinder policies). In addition, it has policies to 'naturalize' areas of 'open space' outside of natural areas. This may lead to additional areas of natural heritage or enhance existing areas.

In terms of restoring terrestrial connectivity, Oakville has policies regarding the protection of 'natural corridors' defined as 'generally' a minimum of 30 metres in width, that enable pedestrian or wildlife passage, wildlife habitat, and hydrological functions.' Natural corridors are both terrestrial and hydrological; however, few terrestrial corridors (not associated with streams) are apparent on Oakville's Natural features map within their official plan. Development will not be permitted within 'significant natural corridors' if an EIS indicates that it will 'significantly impact' the ecological functions which the area provides. The term 'significant natural corridor' is not defined. For proposals within and adjacent to 'natural corridors' that have not been evaluated through a subwatershed study, an EIS is required to demonstrate that the proposal will not 'significantly impact the habitat quality of the resident wildlife species,' and to determine the 'potential impact that may occur.' Oakville also has policies for the maintenance of 'community park links.' These areas tend to be utility corridors. In addition, Oakville has a policy to establish 'greenway links' in all new communities by linking privately and publicly owned elements of their open space system.

Maintaining, restoring and enhancing 'biological diversity' is an objective for Oakville's goal of promoting ecosystem health. However, there are no specific policies that specify what and how 'biological diversity' will be maintained. The City has developed policies to protect individual areas and features recognized for their contribution in conserving native biodiversity. It has policies for promoting corridors (terrestrial and hydrological), however there are no policies that require or promote their design or management to achieve specific biodiversity or native biodiversity goals. Oakville also 'promotes' the use of native plant species within municipal-owned properties.

Oakville has a policy to promote stewardship of public and private natural areas. In terms of public natural areas, it has a policy to implement this by generating awareness of the importance of their natural areas by providing information, involving the community in natural area 'clean-up' and restoration programs and by increasing resident awareness of the impacts on the natural environment of their daily activities.

In terms of privately owned natural areas, Oakville has a policy that it may purchase, negotiate density transfers, land exchanges, long-term leases, easement agreements, or land trusts, where conditions of approval are insufficient to preserve or protect privately owned natural areas. Oakville has a general policy to encourage stewardship and education among private landowners participating in land stewardship programs initiated by other agencies.

Pathfinder Policies

There is a policy to conduct a study of the 'natural heritage' of individual natural areas prior to the development of secondary plans (and site-level EIS). According to a subwatershed study, in addition to this natural area study, each natural area and its adjacent 120 metres are evaluated to classify it as either an area where no development (structures) will be allowed, or where development may be allowed, but requires further study. In addition, areas that may accommodate development are subject to an EIS. Studies of natural areas conducted by the municipality outline its 'health and sustainability' and identify specific development mitigation measures. The development will not be approved if it significantly impacts the integrity of the natural features, the ecological functions, or does not comply with any of the policies governing the individual natural areas. This policy appears to offer an additional level of preservation to all natural areas (which may be identified as no development where some development may have been allowed under the individual natural area policies) and to natural areas where subwatershed studies have not yet been conducted. EIS assessment criteria are rigorous for all designations and, 'where appropriate,' proposals are subject to review by the region's ecological advisory committee.

The protection of provincial ANSIs has been enhanced by prohibiting all development (limited to structures, not site alteration) within these areas.

Locally significant natural areas have been designated including: locally significant ANSIs, woodlands, and wildlife habitat. Development (buildings or structures) is prohibited within local ANSIs and wildlife habitat if an EIS indicates that it will 'significantly impact' 1) the 'long term preservation' of the local ANSI's features and functions for which it was defined, and 2) the ecological functions of wildlife habitat or the 'available habitat' of the 'wildlife species.' There is no definition of 'significant impacts' provided. 'Development' is prohibited within 'significant woodlands,' however for those not deemed 'significant,' the allowable level of impact within these areas is to be determined through an EIS. The 'level of potential impact' that may occur in all these areas is to be established through the subwatershed study, or if missing, through an EIS. If a subwatershed study is missing for adjacent lands (120 metres from local ANSI, lands 'contiguous' to the natural area, or those identified in a provincial or municipal guideline from woodlands and wildlife) to all of these areas, proponents are required to conduct EIS to demonstrate the proposal will not result in any of the above impacts.

Oakville has policies that require buffers for all natural areas where no development is to occur, in accordance within a subwatershed study, a municipal natural area study or an EIS. However, it is not clear whether this policy requires that buffers be established adjacent to all of these areas. Oakville also has a policy for protecting trees, and requires stormwater management practices that mitigate impacts related to trees, hydrological regimes, erosion and siltation. In addition, proponents are required to prepare landscape plans that 'integrate development with natural features' and maximize the number of new trees planted. It is not clear what 'integrating the development' means in terms of protecting the natural area, and the ecological functions of adjacent land.

Within its official plan, Oakville assigns each type of open space areas to one of three standardized maintenance regimes: active, meadowland and natural parkland. Most natural areas are maintained in a 'natural state,' according to the natural parkland designation, however there may be areas within, or adjacent to, the natural area that are maintained according to the other categories. The details of these regimes are not outlined within the official plan. For all types of open space, Oakville has a policy to naturalize areas of these lands, where appropriate, and use only native plants. See Table D.21 for a summary of enhanced and pathfinder policies for protecting natural heritage areas.

Table D.21 Oakville Enhanced and Pathfinder Policies: Natural Heritage Areas

Enhanced Policies	**OP-W**	**OP-A**
Provincially-recommended policies		
Restoring natural heritage areas and their connectivity		
Potential natural heritage areas are protected or restored	partial	partial
Other terrestrial corridors or linkages protected	√	√
Biodiversity policies		
Supporting the function of Biodiversity or native biodiversity is one of the goals of environmental policies	√	
Policies that support areas and/or corridors specifically planned to support a biodiversity goal, specialized or area sensitive wildlife	√	
Regionally-recommended policies		
Watershed/subwatershed studies take place prior to or in conjunction with site EIS	√	
Standardized management regimes		
Natives only/discourage use of invasive exotics in municipal lands	√	partial
Promotion of resident education and stewardship		
Public natural areas	√	√
Private natural areas	√	√
Pathfinder Policies		
Inventories of natural areas prior to secondary plans/site EIS	√	
Increased level of preservation for designated areas	√	
Rigorous assessment criteria for demonstrating development compatible with features and functions	√	√
Other natural features or areas protected (beyond those designated by the province or region)	√	√
Specific mitigation measures required		
Buffers	partial	
Tree preservation (including addition tree plantings)	√	√
Storm water management (including erosion/siltation control)	√	√
Standardized management regimes		
Naturalization	√	√
Course of action should a privately owned natural area be threatened by a development proposal	√	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
*areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

D.6.2 Hydrological Function Policies

Basic Policies

Basic policy requirements have been met for regulating development within all provincially designated natural heritage features related to hydrology, including provincially significant wetlands, and significant valley lands. Policy requirements for protecting fish habitat are assumed to be met through other policies that preserve wildlife habitat, significant valley lands, riverine flood plains and/or natural corridors (see below under Enhanced policies for definitions of these areas). Provincial policy requirements regarding proposals within lands adjacent to hydrological features and corridors are partially met. They do not require proponents to assess the ecological function of adjacent land use.

The Oakville Official Plan fulfills the provincial requirement for watershed and subwatershed planning. It also restricts development and site alteration within municipal drinking supply areas, vulnerable ground and surface water features and functions. They also have policies to restrict land uses within areas adjacent to sensitive surface water and ground water features. Where a subwatershed plan has not been conducted, a subdivision-scaled EIS must be prepared for developments adjacent to watercourses, headwaters, and aquifers.

Oakville partially fulfills the provincial requirement to maintain linkages and related functions between surface water features, ground water features, hydrologic functions and natural heritage areas. It has policies that protect surface water features within significant valley lands, riverine flood plains and natural corridors. Terrestrial corridors (protected under the ‘natural corridors’ designation) also contribute to linking these surface water systems with terrestrial natural areas. No policies relate to linking groundwater areas, or maintaining linkages or functions between groundwater, surface water and/or terrestrial areas, features and corridors.

Oakville is in partial compliance to the provincial requirement for the promotion of water conservation and land uses that reduce water contamination. It has a policy for encouraging water conservation fixtures and appliances within new developments, but no policies regarding promoting resident activities that reduce water contamination. Oakville meets the provincial requirements for stormwater management practices. See Table D.22 for a summary of basic policies for preserving and protecting hydrological functions.

Table D.22 Oakville Basic Policies: Hydrological Functions

Provincial Policy	**OP-W**	**OP-A**
Watershed and subwatershed planning	√	
Prohibition of development unless (certain types of development in flood fringe of two zone or special policy area with appropriate flood-proofing))		
Floodplains	√	
No development and site alteration (or within adjacent lands unless no negative impacts to features and functions)		
Provincially significant wetlands	√	partial
No development and site alteration unless it has been demonstrated there will be no negative impacts on features/functions (except agricultural uses)		
Fish habitat	√	partial
Significant valley lands	√	partial
Development and site alteration shall be restricted within and adjacent to these areas such that these features and their hydrologic functions will be protected, improved or restored		
Municipal drinking supplies and designated vulnerable areas	√	√
Vulnerable surface and ground water; sensitive surface and ground water features and their hydrologic functions	√	√
Maintain linkages and related functions between		
Surface water features, ground water features, hydrologic functions and natural heritage features and areas	partial	
Promote efficient and sustainable use of water resources		partial
Ensure storm water management practices minimize storm water volumes, contaminant loads, maintain or increase extent of vegetation and pervious surfaces		√

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
* areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

<u>Enhanced Policies</u>

Oakville has a policy to remediate newly acquired and existing natural areas (in cooperation with other agencies), however they do not have any policies to protect or restore degraded areas that could meet natural area designation criteria once restored.

Policies have been established for preserving major and minor valley lands. No development (structures) is permitted within these valley lands, their buffers and setbacks (if setbacks are required). Development proposals for adjacent land require an EIS, unless the area has been assessed within a subwatershed study. Development (structures and site alteration) will not be allowed adjacent to these areas if they ‘significantly impact’ the features and functions of the valley lands for which they were designated. Oakville also has policies for regulating development within ‘natural corridors’ (water courses which are not included within the valley lands designation). Policies for these latter areas are described within the enhanced policies section for natural heritage areas.

The area of the valley lands below the top of bank boundary is to be maintained in a 'natural state.' If this area has been degraded by current or previous land uses, the municipality will 'naturalize' it, 'where appropriate.'

Pathfinder Policies

Policies have been established for protecting locally significant wetlands. Proposals will not be approved if they will 'significantly impact the wetland functions' for which the wetland was designated. In addition, the EIS must demonstrate that the development will not lead to future demand for development that will result in a significant impact on its designated functions, or 'conflict' with existing wetland management practices. Proposals within 120 metres adjacent to these wetlands are subject to an EIS where a subwatershed study has not been prepared.

Specific mitigation measures are required for both major and minor valley lands. Development is prohibited within 15 metres of the top of bank of significant valley lands, and 7.5 metres of the top of bank of minor valley lands. In addition, a structure setback (above and belowground) is required from the top of valley bank, to be determined by an EIS or a subwatershed plan. The setback is required to 'minimize encroachment upon the natural scenic resource of the valley, prevent slope instability and minimize environmental disruption' (policy 4.3.2.1 i, p.111). The terms 'encroachment' and 'environmental disruption' are not defined.

A 15-metre buffer from the 'stable top of bank' plus a building setbacks are also required for development or redevelopment proposals within lakefront land. Part of this land (only that suitable for development) may be acquired as part of the parkland dedication, or may be purchased by the city.

Boundary delineation is required between shoreline resident properties and the linear shoreline parkland through landscaping, signage, fencing, and/or a public road. Boundary delineation is to be established through consultation with adjacent residents. This delineation is to provide a 'physical and legal separation,' however there is no mention of what these 'separations' are meant to achieve. See Table D.23 for a summary of enhanced and pathfinder policies for protecting hydrological functions.

Table D.23 Oakville Enhanced and Pathfinder Policies: Hydrological Functions

Enhancement Policies	**OP-W**	**OP-A**
Provincially-recommended policies		
Restoring hydrological features and their connectivity		
Areas of potential natural habitat/hydrological function protected or restored	partial	
Other hydrological corridors protected (beyond those designated by province or region)	√	√
Biodiversity policies (see under natural heritage features)	√	
Regionally-recommended policies		
Watershed/subwatershed planning occurs prior to/in conjunction or instead of site EIS	√	√
Standardized management regimes (see under natural heritage features)	√	√
Education/stewardship policies (see under natural heritage features)	√	√
Pathfinder Policies		
Inventories of natural areas prior to secondary plans/site EIS(see pathfinder natural heritage policies)	√	
Increased level of preservation for designated areas	√	
Rigorous assessment criteria for demonstrating no negative impacts on features and functions	√	√
Other hydrological areas protected (beyond those designated by province/region)	√	√
Specific conditions of development		
Buffers (major and minor valley lands and Lake Ontario shorelines)	√	

Structure setbacks (Major and Minor Valley lands and Lake Ontario Shorelines)	√	
Tree management policies (including supplemental plantings)	√	√
Storm water management policies (including erosion and siltation controls)		√
Mitigation of impacts on future management		
Site EIS evaluates future impacts on natural area management practices (local wetlands)	√	
Mitigation of incremental impacts of development/land use change/resident activities		
Site EIS evaluates impacts of future demand for development generated by development (local wetlands)	√	
Mitigation of future impacts of adjacent residents on natural area (or vice versa)		
Property line demarcation (in conjunction with resident)	partial	
Standardized management regime		
Naturalization	√	
Course of action should a natural area threatened by development (see under natural heritage areas)	√	

[1]OP-W and SP-W: official plan (OP) and secondary plan (SP) policies for within the area;
[2]OP-A and SP-A: official plan and secondary plan policies for lands immediately adjacent to the area.
N.A. no required policies
 * areas were not identified within the planning area
Partial: municipality has policies that partially meet requirements
√: municipality has a policy of this kind, or that meets provincial or regional requirements

Appendix E

Test Statistics and Probability Values

Tables E.1 and E.2 provide the test statistics and significance levels of the two-sample Kolomogorov-Smirnov tests for uniformity of mean frequency and mean intensity of encroachment between boundary types for all encroachment types. Tables E.3 through to E.8 provide the test statistics and significance levels of the two-sample Kolomogorov-Smirnov tests for uniformity of mean frequency and mean intensity of encroachment between boundary types for waste disposal, yard extension and forest recreation categories of encroachment. Table E.9 provides the significance levels of Kolomogorov-Smirnov two-sample tests for uniformity of extent of encroachment between boundary types. In each table, the boundary types in first column had significantly higher intensities of encroachment than the boundary types in the columns to the right. N.S. means there were no significant differences in intensity between the two boundary treatments.

Table E.1 Test statistics and probability values of two-sample Kolomogorov-Smirnov tests for differences in frequency of encroachment between boundary types

Boundary Type	Municipal Boundary Post	Grass strip	Grass strip, path	Fence, gate	Fence, gate, grass strip	fence, gate, grass strip, path	Fence	fence , grass strip	Fence, grass strip, path
No, or minimal boundary demarcation	Z = 2.607, P = .000	Z = 1.290, P = .072	Z = 1.769, P = .004	Z = 2.129, P = .000	Z = 1.767, P = .004	Z = 2.277, P = .000	Z = 2.095, P = .000	Z = 1.658, P = .008	Z = 2.399, P = .000
Grass strip, path	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.449, P = .030	N.S.
Fence with gate	Z = 16.8, P = .011	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.649, P = .009	Z = 2.140, P = .000
Fence , gate, grass strip	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.597, P = .012	Z = 1.511, P = .021
Fence , gate, grass strip, path	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.476, P = .026	Z = 1.353, P = .051
Fence	Z = 1.636, P = .010	N.S.	N.S.	N.S.	N.S.	Z = 1.358, P = .050	N.S.	Z = 1.631, P = .010	Z = 2.045, P = .000

Table E.2 Test statistics and probability values of two-sample Kolomogorov-Smirnov tests for differences in intensity of encroachment between boundary types

Boundary Type	Municipal Boundary Post	Grass strip	Grass strip, path	Fence, gate	Fence, gate, grass strip	fence, gate, grass strip, path	Fence	fence , grass strip	Fence, grass strip, path
No, or minimal boundary demarcation	Z = 2.517, P = .000	Z = 1.332, P = .058	Z = 1.550, P = .016	Z = 2.578, P = .000	Z = 1.761, P = .004	Z = 2.511, P = .000	Z = 2.977, P = .000	Z = 1.658, P = .008	Z = 2.499, P = .000
Municipal boundary post	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.420, P = .035	N.S.
Grass strip, path	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.449, P = .03	N.S.
Fence with gate	Z = 1.659, P = .008	N.S.	N.S.	N.S.	Z = 1.387, P = .043	Z = 1.902, P = .001	Z = 1.565, P = .015	Z = 1.682, P = .007	Z = 2.021, P = .001
Fence , gate, grass strip	N.S.		N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.597, P = .012	Z = 1.511, P = .021
Fence , gate, grass strip, path	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.581, P = .013	
Fence	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	Z = 1.631, P = .010	Z = 1.727, P = .005

Table E.3 Significant differences in waste disposal mean frequency between boundary types

	Municipal Post	Grass strip and path	Fence, grass strip	Fence, grass strip, path
No, or minimal boundary demarcation	N.S.	N.S.	N.S.	Z = 1.566, P = .015
Fence with gate	N.S.	N.S.	Z = 1.345, P = .053	Z = 1.819, P = .003
Fence with gate, grass strip	N.S.	Z = 1.329, P = .059	Z = 1.409, P = .038	Z = 1.658, P = .008
Fence with gate, grass strip and path	N.S.	N.S.	Z = 1.550, P = .016	Z = 1.529, P = .019
Fence	Z = 1.722, P = .005	Z = 1.678, P = .007	Z = 1.550, P = .016	Z = 2.275, P = .000

Table E.4 Significant differences in waste disposal mean intensity between boundary types

	Grass strip and path	Fence, grass strip	Fence, grass strip and path
No, or minimal boundary demarcation	Z = 1.332, P = .058	Z = 1.407, P = .038	Z = 1.474, P = .026
Fence with gate	Z = 1.579, P = .014	Z = 1.480, P = .025	Z = 1.819, P = .003
Fence with gate, grass strip	Z = 1.778, P = .004	Z = 1.597, P = .012	Z = 1.819, P = .003
Fence with gate, grass strip and path	Z = 1.436, P = .032	Z = 1.581, P = .013	Z = 1.529, P = .019
Fence	Z = 1.857, P = .002	Z = 1.590, P = .013	Z = 2.045, P = .000

TableE.5 Significant differences in yard extension mean frequency between boundary types

	Municipal Boundary Posts	Fence, gate	Fence, gate and grass strip	fence, gate, grass strip and path	Fence	fence with grass strip	Fence, grass strip and path
No, or minimal boundary demarcation	Z =2.090, P = 0.000	Z = 2.219, P = .000	Z = 2.257, P = 0.000	Z = 2.919, P = 0.000	Z = 3.056, P = 0.000	Z = 1.508, P = 0.021	Z = 2.776, P = 0.000
Fence with gate	N.S.	N.S.	N.S.	Z = 1.766, P = 0.004	Z = 1.584, P = 0.013	N.S.	Z = 1.670, P = 0.008
Municipal boundary marker	N.S.	N.S.	N.S.	Z = 1.721, P = 0.005		N.S.	Z = 1.665, P = 0.008

Table E.6 Significant differences in yard extension mean intensity between boundary types

	Municipal Boundary Posts	Fence, gate	Fence, gate and grass strip	fence, gate, grass strip and path	Fence	fence with grass strip	Fence, grass strip and path
No, or minimal boundary demarcation	Z =2.247, P = 0.000	Z = 2.219, P = 0.000	Z = 2.257, P = 0.000	Z = 2.919, P = 0.000	Z = 3.157, P = 0.000	Z = 1.508, P = 0.021	Z = 2.776, P = 0.000
Fence with gate	N.S.	N.S.	N.S.	Z = 1.766, P = 0.004	Z = 1.625, P = 0.010	N.S.	Z = 1.670, P = 0.008
Municipal boundary marker	N.S.	N.S.	N.S.	Z = 1.721, P = 0.005		N.S.	Z = 1.665, P = 0.008

Table E.7 Significant differences in forest recreation mean frequencies between boundary types

Boundary Type	No, or minimal boundary demarcation	fence, gate, grass strip, path	Fence
Fence, grass strip, path	Z =1.466 P = .027	Z = 1.326, P = .059	Z = 1.804, P = .003
Fence with gate	N.S.	Z = 1.336, P = .056	Z = 2.206, P = .000

TableE.8 Significant differences in forest recreation mean intensities between boundary types

Boundary Type	No, or minimal boundary demarcation	fence, gate, grass strip, path	Fence
Fence, grass strip, path	Z =1.559 P = .015	Z = 1.502, P = .022	Z = 1.880, P = .002
Fence with gate	N.S.	Z = 1.336, P = .056	Z = 2.206, P = .000

Table E.9 Significant differences in mean maximum extent of encroachment between boundary types

	Grass Strip, Path	Fence, gate and grass strip	fence, gate, grass strip and path	Fence	fence with grass strip	Fence, grass strip and path
No, or minimal boundary demarcation	Z = 1.653, P = 0.008	Z = 1.723, P = 0.005	Z = 2.092 P = 0.000	Z = 2.404, P = 0.000	Z = 1.508, P = 0.021	Z = 1.513, P = 0.021
Fence with gate	Z = 1.474, P = 0.026	Z = 1.514, P = 0.020	Z = 1.904, P = 0.001	Z = 2.360, P = 0.000	N.S.	N.S.
Municipal boundary marker	N.S.	Z = 1.387, P = 0.043	N.S.	N.S.	N.S.	N.S.