Public perceptions of risk and acceptability of forest vegetation management alternatives in Ontario

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We examined public perceptions of risk and acceptability for 9 alternatives to controlling forest vegetation in Ontario (N = 2,301) in the fall of 1994. The proportion of respondents indicating whether an alternative was 1) difficult to control, 2) potentially catastrophic, 3) a problem for future generations, and 4) a personal worry determined perceptions of risk for each vegetation management alternative. Ranking of alternatives from highest to lowest perceived risk was: aerially-applied herbicides > biological control > ground-applied herbicides > mulches > prescribed fire > heavy equipment > cover cropping > manual cutting > grazing animals. Public acceptance was lowest for aerially-applied herbicides (18%) followed by ground-applied herbicides (37%), biological control (57%), prescribed fire (57%), mulches (65%), heavy equipment (72%), cover cropping (80%), grazing animals (82%), and manual cutting (89%). Public acceptability of various agents for biological control differed depending on the proposed agent. Natural plant toxins were viewed as most acceptable (73%) followed by microorganims (42%), genetically-engineered organisms (39%), and viruses (21%). We found a strong correlation between a risk perception index and acceptability of the alternatives for the general public ($r^2 = 0.84$) and those in timber-dependent communities ($r^2 = 0.89$). Our results suggest that stronger public support can probably be achieved for forest vegetation management programs that include non-herbicide alternatives.

Key words: forest vegetation management, public opposition, risk perception, herbicides, biological control, prescribed fire, mulches, heavy equipment, cover cropping, grazing animals, manual cutting

Nous avons étudié les perceptions du public en matière de risque et d'acceptation de 9 alternatives de contrôle de la végétation forestière en Ontario ($N = 2301$) au cours de l'automne de 1994. La proportion de répondants indiquant qu'une alternative était 1) difficile à contrôler, 2) potentiellement catastrophique, 3) un problème pour les générations futures, et 4) une inquiétude personnelle, déterminait les perceptions de risque pour chacune des alternatives de contrôle de la végétation. Le classement des alternatives selon une échelle du plus haut risque au plus faible était: application de phytocide par voie aérienne > contrôle biologique > application de phytocides par voie terrestre > paillis > brûlage dirigé > équipement lourd > production d'une récolte jouant un rôle protecteur > éradication manuelle > broutage animal. L'acceptation du public était la plus faible pour les phytocides appliqués par voie aérienne (18 %), suivie de l'application par voie terrestre de phytocides (37 %), du contrôle biologique (57 %), du brûlage dirigé (57 %), des paillis (65 %), de l'équipement lourd (72 %), des récoltes protectrices (80 %), du broutage (82 %), et de la éradication manuelle (89 %). L'acceptation du public des différents agents de contrôle biologique différait selon l'agent proposé. Les toxines naturelles de plante étaient considérées comme éatnt les agents les plus acceptables (73 %), suivies des micro-organismes (42 %), des organismes issus du génie génétique (39 %), et des virus (21 %). Nous avons trouvé une forte corrélation entre l'indice de la perception du risque et l'acceptation des alternatives chez le grand public (r^2=0.84) et au sein des communautés dépendantes des activités forestières (r^2=0.89). Nos résultats suggèrent que appui plus fort de la part du public peut probablement être obtenu pour les programmes de contrôle de la végétation forestière qui comprennet des alternatives autres que les phytocides.

Mots clés: contrôle de la végétation forestière, opposition publique, perception du risque, phytocides, contrôle biologique, brûlage dirigé, paillis, équipement lourd, récolte protectrice, broutage, éradication manuelle

Introduction

Integrating the public into decision-making is an increasingly important part forest of management (Salwasser 1994, Marcin 1995). Understanding the degree to which the public finds specific forestry practices socially acceptable is a vital part of this process (Brunson 1993).

Like clearcutting, the use of herbicides to manage forest vegetation has generated considerable public debate across North America over the past two decades (Wagner 1994). A 1989 national survey of Canadians reported that 71 percent opposed the use of chemicals in the forest, with the vast majority believing that pesticides are harmful to fish and wildlife (90%) and to people living in the area (78%) (Environics Research Group 1989). Increased understanding of public attitudes towards forest herbicide use is clearly needed to develop better strategies of public involvement on this contentious issue (Buse *et al.*, 1995).

Stimulated by public opposition to herbicides, research efforts in recent years have sought to develop alternatives to herbicide use, especially aerial forms of application (McDonald and Fiddler 1993, Wagner 1993, Wagner *et al.* 1995, Comeau *et al.* 1996). Alternatives to aerially-applied herbicides that have been examined include: ground-applied herbicides (tractor-mounted sprayers, granular formulations, capsule delivery systems, backpack sprayers), biological control (naturally-occurring organisms such as fungal pathogens or phytotoxins derived from natural sources), prescribed fire, mulches (the spreading of materials around desired trees to control competing vegetation), heavy motorized equipment for soil scarification or cutting of vegetation, cover cropping (seeding of desirable non-crop plants to suppress or eliminate unwanted vegetation), grazing animals (primarily sheep), and manual cutting with brushsaws.

Although most non-herbicide alternatives have been available substantially longer than herbicides, they have emerged as alternatives because herbicide application has come to dominate most forest vegetation management programs over the past four decades. Technological advances, such as new plastic

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materials for mulches, lightweight cutting-machines, culturing of fungal pathogens, and extracting natural phytotoxins, also have generated interest in refining alternative approaches. Strategies for integrated vegetation management also require that a wide variety of vegetation control methods be available that can be used in a complementary manner (Wagner 1994).

Just as public opposition to herbicides has been based on a perception of unacceptable health and environmental risks relative to the perceived benefits, the acceptability of any proposed alternatives also will be linked to their perceived net risks (Metcalf 1993, Sachs 1993). Efforts to quantify and understand how people perceive risk has been a significant research focus over the past two decades (Slovic 1987). The National Research Council (1996) in the U.S. recently defined "risk" as "a concept used to give meaning to things, forces, or circumstances that pose danger to people or to what they value. Descriptions of risk are typically stated in terms of the likelihood of harm or loss from a *hazard* and usually include an identification of what is 'at risk' and may be harmed or lost (e.g., health of human beings or an ecosystem, personal property, quality of life, ability to carry on economic activity), the hazard that may occasion this loss, and a judgement about the likelihood that harm will occur."

Slovic (1993) concludes that public reactions to risk can be attributed to the sensitivity of the technical, social, and psychological qualities of hazards, which are not captured in scientific risk assessments. Qualities such as uncertainty in risk assessments, perceived inequity in the distribution of risks and benefits, as well as aversion to being exposed to risks that are involuntary, not under one's control, or dreaded are important features of risk perception (Slovic 1987). As a result, the role of social values in risk perception and acceptance has become apparent. Trust in those managing and making decisions about risks also has been identified as an important dimension of risk perception (Slovic 1993). Understanding the relation between public perceptions of risk and scientific risk analysis is essential for developing good risk communication, and vital if industry and government are to successfully manage their activities (Powell and Leiss 1997).

Efforts to develop alternatives to aerially-applied herbicides in forestry have generally been justified under the assumption that the proposed alternatives would be perceived as having lower risk and therefore be more socially acceptable. There is, however, little information available on public perceptions of risk and acceptability of forest vegetation management alternatives to test this assumption. The objective of this study was to 1) quantify perceived health and environmental risks of forest vegetation management alternatives by the Ontario public, 2) document public acceptability of those alternatives, and 3) examine the relation between perceived risks and public acceptability of the alternatives. We also compare responses of the general public with those from timber-dependent communities in Ontario. Data used for this study were part of a larger survey that has resulted in several other publications (Decision Research 1995, Gregory *et al.* 1997, Mertz *et al.* 1997, Satterfield and Gregory 1998, Wagner et al. 1998).

Methods

Survey Design and Sampling

The database for this study came from a survey of residents 18 years of age and over from the province of Ontario, Canada. Questions about the risk and acceptability of nine forest vegetation management alternatives were asked as part of a larger telephone-administered questionnaire about other issues that included 140 questions and took 30 to 40 minutes to complete. The questionnaire was developed by Decision Research of Eugene, Oregon. All data were collected between September and November 1994 by Goldfarb Consultants, an Ontario firm specializing in survey research, using a computer-assisted telephone interviewing (CATI) system. A complete description of the survey instrument and its administration is presented by Decision Research (1995).

Stratified random samples were drawn for the general public ($N = 1,500$) and residents of timber-dependent communities ($N = 801$). The frame for this population was the 1991 Census of Households in Ontario (Statistics Canada 1991). The surveyed population was stratified by community size to ensure proportionate representation of all areas in the province. Interviews for the general public and timber-dependent community sample had a response rate of 30% (±2.6%, $\alpha = 0.05$) and 33% (±3.5%, $\alpha = 0.05$), respectively. Although these response rates are lower than we would have preferred, such rates are not atypical for surveys dealing with issues of a specific and technical nature. Since these data may not necessarily generalize to these target populations, however, some caution is needed with inferences.

We compared the survey sample for the Ontario public with information from Census Canada for purposes of weighting the data for appropriate analyses. Our unweighted sample provided responses for 53.5% females, about 2% greater than Census Canada data for the Ontario population over age 18. Education across three categories (high school and less, some college, and college plus) varied by 1% or less between our sample and the census. Income by category varied by less than 1.1% over seven categories. Age showed the greatest variation, with our sample interviewing 7.5% more people in the 30–54 age group and about 6% fewer people in the over 55 age group. We weighted our response sample to conform with census Canada data.

The geographical location of potential timber-dependent communities was defined as those in northern Ontario (north of the French River). Information on northern Ontario's 374 communities was obtained from the Statistics Canada (1993) SIC and SOC Manuals for Canadian Business and from the 1991 Canada Census (Statistics Canada 1991). Timber-dependence was determined from an index, calculated by adding the proportion of total timber industry employment and the proportion of businesses in the timber industry for each community. Based on this index, 133 of these communities were anywhere from 5% to 67% timber-dependent. We separated communities according to low (5% to 9.9%), medium (10% to 19.9%) and high (20% to 66.7%) dependency. Two hundred fifty people were randomly sampled from highly dependent communities, 251 from moderately dependent communities, and 300 from low dependence communities. No difference ($P > 0.05$) was found between low-, medium-, and high-dependence communities. The timber-dependent community respondents, therefore, include the combined figures from low-, medium-, and high-dependence communities.

Questions, Response Scale, and Analysis

Perceptions of risk for nine forest vegetation management alternatives were assessed using the degree of respondent

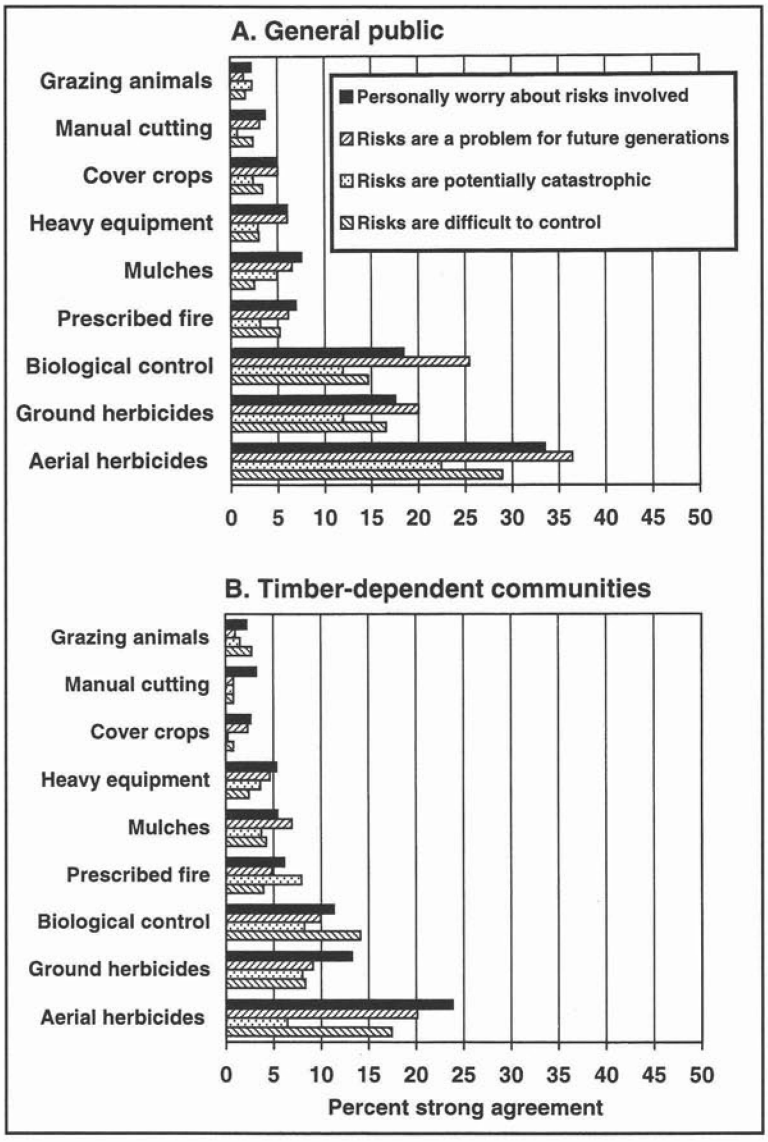

Fig. 1. Proportion of the general public (A) and timber-dependent communities (B) in Ontario *strongly agreeing* with 4 statements about the risk of nine forest vegetation management alternatives.

agreement with statements about four dimensions of risk that have proven useful in other studies (Slovic 1992, 1997). Respondents were asked to rate whether they strongly disagreed, disagreed, agreed, or strongly agreed that the risks of each alternative are 1) difficult to control, 2) potentially catastrophic, 3) a problem for future generations, and 4) a personal worry. Due to the length of the survey, responses to the four risk statements were gathered using a random rotation sequence that ensured a minimum sub-sample of 133 general public and 66 timber-dependent community respondents rated each vegetation management alternative. The proportion of each sample strongly agreeing or agreeing with the four risk statements was used as the basis for quantifying public perceptions of risk for each alternative.

The nine alternatives for forest vegetation control listed below were rotated in their presentation and rated by the respondents:
1) spraying herbicides from helicopters or airplanes,
2) ground-applied herbicides from tractors or workers using backpack equipment,
3) biological agents such as natural toxins or microorganisms,
4) prescribed or managed fires,
5) mulches such as plastic or paper,
6) bulldozers and other heavy motorized equipment,
7) cover crops such as grasses and clover,
8) manually clearing brush using chainsaws or other hand-held equipment, and
9) grazing animals such as sheep and cattle.

In addition, respondents were asked to individually rate the acceptability of four specific forms of biological control (natural plant toxins, microorganisms, genetically-engineered organisms, and viruses).

Respondents rated the acceptability of each alternative as very unacceptable, unacceptable, acceptable, or very acceptable. To examine the relation between the four dimensions of risk and the acceptability of the vegetation management alternatives, a risk perception index was calculated using the sum of the percentages of respondents strongly agreeing with the four risk statements. We regressed this index with the proportion of each sample population either accepting or strongly accepting each alternative.

Results

Perceptions of Risk

The proportion of those respondents strongly agreeing with the four risk statements provided the clearest means to rank the

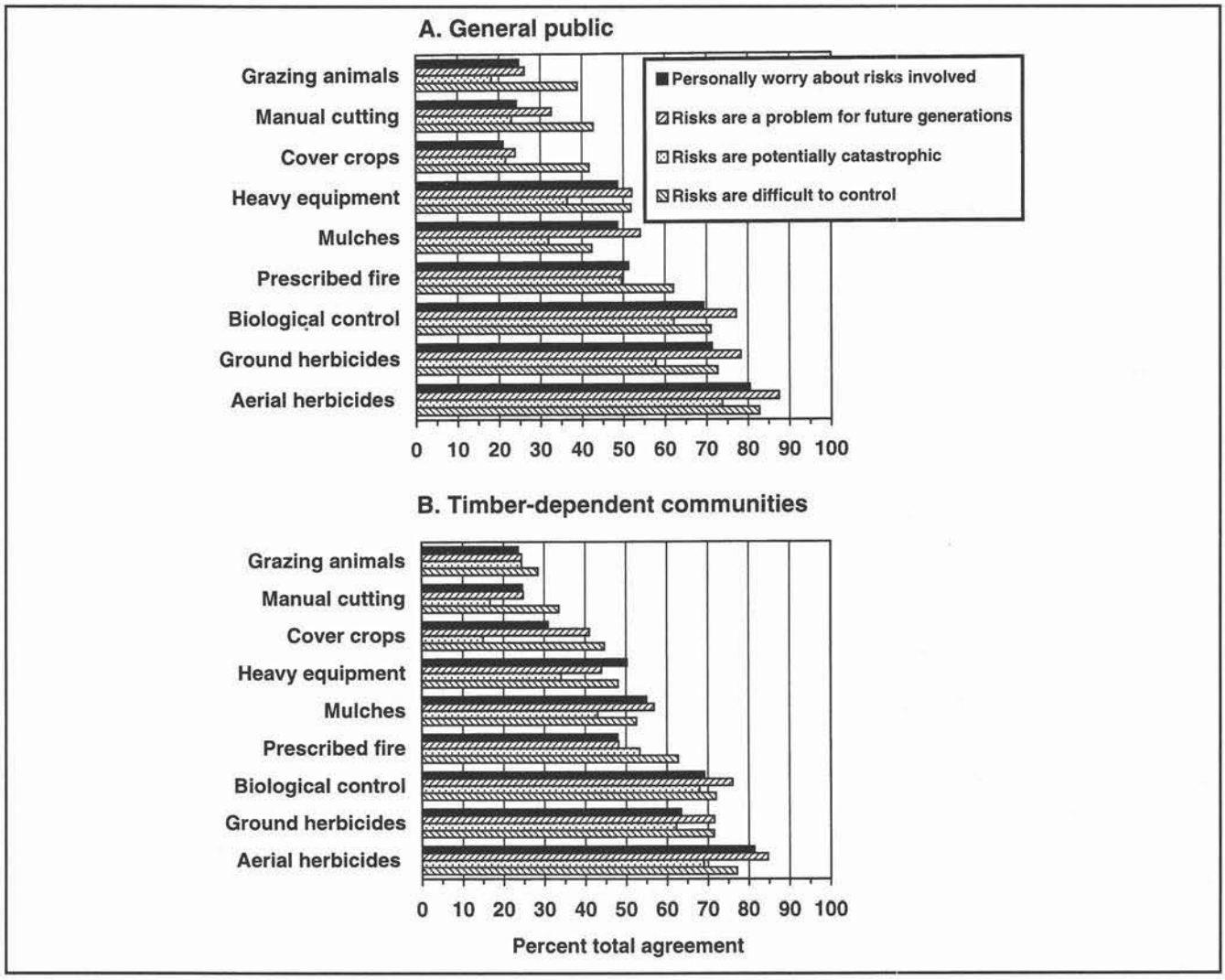

Fig. 2. The proportion of the general public (A) and timber-dependent communities (B) in Ontario *agreeing and strongly agreeing* with four statements about the risk of 9 forest vegetation management alternatives.

perceptions of risk among the alternatives (Fig. 1). The general public (Fig. 1A) perceived aerial herbicides as the riskiest alternative. For aerial herbicide spraying, 29% strongly agreed that it was difficult to control, 22% strongly agreed that the risks are potentially catastrophic, 36% believed strongly that the risks would be a problem for future generations, and 34% were worried strongly about the personal risks of aerial spraying. The next riskiest alternatives were ground herbicides and biological control with 12% to 25% of the general population strongly agreeing with the risk statements. Prescribed fire, mulches, heavy equipment, and cover crops received similar ratings with less than 8% strongly agreeing. Manual cutting and grazing animals were perceived as least risky with less than 4% of the general population strongly agreeing with any of the risk statements.

Ranking of alternatives by timber-dependent communities was similar to that of the general public; however, those from timber-dependent communities were less likely to respond with strong agreement to the risk statements, especially for aerial herbicides, ground herbicides, and biological control (Fig. 1B).

Although the degree of strong agreement depicts the highest degree of anxiety about a particular alternative, it is important to characterize all agreement with risk statements to gauge overall levels of public concern (Fig. 2). Large concerns about aerial herbicides were clearly expressed with 83% of the general public agreeing that they are difficult to control, 74% agreeing that the risks are potentially catastrophic, 87% believing that the risks will be a problem for future generations, and 80% personally worrying about the risks (Fig. 2A). Ground herbicides and biological control generated concerns for between 55% and 80% of the general public. Despite the low scores in the strong agreement categories for the non-herbicide alternatives, between 20% and 60% of the general public still expressed concern about the risks of these approaches.

Differences in risk perception between the general public and timber-dependent communities were no longer apparent when total agreement to the risk statements was examined (Fig. 2B).

Acceptability of Alternatives

We found substantial differences in the public acceptability of the nine vegetation management alternatives (Fig. 3). Only 18% of the general public found aerial herbicides acceptable (Fig. 3A). Ground-applied herbicides were acceptable to 37%.

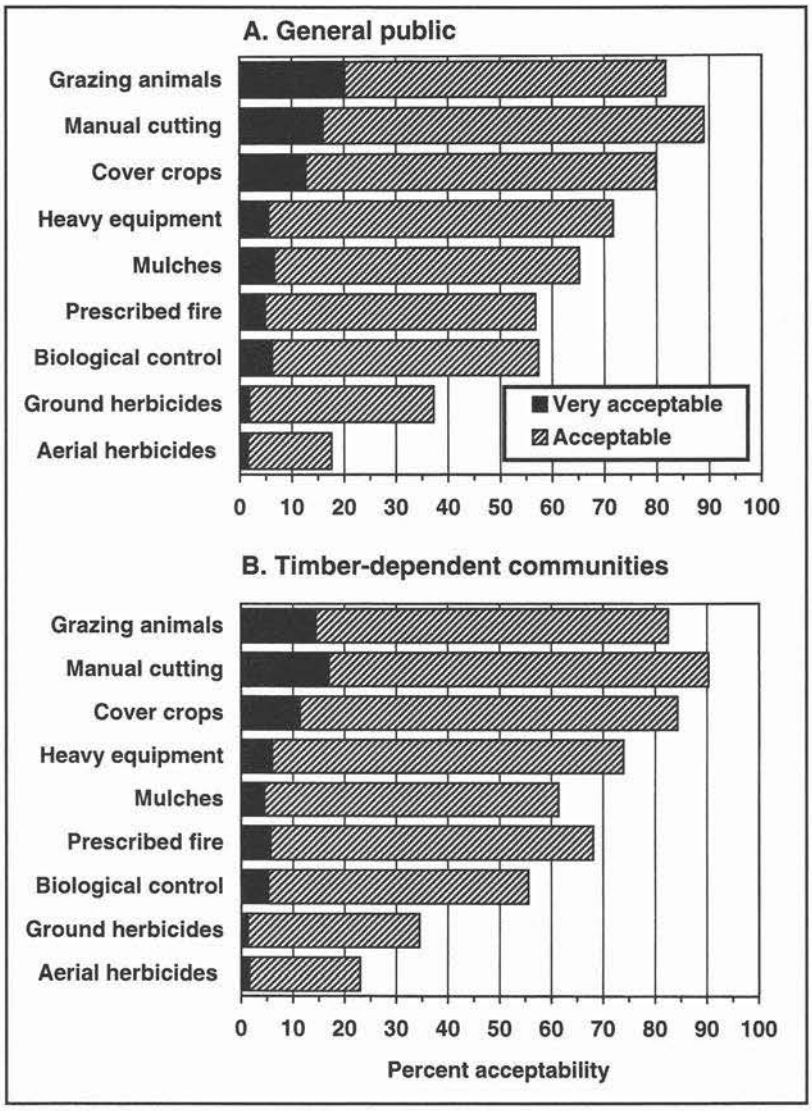

Fig. 3. Proportion of the general public (A) and timber-dependent communities (B) in Ontario finding nine forest vegetation management alternatives as acceptable or very acceptable.

All other alternatives were acceptable to more than half of the population, with cover crops, manual cutting, and grazing animals being acceptable to over 80% of the general public.

Our examination of various forms of biological control revealed substantial differences in acceptability depending on the proposed agent (Table 1). Natural plant toxins were viewed as most acceptable (73%) by the general public followed by microorganisms (42%), genetically-engineered organisms (39%), and viruses (21%).

Little difference in the ranking and absolute acceptability of alternatives was apparent between the general public and timber-dependent community samples (Fig. 3B, Table 1). Despite greater perceived catastrophic potential for prescribed fire (Fig. 1), timber-dependent communities found prescribed fire to be more acceptable than the general public (Fig. 3).

Relation Between Risk Perception and Acceptability

Regressing total acceptability scores (acceptable plus very acceptable) with the risk perception index for each alternative revealed an inverse relation between the two factors (Fig. 4). Similar strong relationships were found between the general public ($r^2 = 0.84$) and timber-dependent community ($r^2 = 0.89$) samples. The slope of the relationship, however, was steeper ($P = 0.0078$) for timber-dependent communities ($y = 89.77 - 1.03x$) than the general public ($y = 82.94 - 0.542x$), indicating that those in timber-dependent communities expressed a lower degree of acceptance than the general public at higher levels of perceived risk. This difference was due largely to a stronger reaction by the general public to risk statements about aerial herbicides, ground herbicides, and biological control.

Discussion

Eighty-two percent of the general public and 77% of those in timber-dependent communities found aerial herbicide use to be unacceptable, and by far the most unacceptable alternative among those presented. This level of opposition is slightly higher than a 1989 survey that indicated 70% opposition in Ontario (Environics Research Group 1989). Application of herbicides by ground using tractors or backpack sprayers was more acceptable, but still opposed by 63% and 65% of the general public and timber-dependent communities, respectively. This result also is consistent with the earlier survey of Canadians indi-

Table 1. Acceptability ratings for four methods of biological control by the general public and timber-dependent communities in Ontario

Form of biological control	Acceptance (%)			
	Very acceptable	Acceptable	Unacceptable	Very unacceptable
General public				
Natural plant toxins	9.9	62.9	20.9	2.2
Microorganisms	2.6	39.3	42.8	6.3
Genetically-engineered organisms	2.4	37.0	44.5	9.5
Viruses	1.3	19.5	54.9	18.0
Timber-dependent communities				
Natural plant toxins	7.8	64.9	21.4	1.9
Microorganisms	2.7	35.8	49.5	4.3
Genetically-engineered organisms	1.5	34.2	53.4	5.2
Viruses	0.5	22.4	59.8	12.2

cating that if herbicides are to be used, 66% preferred that ground-based methods be employed (Environics Research Group 1989). Public preferences for ground-based approaches appear to be based on perceptions of greater control over where the herbicide is actually applied (Decision Research 1995) and being less harmful to the environment (Environics Research Group 1989).

This 1989 survey also indicated that biological control was favored as an alternative to forest chemicals by 73% of the Canadian public (Environics Research Group 1989). We found that levels of support for biological control varied substantially depending on the specific agents proposed for use. Recent public awareness through the media regarding the risks of viruses and debates about risks associated with genetically-engineered organisms probably played a large role in the relatively low acceptance ratings these approaches received (Gregory and Lichtenstein 1994). Use of the word "natural" associated with plant toxins may have lowered the perceived risk and increased acceptability of this alternative.

All other non-herbicide methods of vegetation control also received majority support from the public in our survey. Methods such as cover cropping, manual cutting, and grazing animals received greater than 80% support. Therefore, research efforts to develop alternative approaches for forest vegetation control, based on an assumption of increased social acceptability, are clearly supported from our study.

The acceptability of non-herbicide alternatives by forestry professionals in Ontario is at least as great or greater than that of the public (Wagner *et al.* 1998). The greatest difference between the public and forestry professionals is in the level of support and perceived risk of practices, like herbicide application, that the public finds risky and unacceptable. Even when faced with situations similar to those under which forest managers operate, the public differs from forestry professionals in their choice of vegetation management approaches (Gregory *et al.* 1997). This troublesome gap between the public and forestry professionals is an important issue for policy makers and underlies many communication problems with the public in formulating and obtaining support for forest management plans.

We demonstrated that there is a good relationship between perceived risks and the level of public support an alternative received. People's perceptions of risk, particularly risks where there is a perceived lack of control and high catastrophic potential, are correlated with a desire to see those risks strictly regulated (Slovic 1987). Based on perceptions of risk for vegetation management alternatives in this study, public demands for regulatory control are likely to be substantially greater for herbicides and biological control than for cover crops, manual cutting, or grazing animals.

When evaluating perceptions of risk, as we have done, it should be recognized that public responses are based on a complex, multi-dimensional construct which combines a number of potential variables including danger, trust in managers, ethical values, worldviews, and ideas about how the decision process works with regard to the risk item being rated. As such, risk perception is a social construct (not observed directly) formed by psychological, affective, and cultural features, rather than solely from technical information. As a result, there can be variation from one respondent to another in the emphasis that each places on these variables. However, representative samples that obtain risk ratings over a number of items will show patterns of public perception of risk that can be compared within and across samples to identify similarities and differences for social groups and by socio-demographic categories (Slovic 1987).

Research about other hazards and risks management programs suggest that recognizing public perceptions of risk is important when communicating with them (Flynn et al. 1993, Walker 1995, National Research Council 1996, Powell and Leiss 1997). Differences in public perceptions of risk also are associated with socio-demographic factors. Women, those who are older, those with lower incomes, and those with lower levels of formal education tended to perceive greater risks in our survey (Decision research 1995) as well as other studies (Flynn *et al.* 1994, Krewski *et al.* 1995). McNabb and Bliss (1994) also found support for herbicide use among forest land owners in the southeastern US to be correlated with gender, age, and income. Differences among these groups should be recognized when developing public communication strategies about forest vegetation management plans.

Public support for practices like herbicide use, however, is based on more than just their perceptions of risk and includes a complex interaction of other factors. Factors such as environmental values, agreement with the goals of forest management, and trust in science and forest managers help predict the degree of public support for herbicide use (Mertz *et al.* 1997). Trust in managers has a large influence on public perceptions of risk and resulting public support for programs that control or use hazardous materials (Bella *et al.* 1988a, 1988b; Flynn *et al.* 1992; Slovic 1997). Environmental values have a significant indirect influence on support for herbicides by affecting risk

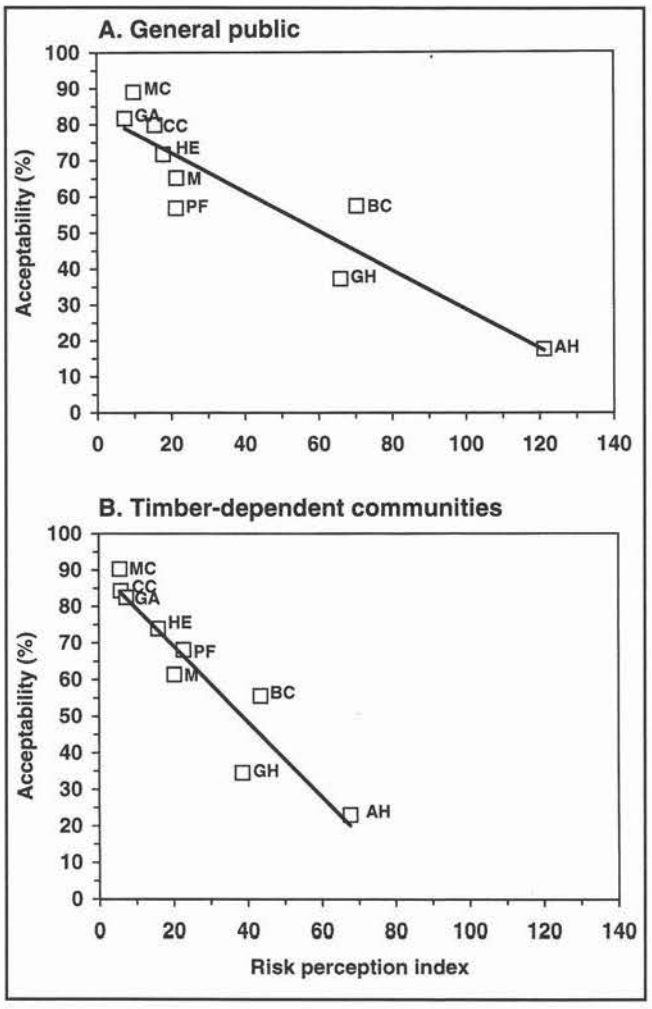

Fig. 4. Relation between risk perception index (sum of percentage of those strongly agreeing with four risk statements) and the acceptability (percentage of acceptable plus very acceptable responses) of nine forest vegetation management alternatives for the general public (A) and timber-dependent communities (B) of Ontario. Symbols are: AH = aerial herbicides, GH = ground herbicides, BC = biological control, PF = prescribed fire, M = mulches, HE = heavy equipment, CC = cover crops, MC = manual cutting, GA = grazing animals. Regression equations and r^2 are presented in text.

perceptions, agreement with forestry goals, and trust in forest managers. Factors that increase trust in forest management organizations and forestry professionals will likely serve to increase support for all approaches to vegetation management.

In addition to indicating strong support for non-herbicide alternatives, the public strongly agreed with the goal of forest vegetation management. Controlling unwanted vegetation to improve the survival of planted trees was supported by 82% of the general public and 78% of those from timber-dependent communities (Decision Research 1995). Forest management practices perceived as restorative, such as replanting logging roads and stocking streams with fish, also were soundly endorsed. Strong public support for forest vegetation management programs, therefore, can likely be achieved through sincere efforts to include non-herbicide alternatives and other practices perceived as environmentally sensitive and restorative. Since the public is likely to discount cost/benefit analyses of vegetation management programs when significant environmental risks are perceived, open and candid presentation of all the costs and tradeoffs for the various alternatives should be part of all communications with the public. Such efforts may help improve public trust of vegetation management programs and could increase public support for herbicides if they are used judiciously as part of an integrated management effort.

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