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NEW URBAN SETTLEMENTS IN A PERSPECTIVE OF PUBLIC AND PRIVATE INTERESTS

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Abstract

Changes of land use pattern and urban form could be seen as a dynamic result of the trade off by public and private interests. Private interest – individual residents or firms – tries, according to micro economic theory, to maximize their individual utility. Public interests – conveyed by government institutions on different geographical levels - on the other hand, try according to macro economic theories to maximize the general welfare in a community according to the preferences of the political system. The focus is to measure the importance of spatial locations factors regarding new residential and commercial buildings in relation to the existing urban form, political guidelines and ecological features. In the region transportation infrastructure systems, as high speed commuting train and highways, have been implemented in the middle of the period. The time period investigated is 1992-2000. The importances of the location factors were obtained by logistic regression analysis and transformation of the β - values into elasticities. The dependent variables were settlements of new urban elements in pixels of 50*50 meters. Independent variables where distances to existing urban elements, presence of public interests and some ecological features as south faced hill slopes, distance to water areas and geology. Results from this projects reveals that new urban settlements in general are located in proximity to existing urban settlements of the same kind, in remotness to existing urban focal points and to some extend within planned areas. National/regional transportation nodes do not have any apparent influence on the location. A general conclusion from this investigation is that the built environment develops towards a further dispersed rural spatial pattern though with some correspondence to the comprehensive land use plan.

INTRODUCTION

Changes of land use pattern and urban form could be seen as a dynamic result of the trade off by public and private interests. Private interest – individual residents or firms – try, according to micro economic theory, to maximize their individual utility in competition.[1] Public interests – conveyed by government institutions[2] on different geographical levels - on the other hand, try according to macro economic theories[3] to maximize the general welfare in a community according to the preferences of the political system. The topic of this paper is to get a picture of this spatial tension in atypical municipality in Sweden. The focus is to measure the importance of spatial locations factors regarding residential and commercial settlements in relation to the existing urban form, the political guidelines and some ecological features. The social reasons and the social and ecological impacts of the change in urban form are however not studied. The time period investigated is 1992–2000.

The municipality of Strängnäs is situated 80 km west of Stockholm, see figure 1. The municipality had approximately 28 000 inhabitants in the year 1992 and approximately 29 600 inhabitants in the year 2000. In the municipality there are about 2 700 workplaces situated. There are six small settlements in the area with 500 to 11 000 inhabitants. About 45 % of the employees work in the public service sector (public management, health care, education and research) and about 55% in commercial activities, mainly manufacturing (18%) and trade and finance (21%).[4]

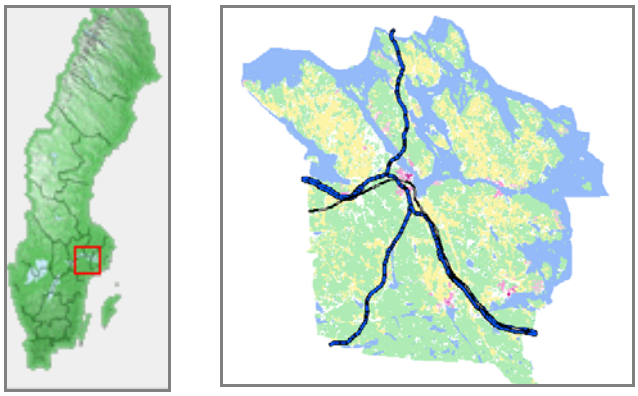

Figure 1. The geographical location of the municipality of Strängnäs and the directions of the national transportations systems and the land use.[5]

In 1992 decision regarding construction of high-speed commuting trains to the Stockholm region was taken.[6] The railway system was implemented in 1997 and implied 45 minutes travel time from Strägnäs town to Stockholm City. During the same year (1997) a highway, connecting the national road system in the municipality with the highway system in the Stockholm region, was constructed. In 1992 this project was in the planning stage.[7] The highway and the national road have approximately the same direction as the high-speed railway. A comprehensive land use plan, however not compulsory, for the municipality was

[1] (de la Barra, 1989).
[2] (Harvey, 1973).
[3] (Johansen, 1977).
[4] (The Municipality of Strängnäs, 2003).
[5] (Lantmäteriet, 2003)
[6] (The Municipality of Strängnäs, 1992).
[7] (The Municipality of Strängnäs, 1992).

adopted in 1992.

The focus in this study is the spatial development. Main questions to be answered are:

- What kind of spatial relations characterize the development of urban form in the municipality of Strängnäs during the time period 1992–2000?
- Does the spatial outcome correspond to the political guidelines – the macro economic perspective or to the private interests – the micro economic perspective?

According to contemporary arguments[8] society now a days could be labelled as a postindustrial knowledge society where communication, knowledge, art and creativity are the main characteristics. This definition derives from the concept of network economies. The industrial age was characterized by improvement in production and transportation.[9] In the age of the knowledge-based society decreasing cost and improvement of the transmission of information is significant.[10] One possible consequence of the implementation of information technology was the global economy. This change diminished the possibilities for the national political systems to govern the national economies and regions and municipalities searched for a higher degree of independence. This break might be apparent as educational infrastructure now seems to grow in importance as location factor. However, if the experiences from the industrial epoch are still valid then the regional and national transport nodes should be of importance as location factors for firms and households as well as urban focal points.

The planning situation today could, as Hall (1992) put it, be described as a "complexity of planning in a mixed economy" where the private interests initiate a considerable degree of the development and the public democratic interest is composed of individuals and groups with opposite opinions about an appropriate development.[11] However, the political systems on different levels put attention to the urban form and its relationship to the ecological and social systems. Concepts like social, economical and ecological sustainability are emphasized.[12] Even if Sweden did not become a member of the European union until than 1995, and the study period is 1992–2000, some of the political guidelines on the European level could be mentioned. Principles for a European spatial development policy and the European spatial development perspective (ESDP) were adopted in 1999, where control of the physical expansion of towns and cities, and mixture of functions and social groups are emphasized. [13, 14] Similar political intentions could be found on the national Swedish level in the building and planning Act from 1987,[15] the management of planning resources Act from 1987,[16] in guidelines from the Swedish National Board of Housing, Building and Planning (1999)[17] and in other recent national governmental documents.[18] On the local level the political guidelines regarding land use, urban form and spatial development are expressed in the municipal comprehensive plans. For the municipality of Strängnäs such plans exist for 1984, 1992 and 2000.

[8] (Andersson and Strömquist, 1988)
[9] (Westlund, 1998).
[10] (Westlund, 1998).
[11] (Hall, 1992).
[12] (World Commission on Environment and Development, 1987).
[13] (Federal Ministry for Regional Planning, Building and Urban Development, 1995)
[14] (The European Commission, 1999).
[15] (The Swedish Parliament, 1987a).
[16] (The Swedish Parliament, 1987b).
[17] (The Swedish National Board of Housing, Building and Planning, 1999).
[18] (The Swedish Parliament, 2000).

BACKGROUND

Anderson, Kanaroglou and Miller (1996) depict theories on spatial features in terms of urban form, urban interaction and urban spatial structure. The urban form refers to the relative location of residences, work places, shopping malls, and recreation areas. It is also interpreted in terms of their densities, and the location of transport infrastructure.[19] The urban interaction, in turn, refers to the flow of goods, people and information. Finally, the urban spatial structure refers to a set of organising principles that define the relationship between the urban form and the urban interaction.[20]

The spatial outcome of the public-private tension – the change of urban form – during the period 1992–2000 might be understood from an urban economic perspective. Here are some of the established theories briefly presented. First described are aspects of individual choice, then spatial consequences of the competition of spatial activities, and third the influence of change in accessibility. Last the concept of the public interest is defined by its historical origin, and a theoretical scheme of planning is depicted.

Private interests

The fields of urban economics have been generally described by researchers as Alonso,[21] de la Barra,[22] Kivell,[23] O´Sullivan,[24] Mills and Hamilton.[25] As mentioned in the introduction the private interests, individual residents or firms, are assumed to maximize their individual utility.[26] At the same time, it has been demonstrated that the actors in reality are not consistent in their choices – they do not always choose the best alternative but a sufficient one.[27] Already M. Weber (1864–1920) pointed out other non-rational reasons for action like affection and traditions (together with goal and value related rational reasons).[28]

The market forces in urban economics could be described, as usual, in terms of demand and supply. The urban land use is then determined by the actors' needs, demands and competitiveness. According to Harvey (1973) the actors representing the private interests are: occupiers of housing, estate agents, landlords and developers.[29] Jobs, housing, shopping and other activities constitute the needs. In the competition for land the actor that outbids the others will acquire the site and hence determine the land use.[30]

Here three land use allocation approaches are described. Two are classical with a monocentric and a polycentric urban structure, which explain the allocation of land use and the subsequent land value surface. Last, a conceptual spatial interaction model is presented to illuminate the affect of infrastructure investment on the location of firms and households.

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[19] (Andersson, Kanaroglou and Miller, 1996)
[20] (Bourne, 1982)
[21] (Alonso, 1960).
[22] (de la Barra, 1989).
[23] (Kivell, 1993).
[24] (O´Sullivan, 1990)
[25] (Mills and Hamilton, 1994)
[26] (de la Barra, 1989).
[27] (Hagen, Mortensen, 1996).
[28] (Månsson, 1996).
[29] (Harvey, 1973).
[30] (Kivell, 1993).

In the monocentric urban model (with a homogenous land, a single employment centre, and elastic demand for land) it is assumed that land use is distributed according to a bid-rent function, which depends on the land use capability to produce profit (use value or exchange value) in relation in the distance to the city centre and availability to retail markets, labour and so forth. The combined bid rent functions produces hence a land value surface. The Alonso (1960) location and land use model operational on both households and firms, considers three composite elements: amount of land consumed and cost per unit land, transportation cost, price per composite goods consumed and the amount of composite goods consumed.[31] The total cost is equal with the income and is distributed on the composite elements depending on the location of the household/firm and the location of the work place/market.

In a polycentric urban model Christallers (1933) and Lösh (1940) introduce multiple market areas and a hierarchical economic system.[32] In this model the following assumptions are presumed: a large featureless plane and evenly distributions of consumers. Depending on the distance to the consumer from a producer the profit per goods unit decreases due to increasing transportation costs. In this situation another producer could establish at a certain distance and a hexagonal pattern of producers could then evolve. By further division of production a specialized firm could establish, which would serve the existing producers. This situation in turn might lead to a hierarchical polycentric market system, see figure 2.

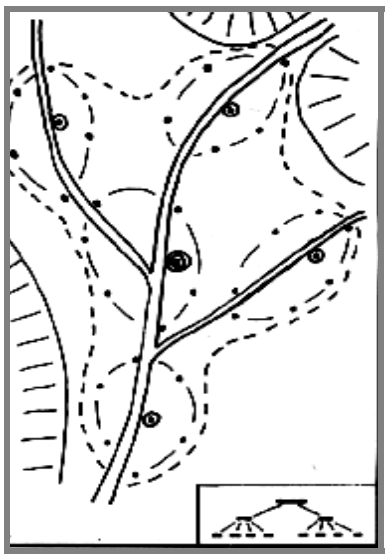

Figure 2. Sketch of a third tiered ordered urban system.[33]

As the economic specialization evolves even further and more commodities are introduced into the market, the region will grow in complexity. The transportation systems could then be divided into a local and a regional structure. Local transportation systems will distribute goods and labour in the local market and regional transportation systems will distribute goods and labour for the regional market.[34]

A number of models have been developed to depict the spatial interaction of firms, households and infrastructure on the regional level, for instance, see Wegener (1996). Spatial

[31] (de la Barra, 1989).
[32] (Quoted by de la Barra, 1989).
[33] (Nissen, 1988).
[34] (de la Barra, 1989).

interaction models operate in spatial zones where activities are aggregated into categories, as for instance in the members' socio-economic characteristics.[35] These theories are based on gravity models where, for instance, the locations of residential areas are a function of proximity to workplaces.[36] The central elements in the interaction models are the activities within the zones and the abstract flow of activities in between.[37] The magnitude of the flow depends on the activities in the zones and the infrastructure friction (distance, costs, time).[38]

An increase in infrastructure leads hence to a shift in productivity for the region concerned.[39] Changes in infrastructure provision thus result in a differentiation in the spatial productive landscape (Rietveld and Bruinsma, 1998). In figure 3 below it is described how the volume and location of firms and households depends on the accessibility of the location and the productivity of the firm or household. An investment in transport infrastructure will decrease the transportation costs in time and / or money. This change will lead to an increase in accessibility of locations, productivity of firms and households and in movement of freights and people. This development, in turn, could lead to an expansion of economic activities and population.

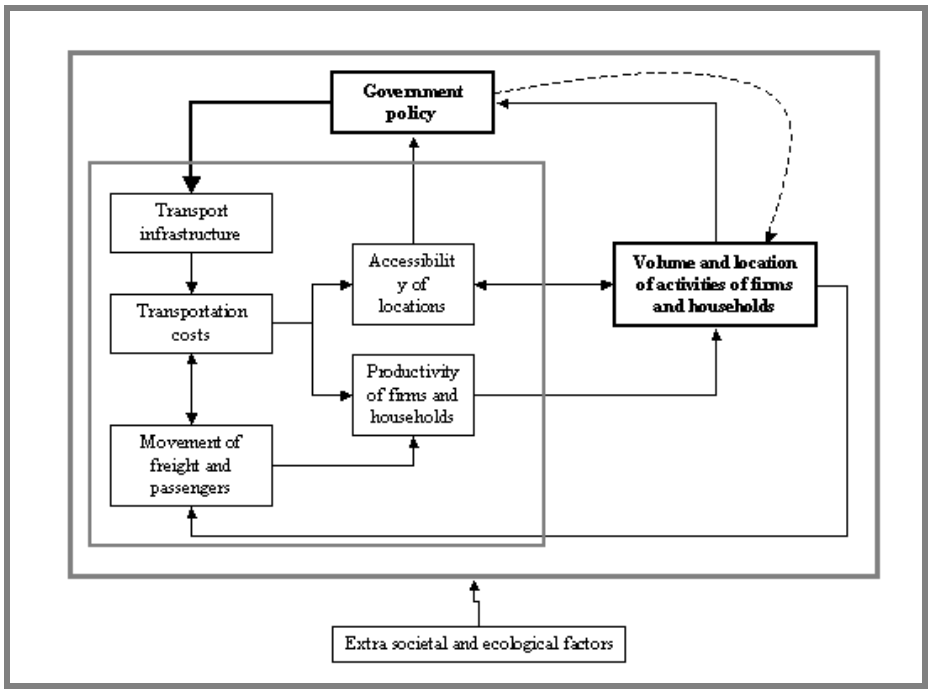

Figure 3. Conceptual model of the urban spatial structure on the relationship between the urban interaction and the urban form. Developed from Bruinsma, Rienstra and Rietveld (1996).[40]

Each agent – a household or a firm – tries to maximize their utility in competition with other agents. Those land users who can outbid the others determines the actual land use and the land values. In a monocentric urban system the urban focal points should be of great importance according to the location of new urban elements. In a specialized economy with further division of goods and service production it is, according to these theories, assumed that the

[35] (de la Barra, 1989).
[36] (Hansen, 1959), (de la Barra, 1989).
[37] (de la Barra, 1989).
[38] (de la Barra, 1989).
[39] (Rietveld et al., 1998).
[40] (Bruinsma, Rienstra and Rietveld, 1996).

regional/national transportation nodes will increase in importance as location factors for firms and labour. Infrastructure investments will hence affect the attractiveness of a location and change the land use. Though, if the spatial economical system in the municipality of Strängnäs correspond to microeconomic theories and is changing from a local monocentric urban system into a regional more complex economic urban system, then the regional transport nodes should increase in importance as location factors for commercial and residential settlements. If however the economical prerequisites for the location of new households and firms correspond to the "post industrial knowledge society" then it might be assumed that other spatial patterns will emerge.

Public interests

Justification for planning intervention has been examined by scholars like Johansen (1977), Klosterman (1985) and Foglesong (1986). The balance of public and private interest has varied according to the political context in time and space.[41] According to contemporary planning theories, the reason to maintain the public interests is to correct markets failures involving (1) public or collective consumptions goods; (2) externalities or spill over effects; (3) prisoners´ dilemma conditions; and (4) distributional issues.[42] When it comes to urban economics, one of the production factors – the land use – differ from other parts in the market economy. This distinction, which Fogelsong (1986) term the central contradiction,[43] originates from the tension of the social character of land and its private ownership and control. However, the public interests today, when the local economy faces external competition in a higher degree according to the development of the global economy the development of urban infrastructure, is also one of the last opportunities for national governments to advance their cities in the international competition.[44]

In the Swedish planning system, the municipality has monopoly regarding the land use regulations. An indicative land use plan should portray the principal existing and planned land use according to national and local public interest. The comprehensive planning process includes consultation with the County Council, other municipalities and public authorities.[45] Citizens' viewpoints are also incorporated in the process. The legal determination of land use is performed in the detailed development plan for specific areas, which is an agreement between the municipality, the public and the landowners in the areas concerned. The detailed development plan makes it possible for the intentions of the comprehensive plan to be implemented.[46] This instrument is obligatory in cases when the change considers built up areas or single building units when there is a risk of significant impact on the environment. In other cases only permission from the municipality is required.[47]

Johansen (1977) developed a basic decision theoretical scheme of planning in the field of macroeconomics, see figure 4.[48] This scheme might be used for comprehensive land use planning. The main thought is that the central authority could affect the structure of the land use by comprehensive land use plan, detailed development plans and other means of control (a) with the intention to reach a certain position on a preference scale (W). This position

[41] (Kivell, 1993).
[42] (Klosterman, 1985).
[43] (Foglesong, 1986).
[44] (Rietveld and Bruinsma, 1998).
[45] (The Swedish Parliament, 1987)
[46] (Alfredsson, Wiman, 2002).
[47] (The Swedish Parliament, 1987)
[48] (Johansen, 1977).

should correspond to the intentions in the comprehensive land use plan. The structure of the land use is however also affected by a set of non-controlled exogenous factors (x) as for instance the extra-economical system. Hence, policies and exogenous factors affect the dynamics of the land use structure (f (a, x)) and originate to a state of the actual land use (y). The state of the actual land use (y) could then by the preference function (W(y)) be compared with the intended position on the preference scale (W) – the comprehensive land use plan. Other constraints are the freedom of action in policy making (A) and all possible states of the exogenous factors (X).

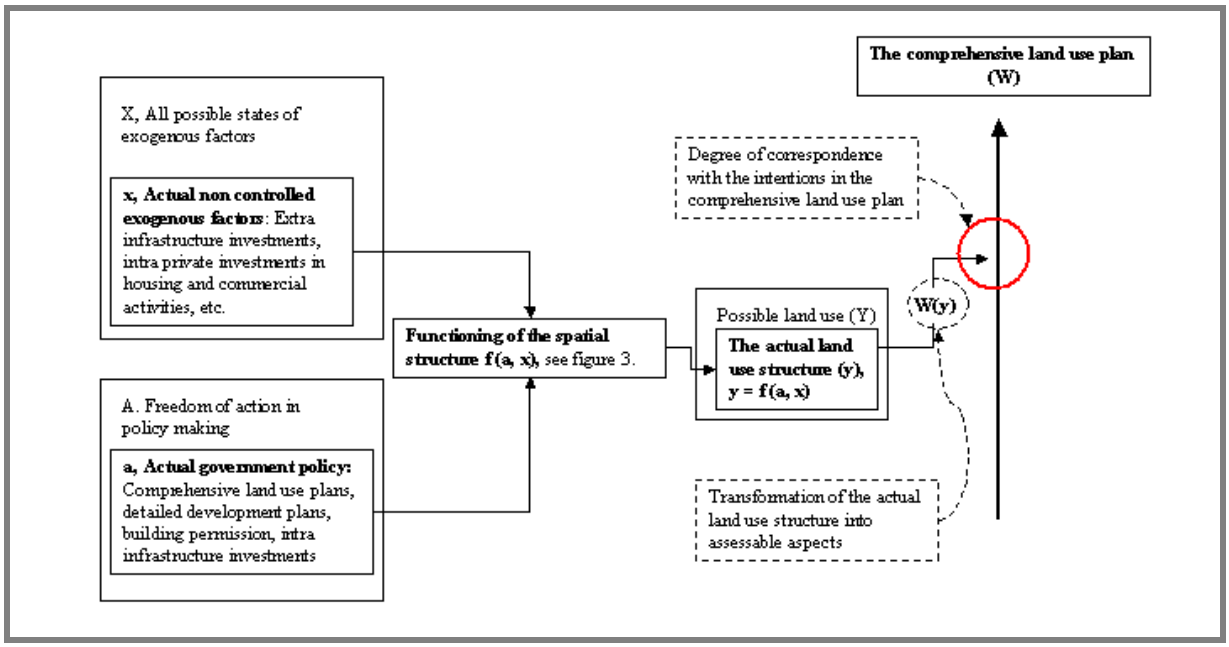

Figure 4. A decision theoretic scheme of comprehensive land use planning developed from Johansen (1977).[49]

METHOD

The current case study has been inspired by a previous analysis performed by Rietveld and Wagtendonk (2000). In the study main factors for residential locations in the Netherlands during the period 1980–1995 were investigated. The aim was to examine the weight of political forces regarding compact city, zoning, and new towns versus market forces. In the study a logistic regression analysis was used. The dependent variable was constituted by the number of new dwellings in a pixel of 500*500 meters and independent variables were constituted by a number of spatial features as: proximity to existing residential areas, proximity to employment, distance to transport nodes and so forth.

Here, location factors representing both private interests and public interests are taken into account. The assumption is that the attraction of a location depends on the accessibility to spatial utilities as work places, employees, services, transportation nodes, recreation areas etc and that the private interests try to include access to these utilities in their location choice.In this study the state of urban form in 1992 and the change of urban form in 1993-2000 was obtained also by logistic regression analysis. Dependent variables were the establishment of 5 specific types of urban elements ($y_{1\text{-}5}$) in relation to 22 explanatory variables ($x_{1\text{-}22}$), see table

[49] (Johansen, 1977).

1. The dependent variables were establishment of single family residential houses, multifamily houses, recreation houses, industry buildings and buildings for other commercial activities. The independent variables were measured in terms of the distance to other urban elements (x_{1-9}) and the presence of public interests in form of land use regulations (x_{10-14}). Some ecological features were also included (x_{15-22}).

VARIABLES	DESCRIPTION
i, j	Locations
t	Time periods: 1992, 1993–2000, 1993–1996, 1997–2000.
Dependent variables (y_{1-5})	Occurrence of the variable in a location (i) during the time period (t).
RS_{it}	Single family house.
RR_{it}	Recreation house.
RA_{it}	Apartment house.
FI_{it}	Industrial building.
FL_{it}	Service and shopping building.
Independent urban variables (x_{1-9})	Distance (D) to the existing urban element (x) from a location (i) during time period (t).
RSD_{it}	Single family house.
RRD_{it}	Recreation house.
RAD_{it}	Apartment house.
FID_{it}	Industrial building.
FLD_{it}	Service and shopping building.
CD_i	Urban centre facility.
PBD_i	Public service facility.
$STND_i$	Railway stations.
$NRND_i$	National road nodes.
Independent public variables (x_{10-14})	Occurrence of the variable in a location (i).
$S30205_i$	National interests of water front resource.
$N50102_i$	National interests of nature resourse.
$K50103_i$	National interests of cultural resourse.
$R50104_i$	National interests of recreation resourse.
$P504_i$	Occurrence of local political guidelines for building area.
Independent ecological variables (x_{15-22})	Occurrence of (0/1) or distance to the variable from a location (i).
WD_i	Distance to water areas.
$L201\_AS_i$	Flat or south sloping landscape.
$G20101R_i$	Geology rock resourse.
$G20101E_i$	Geology esker resourse.
$G20101S_i$	Geology sand resourse.
$G20101M_i$	Geology moraine resourse.
$G20101C_i$	Geology clay resourse.
$G20101O_i$	Geology residual resourse.

Table 1. Dependent and independent variables used in the regression analysis.

The specific independent variables were distance to residential and commercial settlements; central points of build up areas, schools, health care facilities, theatres and sport centres; transportation nodes as railway stations and national road nodes; the presence of designated national interests as water front preservations, natural and cultural resources and recreational values and the planned land use for building purposes from the municipality; distance and character of some ecological features, as: water areas, topographic aspect and geological fractions as rock, esker, sand, moraine, clay and residual.

The probability (P_{yit}) for a occurrence of a specific dependent variable (y) in relation to all independent variables ($x_{1\text{-}22}$) in the period (t) in a pixel (i) is received from following formula:

$$\ln\left(\frac{P_{yit}}{1 - P_{yit}}\right) = \beta_{yt} + \beta_{yx1t} * x_{1it} + \ldots + \beta_{yx22t} * x_{22it} \quad [1]$$

and:

$$P_{yit} = \frac{\exp(\beta_{yt} + \beta_{yx1t} * x_{1it} + \ldots + \beta_{yx22t} * x_{22it})}{1 + \exp(\beta_{yt} + \beta_{yx1t} * x_{1it} + \ldots + \beta_{yx22t} * x_{22it})} \quad [2]$$

The probability values (P_{yit}) will according to this definition exhibit values in the range of 0–1. β_{yxt} depicts the influence of the specific location factor (x) on the probability (P_{yit}) in time (t) in all locations (i).

However, to be able to compare the relative importance of the location factors the average elasticity of the weights were computed, see equation [3]. The average elasticity depicts a linear relationship between the probability for an establishment of an urban element in a location and the dependent variable. The elasticity (E_{yxi}) depicts the relative change of the probability ($\Delta P_{yij}/P_{yi}$) regarding a dependent variable (y) according to the relative change of the independent factor ($\Delta x_{ij}/x_i$):

$$E_{yxit} = \beta_{yxt} * x_{it} * (1\text{-}P_{yit}) \quad [3]$$

An average elasticity value (E_{yxt}) of "0.8" indicates that a change of the specific location factors ($\Delta x/x_i$) in location (i) by for instance 10 % results in a change of the probability ($\Delta P_y/P_{yi}$) of 8 %. As the value of ($\Delta P_y/P_{yi}$) is relatively small the effect on the average elasticity (E_{yxt}) is strongly dependent on the value of the independent variable (x_i). Thus, the elasticities are dependent on the entire model and must hence be evaluated with respect to the characteristics of the independent variable.

Data

The material used in the investigations depicts urban form elements and spatial public interests as well as ecological features. The total number of pixels investigated were approximately 310 000. And the total numbers of pixels where urban elements occur in the year 2000 were approximately 6200. That is only 2 % of the region investigated (water areas excluded).

The material used to depict urban and ecological features are the national real estate tax register and digital maps from the Swedish survey organization (Lantmäteriet) and the geological survey of Sweden. The real estate tax register contains information about the use of buildings, the year of construction, floor space, land value and location among other things. The smallest unit in the register is the so-called "value unit" representing the use of a part of a building, in the following called "building unit". The residential building units consist of eight sub classes, for instance: permanent dwellings for 1–2 families, recreation houses and multi family houses. The commercial building units also consist of eight subclasses: "commercial space" (offices and services), industry etc. The digital maps depict the overall land use e.g. infrastructure, water areas, elevation, geology and so forth.

In the comprehensive land use plan, adopted in 1992,[50] are goals regarding location of urban elements mentioned in terms of proximity to nature, proximity between residents and firms to gain a mixture of social life, a freedom of choice between a urban or rural living environment, mixture of residential types and in general maintaining cultural resources among others. Goals regarding location of residents and firms in relation to regional/national transportation nodes are not explicit mentioned. However, in Strängnäs, where one of the stations and the national highway exits were planned to be located, the station area is declared to be developed with residents and commercial functions in an urban environment. The other station and the highway exit – Läggesta – is situated between two small towns in the southeastern part of the municipality. Here the development instead is intended to take place in the two existing built up areas some distance away from the station. The municipality is divided into nine sub-areas where the future land is described in further detail in terms as area with regulated land use, area where a considerably change of land use are planned and area of future strategic importance. The land use is then described as residential and/ or commercial in shifting degrees.

The comprehensive plan also depicts areas of national interests regarding nature, recreation, cultural resources and preservation of waterfront areas. These regulations affect approximately 60 percent of the municipality. In general, the future land use in the municipality is described in passive form with a focus at different patches existing in the built up areas. Descriptions of different future scenarios or political statements of the inherent urban structure or the urban characteristics in terms of urban densities, integration of land use, urban-rural relations and environment are not performed. Ecological or social consequences on different levels caused by various spatial developments are not analysed. The spatial distribution of the detailed development plans was obtained from the municipality to depict already planned areas in 1992.

The comprehensive land use plan were digitised and structured into national public interests and local land use regulations. The building units from the real estate tax register were geocoded into pixels of 50*50 meters and classified according to time periods 1992, 1993–1996, 1997–2000 and 1993–2000, and purpose residential (single family houses, recreation houses and apartment houses) and commercial (industries and service and shopping). Other urban elements as public buildings, transportation nodes as well as land value information were also extracted from the real estate tax register. The geological map was reclassified into six new classes rock, sand, moraine, esker, clay and residual. The elevation data model was transferred into a topographic aspect where flat and south sloping areas were assigned a value of one and north sloping areas where assigned a value of zero.

RESULTS

Here are the results from the regressions analysis presented. First, a static location model representing the importances of the location factors in 1992 is presented. Second, incremental location models representing the importance of the location factors in 1993-2000 are presented. Finally an appraisal of the received location model 1993-2000 is presented.

[50] (The Municipality of Strängnäs, 1992).

Static location model for urban settlements 1992

The general spatial distribution of urban form in the year 1992 is depicted by beta (β) and the average elasticity (E_{yxt}). The beta value gives information of how the probability for occurrence of an urban element in a location (i) is affected by the value of the independent variable, see equation [2]. Table 2, part one – the distance to urban elements – should be interpreted as follows: negative values denote that proximity is important. In part two – spatial regulations – positive value denotes that the existence in a site of the independent variable enhance the probability. In part three – ecological factors – negative value of the distance to water areas denotes that proximity enhance the probability and, at last, existence of topographic aspect denotes that flat topography or south sloping hills sides enhance the probability.

If the threshold value of the elasticity is put to 1, following could be noted for significant location factors regarding each urban element. Single family houses (3349 locations) are located in proximity to public buildings as schools, health care facilities, etc. Recreation houses (2447 locations) in turn are generally located in proximity to singe family houses. Multi family houses (306 locations) are situated in adjacent locations to service and shopping facilities and to some degree in proximity to single family houses and railway stations. Buildings for industrial purposes (132 locations) are located in proximity to other commercial buildings for service and shopping, and to some extend in proximity to single family houses and public buildings. Last, buildings for service and shopping purposes (241 locations) are located in proximity to multi family houses, industrial buildings and railway stations.

Public interests and ecological features exhibits in general low importances and regarding multi family houses and buildings for industrial and service purposes even low degree of significance.

SPATIAL STATISTICS: STATE OF URBAN FORM 1992

		BETA VALUES (β)					ELASTICITY (E) (MEAN)					DESCRIPTIVE STATISTICS DISTANCE (KM)	
OCCURRENCE IN A PIXEL (0/1)	DEPENDENT VARIABLES (TIME)	SINGLE FAMILY HOUSES (92)	RECREATION HOUSES (92)	MULTI FAMILY HOUSES (92)	INDUSTRIES (92)	SERVICE (92)	SINGLE FAMILY HOUSES (92)	RECREATION HOUSES (92)	MULTI FAMILY HOUSES (92)	INDUSTRIES (92)	SERVICE (92)	MEAN	STD. DEV.
	NUMBER OF PIXELS	3346	2447	306	132	241	3346	2447	306	132	241	310943	
	INDEPENDENT VARIABLES (TIME)												
DISTANCE (KM)	**Single family houses (92)**		**-1.66**	**-4.38**	**-1.85**	0.15		**-1.2**	**-3.3**	**-1.4**	0.1	**0.75**	**0.64**
	Recreation houses (92)	**-0.40**		**-0.48**	0.27	**-0.75**	**-0.3**		**-0.3**	0.2	**-0.5**	**0.73**	**0.56**
	Multi family houses (92)	**-0.14**	**0.10**		0.27	**-4.60**	**-0.6**	**0.4**		-0.1	**-18.4**	**4.00**	**2.78**
	Industries (92)	**0.07**	**-0.15**	-0.30		**-1.03**	**0.2**	**-0.5**	-0.9		**-3.2**	**3.06**	**2.22**
	Service (92)	**-0.13**	0.01	**-7.15**	**-0.81**		**-0.5**	0.1	**-29.5**	**-3.4**		**4.13**	**2.89**
	Centres	-0.01	**0.08**	-0.23	0.12	0.17	-0.1	**0.4**	-1.3	0.7	1.0	**5.71**	**3.23**
	Public buildings	**-0.43**	0.02	0.04	**-0.50**	-0.28	**-1.2**	0.1	0.1	**-1.4**	-0.8	**2.71**	**1.69**
	Rail way stations	**0.07**	**0.09**	**-0.20**	-0.09	**-0.24**	**0.6**	**0.8**	**-1.9**	-0.8	**-2.3**	**9.21**	**4.25**
	National road nodes	**-0.08**	0.01	0.04	0.07	-0.02	**-0.5**	0.1	0.3	0.5	-0.2	**6.92**	**3.98**
EXISTENCE (0/1)	**Waterfront preservation**	-0.06	-0.09	-0.31	**-0.62**	-0.24	0.0	0.0	**-0.1**	-0.2	-0.1	**0.25**	**0.43**
	Nature preservation	**-0.23**	0.05	-0.47	-0.33	-5.42	**0.0**	0.0	0.0	0.0	-0.4	**0.07**	**0.26**
	Cultural resources preservation	**0.43**	**-0.20**	**0.40**	**-0.41**	**0.42**	**0.1**	**-0.1**	**0.1**	**-0.1**	**0.1**	**0.28**	**0.45**
	Recreation area preservation	**-1.36**	0.05	**-2.00**	-0.84	**-1.18**	**-0.2**	0.0	**-0.2**	-0.1	**-0.1**	**0.11**	**0.31**
	Planned area	**2.32**	**3.17**	**0.52**	**1.00**	**0.77**	**0.1**	**0.1**	**0.0**	**0.1**	**0.0**	**0.05**	**0.22**
ECOLOGICAL FEATURES (KM, 0/1)	**Distance to water areas**	**-0.29**	**-0.68**	-0.33	-0.14	**-0.69**	**-0.3**	**-0.6**	-0.3	-0.1	**-0.7**	**0.96**	**0.77**
	Flat or south sloping landscape	**0.23**	0.04	-0.14	-0.06	-0.02	**0.1**	0.0	-0.1	0.0	0.0	**0.47**	**0.50**
	Geology: Rock	**2.70**	**3.35**	5.46	3.60	5.81	**0.6**	**0.7**	1.1	0.7	0.7	**0.21**	**0.41**
	Geology: Esker	**3.30**	**3.17**	6.84	4.17	6.69	**0.1**	**0.1**	0.2	0.1	0.1	**0.02**	**0.15**
	Geology: Sand	**3.36**	**3.70**	4.98	4.00	5.26	**0.1**	**0.1**	0.1	0.1	0.1	**0.02**	**0.15**
	Geology: Moraine	**2.98**	**3.37**	6.02	3.96	6.00	**0.9**	**1.0**	1.8	1.2	1.2	**0.30**	**0.46**
	Geology: Clay	**2.41**	**2.43**	6.19	3.93	6.30	**0.8**	**0.8**	2.2	1.4	1.4	**0.35**	**0.48**
	Geology: Other	0.59	0.70	6.42	4.78	7.32	0.0	0.0	0.2	0.2	0.2	0.03	0.18
	Constant	-6.10	-8.72	-6.97	-8.85	-7.86							

Table 2 The table presents Beta (β) and the elasticity (E) of the different spatial location factors in the year 1992 for major urban elements in relation to distance to other urban elements, existence of public interests and some ecological features. Significant values are bold and underscored. Descriptive statistics depicts all pixels in the municipality, water areas excluded.

Incremental location models for urban settlements 1993-2000, 1993-1996 and 1997-2000

Here the development of the urban structure during the period 1993–2000 is investigated. First the number of affected pixels outside and inside planned areas are presented, see diagram 1. Second, the spatial relation regarding new urban elements in relation to existing urban and ecological elements and spatial public interests is presented, see table 3. According to the intention to describe the effect of the transport infrastructure investments in 1997 on location of new single family houses are finally the spatial relations in the periods 1993-1996 and 1997-2000 presented, see table 4.

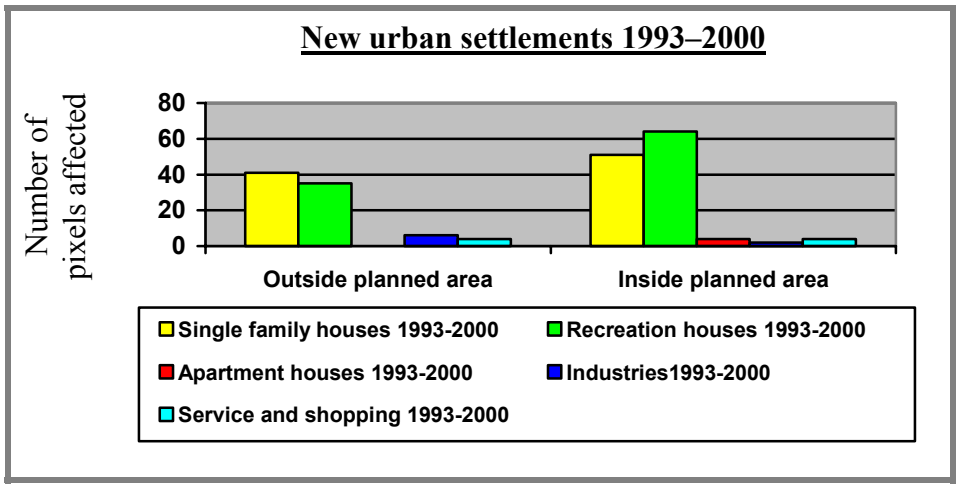

Diagram 1. New urban settlements in relation to local land use regulations.

In the period 1993–2000 were ninety-two pixels affected by new single-family houses for residential purposes, ninety-four pixels for residential purposes and four pixels for new apartment houses. Eight pixels were affected by new industrial buildings and eight pixels for other commercial activities. The number of independent variables that exhibits significance varies depending on the number of pixels affected and the specific urban feature. New single family houses are located in proximity to existing single family houses, multi family houses, railway stations, service and shopping and in remoteness to urban centres. Recreation houses are generally located in proximity to existing recreation houses, and also remoteness to urban centres. Multi family houses are situated in adjacent locations to urban centres. Buildings for industrial purposes are located in considerable proximity to existing industrial buildings. Last, buildings for service and shopping purposes are located in proximity to industrial buildings and in remoteness to existing multi family houses. Public interests have a minor significant influence in the location of single family houses and recreation houses.

In 1997 were the new high-speed rail way and the new high way implemented. These transportation systems improved extensively the accessibility to the Stockholm region. Here are the changes of the importance of location factors for residential single-family houses presented. In the first four years were 45 pixels affected and in the second period were 49 pixels affected by new settlements in this category. However, in table 4 it could be seen that the investment in new transportation system did not result in change of location pattern for new single family houses in favour to locations in proximity to these facilities. In the first period the elasticity value indicating a high change in probability for changes in distance to the transportation nodes. Positive in proximity to railway stations and in remoteness to

highway exits. However, the elasticities are dependent on the entire model and must hence be evaluated with respect to the characteristics of the independent variable. In the second period are the transportation nodes not significant as location factors.

SPATIAL STATISTICS: CHANGE IN URBAN FORM 1993-2000

		BETA VALUES					ELASTICITY (MEAN)					DESCRIPTIVE STATISTICS MEAN DISTANCE (KM)				
OCCURRENCE (0/1)	DEPENDENT VARIABLES (TIME)	Single family houses (93-00)	Recreation houses (93-00)	Multi family houses (93-00)	Industries (93-00)	Service (93-00)	Single family houses (93-00)	Recreation houses (93-00)	Multi family houses (93-00)	Industries (93-00)	Service (93-00)	Single family houses (93-00)	Recreation houses (93-00)	Multi family houses (93-00)	Industries (93-00)	Service (93-00)
	NUMBER OF PIXELS	92	94	4	8	8	92	94	4	8	8	92	94	4	8	8
	INDEPENDENT VARIABLES (TIME)															
DISTANCE (KM)	**Single family houses (92)**	**-4.3**	0.0	6.6	0.1	-2.6	**-3.2**					**0.2**	0.6	0.2	0.2	0.2
	Recreation houses (92)	**-1.1**	**-7.9**	2.5	1.1	-2.6	**-0.8**	**-5.8**				**0.3**	**0.1**	0.8	1.0	0.8
	Multi family houses (92)	**-0.6**	-0.2	5.2	0.4	**1.4**	**-2.3**				**5.7**	**2.7**	5.7	0.2	0.8	**1.0**
	Industries (92)	0.2	0.0	-8.8	**-30.3**	**-6.6**				**-92.8**	**-20.3**	2.1	3.5	0.3	**0.0**	**0.2**
	Service (92)	**0.5**	0.0	1.3	0.9	-1.8	**2.1**					**3.2**	5.4	0.2	1.4	0.5
	Centres	**0.3**	**0.3**	**-7.7**	0.1	-0.1	**1.4**	**1.4**	**-43.7**			**4.5**	**7.6**	**0.4**	2.4	2.8
	Public buildings	**-0.2**	**0.2**	-0.5	-1.5	-1.5	**-0.5**	**0.5**				**1.7**	**3.2**	0.3	0.9	0.5
	Rail way stations	**-0.3**	-0.1	-3.5	-0.5	-0.2	**-2.6**					**7.8**	11.4	2.2	3.7	4.3
	National road nodes	0.1	0.1	3.4	0.3	0.3						6.1	9.5	2.3	3.0	3.3
EXISTENCE (0/1)	**Waterfront preservation**	**1.0**	0.4	0.8	-8.7	-0.3	**0.3**					**0.3**	0.5	0.5	0.0	0.1
	Nature preservation	0.4	-6.8	12.1	-6.9	-3.0						0.1	0.0	0.0	0.0	0.0
	Cultural resources preservation	0.3	-0.2	2.2	0.2	0.2						0.4	0.3	0.5	0.3	0.4
	Recreation area preservation	0.6	**1.2**	-6.5	-4.9	1.3		**0.1**				0.1	**0.2**	0.0	0.0	0.1
	Planned area	**2.0**	**2.1**	12.3	-1.1	0.1	**0.1**	**0.1**				**0.6**	**0.6**	1.0	0.3	0.5
ECOLOGICAL FEATURES (KM, 0/1)	Distance to water areas	-0.1	-0.3	4.9	-0.4	0.9						0.8	0.4	0.5	0.7	1.1
	Flat or south sloping landscape	0.2	-0.3	-.08	-0.7	-0.4						0.5	0.4	0.5	0.4	0.4
	Geology: Rock	5.5	5.4	8.3	-4.9	3.1						0.2	0.3	0.3	0.0	0.1
	Geology: Esker	-1.8	6.3	-2.0	7.2	-3.5						0.0	0.1	0.0	0.3	0.0
	Geology: Sand	5.7	5.2	-2.1	-2.5	-3.0						0.0	0.1	0.0	0.0	0.0
	Geology: Moraine	6.1	5.7	-1.6	3.0	4.0						0.5	0.3	0.0	0.1	0.3
	Geology: Clay	5.3	5.5	8.4	3.5	4.2						0.3	0.3	0.5	0.5	0.6
	Geology: Other	-0.5	5.7	8.5	4.3	-3.2						0.2	0.6	0.2	0.2	0.2
	Constant	-12.3	-12.4	-28.5	-6.8	-10.8										

Table 3. The importance of the distance to existing urban elements and public interests for new urban settlements in the period 1993–2000. Significant values are bold and underscored. Descriptive statistics depicts only pixels with occurrence of the independent variable, water areas excluded.

SPATIAL STATISTICS: IMPORTANCE OF LOCATION FACTORS OF SINGLE FAMILY DWELLINGS 1993-1996, 1997-2000

	DEPENDENT VARIABLES (TIME)	BETA VALUES (β)		ELASTICITY (E) (MEAN)		DESCRIPTIVE STATISTICS MEAN DISTANCE (KM)	
OCCURRENCE IN A PIXEL (0/1)	NUMBER OF PIXELS	Single family houses (93-96)	Single family houses (97-00)	Single family houses (93-96)	Single family houses (97-00	Single family houses (93-96)	Single family houses (97-00)
	INDEPENDENT VARIABLES (TIME)	45	49	45	49	45	49
	DEPENDENT VARIABLES (TIME)						
DISTANCE (KM)	**Single family houses 92, 96**	**-4.33**	**-5.70**	**-3.2**	**-4.19**	**0.18**	**0.14**
	Recreation houses 92, 96	-0.36	**-1.89**		**-1.37**	0.42	**0.27**
	Multi family houses 92, 96	**-0.80**	**-0.38**	**-3.2**	**-1.51**	**2.73**	**2.69**
	Industries 92, 96	0.15	0.22			2.19	2.08
	Service 92, 96	**0.73**	**0.34**	**3.0**	**1.42**	**3.51**	**3.01**
	Centres	**0.40**	0.12	**2.3**		**4.59**	4.36
	Public buildings	**-0.26**	-0.13	**-0.7**		**1.58**	1.81
	Rail way stations	**-0.44**	-0.19	**-4.0**		**8.34**	7.31
	National road nodes	**0.27**	0.02	**1.9**		**6.74**	5.51
EXISTENCE (0/1)	**Waterfront preservation**	**1.45**	**0.73**	**0.4**	**0.18**	**0.38**	**0.31**
	Nature preservation	0.42	0.05			0.07	0.04
	Cultural resources preservation	**0.98**	-0.31	**0.3**		**0.58**	0.33
	Recreation area preservation	**1.14**	0.39	**0.1**		**0.11**	0.04
	Planned area	**2.05**	**1.87**	**0.1**	**0.10**	**0.53**	**0.57**
ECOLOGICAL FEATURES (KM, 0/1)	Distance to water areas	-0.25	0.24			0.70	0.88
	Flat or south sloping landscape	**0.62**	-0.14	**0.3**		**0.64**	0.47
	Geology: Rock	4.91	4.33			0.13	0.20
	Geology: Esker	-1.58	-2.24			0.00	0.00
	Geology: Sand	5.45	4.25			0.02	0.02
	Geology: Moraine	5.77	4.73			0.58	0.43
	Geology: Clay	4.70	4.27			0.27	0.35
	Geology: Other	-0.08	-0.93			0.00	0.00
	Constant	-13.94	-10.69				

Table 4. The table presents the weights of the different spatial location factors in the periods 1993–1996 and 1997–2000 for single family houses in relation to: the distance to other already existing urban elements including central points for dense built up areas as well as transportation nodes of regional character; existence of public interests; and existence of some ecological features. Significant values are bold and underscored. Descriptive statistics depicts only pixels with occurrence of the independent variable, water areas excluded.

Appraisal of the incremental location model

The logistic regression analysis of single family dwellings in 1993–2000 resulted in a probability map where each pixel were assigned a probability value between 0–0.04 (4.3 %), see figure 5. This probability pattern is here compared with the actual location pattern by map algebra.

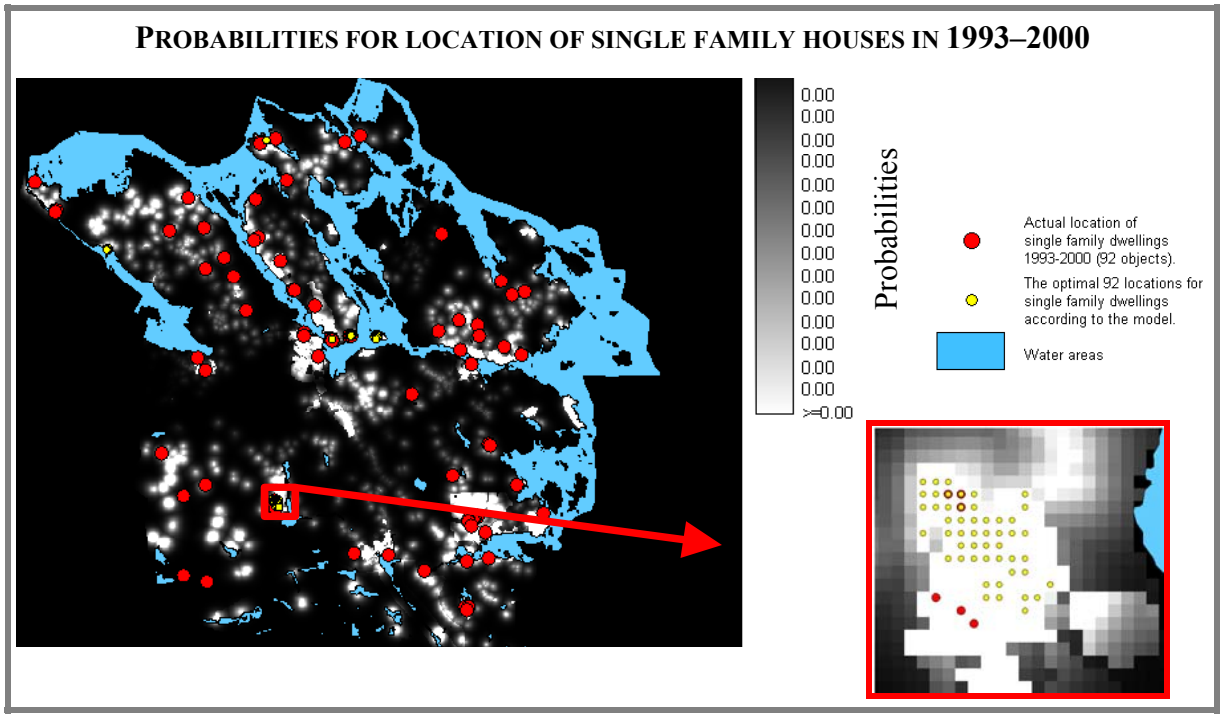

Figure 5. Probability map with the actual locations of new residential settlements during the time period 1993–2000.

By setting a new threshold for the probability to 0.02 the number of the models best choice will correspond to the number of actual single family dwellings settlements. As could be seen in table 5, the reality and the model will correspond regarding the same choices for location in 5 percent of the cases. The odds ratio for the model fit is 205. In figure 5 it is obvious that the best locations to some degree are clustered. The average probability value for the actual 92 locations is 0.5 % that could be compared with an average probability value of 2.6 % in the predicted 92 locations, see table 6.

CLASSIFICATION OF CASES			
Observed	**Fitted_0**	**Fitted_1**	**Percent Correct**
0	310767	87	99.9
0	87	5	5.4
Adjusted Odds Ratio = 205.3			

Table 5. Appraisal of model fit.

PROBABILITIES (%) OF LOCATIONS OF SINGLE FAMILY DWELLINGS				
	The entire municipality	Actual locations	Predicted locations	Corresponding locations
Number of pixels	310000	92	92	5
Minimum	0	0.0	2.2	2.2
Maximum	4	2.8	4.0	2.8
Average	0.03	0.5	2.6	2.4
Population Std Dev	0.10	0.6	0.3	0.2

Table 6. Summary statistics from the probability map based on the actual locations and the predicted locations of single family dwellings in the time period 1993–2000.

CONCLUSIONS AND FURTHER RESEARCH

In general the spatial development of urban form during the period 1993–2000 in the municipality of Strängnäs are characterized of a development of homogenous areas: new residential land use search for location in proximity to existing residential land use and in remoteness to existing commercial land use (including industries). The development for new commercial land use expresses the opposite feature. Proximity to national/ regional transportation nodes does in general not exhibit any significant positive influence on the spatial distribution of new residents and firms.

The spatial distribution of new urban settlements do not correspond to the classical microeconomic theories according to the monocentric or regional polycentric urban scheme where firms and resident locate in spatial relation to urban focal points and regional transportation facilities. For instance new singe family dwellings locate in remoteness urban utilities as work places, service and shopping and transportation nodes, even if proximity to rail way stations is significant it is certainly not important. It seems as a post industrial structure evolve, where clustering effects matters and transportation costs don't matters for the location within the municipality. The fulfilment of the political guidelines expressed in the comprehensive land use plan is intricate to assess according to the vague spatial goals. In general could the fulfilment of the objectives be questioned. The explicit spatial guide lines regarding preservation of areas of national interest have, in those cases when they are significant, actually the opposite effect, those areas are attractive for new settlements and will hence in the long run change in their spatial structure. The local political guidelines, which indicate suitable areas for urban development, have only a minor importance for the location of new single family houses and recreation houses. They do not have any statistical significance for the location of apartment houses, industries and service and shopping. The development does not correspond to the articulated goal of "proximity between residents and firms to gain a mixture of social life",[51] also here the development exhibit an opposite result. However other pronounced goals as "proximity to nature" and a "freedom of choice between a urban or rural living environment"[52] might have been fulfilled.

In summary, the spatial development does not seem to correspond to classical micro economic theories nor the local or the national political ambitions. The spatial outcome might correspond to a market oriented "post-industrial rural lifestyle" where clustering tendencies are evident for a dispersed settlement of residents and firms. A reason for this development might however be political restrictions for exploitations in proximity to the national/ regional transportation nodes, specially the unexploited areas at Läggesta in south-east.

[51] (The Municipality of Strängnäs, 1992).
[52] (The Municipality of Strängnäs, 1992).

The locations of the building units are established by the actual coordinates of the building unit and the central point in the real estate property. In 7 % of the cases the real estate property are classified for farming purposes and the coordinates from the central point are used. In those cases it might be assumed the computed location differ in a considerable degree from the reality. Further on, the real estate tax register does only contain existing building units and the year of construction. It implies that demolition of buildings or changes of use during the period 1992–2000 are not taken into consideration.

The results of the regression analysis presented in tables 2–4 include all factors. Correlation analyses of the location factors have been accomplished. Some urban elements expressed a significant correlation, for instance national road nodes and rail way stations. One of the correlated variables were then excluded, however without any noteworthy difference regarding the result of the logistic regression analysis. The selection of independent variables refer to features identified in micro economics and urban form: clusters of urban elements of the same kind, work places, dwellings, transportation facilities, ecological features and public interests. Elements that might give further explanation of the spatial development are the negative external effect of the entire transportation system, not only the accessibility function of the nodes and the positive external effect of open farming areas and forests for recreation purposes etc.

The results should bee interpreted according to the fact that less than 200 pixels of 300 000 pixels were affected during the period. Thus, even if the spatial changes are significant, should the spatial consequences and the discrepancy to micro economic theories and the spatial guidelines not be overestimated. This study covers the spatial distribution of new urban elements - not the amount of new urban elements, which might have been affected by the implementation of the new transportation systems. It could also be mentioned that the national interest might not have been affected in a negative way by this spatial development, actually the cultural life and the establishment of new urban elements could in the countryside reinforce some threatened ecosystems. These aspects is however not analysed in this investigation.

The effectiveness of land use control and public intervention, with the aim to diminish the phenomenon of urban sprawl, have been discussed and investigated by scholars like Peiser (1989), Nelson (1999) and Rietveld and Wagtendonk (2000). Peiser (1989) studied the phenomenon of urban sprawl by a regression analysis in three areas in the U.S.A. The subjects studied were changes in lot size and residential densities in relation to the distance to central business districts, beltways, “age of sub division” and “home value”. Peiser concludes that areas with policies aiming at preventing urban sprawl exhibit lower densities than other urban areas. Nelson (1999) compared three states in the U.S. A, whereas two had adopted growth regulation and one applied a laissez-fair attitude. Subjects studied were farmland conservation, accessibility via automobile, transit accessibility, energy conservation and tax burden. The conclusion was that growth management’s efforts are effective. Rietveld and Wagtendonk (2000) states that important location factors for new residential areas during the period 1985-2000 are proximity to already existing residential areas and infrastructure access points – with an emphasis of railway stations. The importance of proximity to nature conservation areas is small. A conclusion is that physical planning might have influenced housing developments. The investigation mentioned above reveals that the achievement of land use control has impact, except for Peiser (1989). The subject studied was however the restraint of urban sprawl. The results in this investigation correspond partly to the one

performed by Rietveld et al (2000). Similarities turn out regarding the proximity between new single family dwellings to already existing residential settlements and rail way stations.

The material and the methods used seem to have a considerable potential to depict urban form and changes of urban form. Hence, the spatial outcome of political efforts and other social circumstances could be estimated. Implications of this study might be that the reproduction of the monocentric urban scheme is abandoned, as transportation costs don't seem to be a decisive location factor for the intra-regional system anymore, and hence a dispersed urban structure evolves. Today, this statement may not be surprising. Future investigation could cover appraisal of the social conditions that cause this location pattern. Aspects to be investigated could be referred to in terms of rational, traditional and emotional reasons for action. Other interesting research fields could be how these changes of urban form affect urban form qualities as compactness, integration of functions and accessibility.

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