Edge Effects within Municipal Forests:

Are Municipal Policies Effective in Limiting Residential Encroachment into the edges of Suburban Wooded Parklands?

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Executive Summary

Human activity affects forest edges adjacent to residential development. Impacts occur when activities of residents alter adjacent forest ecosystems. Municipalities sometimes refer to these activities as residential encroachment. Municipal planners, forest and park managers initially protect their woodlands through land use planning; however, activities associated with adjacent land uses, such as residential encroachment, may be degrading the social and ecological values, which originally prompted the protection of the woodlot from development. Although a few municipalities have documented these encroachments within their forests, and developed and implemented policies to address them, little is known about either the activities, their causal factors, or whether municipal policies have been effective in limiting their occurrence.

The purpose of this research is to describe and evaluate the municipal policies for limiting edge-resident encroachment activities within municipal forest edges. Using a mixed method approach, the research incorporates qualitative and quantitative data collection to achieve this purpose. A content analysis review of official and secondary plans, and personal interviews with key municipal informants tested whether selected municipalities within Southern Ontario have policies to address the problem of encroachment, and determine the extent to which municipalities are implementing their policies. Key informants included development, environmental, and park planners, forest managers, bylaw officers and real estate managers within six municipalities: Cambridge, Guelph, Kitchener, Mississauga, Oakville and Waterloo. In addition, field studies, using the unobtrusive measurement of encroachment behaviour, revealed information about the encroachment activities that occurred when municipal policies were implemented within the edges of 38 selected forests within these municipalities. These studies determined the effectiveness of implementing fencing, municipal boundary markers, and no municipal boundary policies for limiting the type, frequency, intensity and extent of encroachment activities.

The content analysis and interviews indicated that, in general, municipal policies were insufficient to address the edge-resident encroachment issue. Policies sometimes had been established; however not at a sufficiently authoritative policy level. Policies were often 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. When the municipalities were successful in implementing policies to prevent edge resident encroachment within natural areas adjacent to newly developing subdivisions; they infrequently implemented their policies for preventing encroachment within natural areas adjacent to established subdivisions. Furthermore, all the municipalities were usually not implementing their policies to remediate existing encroachments within natural areas either adjacent to newly developing or established subdivisions.

The unobtrusive measurement of encroachment activities within municipal forest edges indicated that when no boundary demarcation policy was implemented, high mean frequencies and intensities of all types of encroachment occurred, in addition to high mean maximum extents of encroachment. While both municipal fencing and boundary demarcation policies led to lower mean intensities, and in the case of fencing, lower mean maximum extents of encroachment, than sites with no boundary demarcation policy, encroachment intensities and extents were still significant.

The research concludes that current municipal policies are insufficient to meet the complexity and scope of the encroachment problem. Policies to address existing encroachments relied on bylaw enforcement procedures were highly contentious, resource intensive and, therefore, infrequently implemented. Policy implementation relying on simple boundary demarcation policies does not minimize residential encroachment. Wider more complex boundary policies that include elements that reduce access, spatially separate, reduce forest encroachment, 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. Other policies are required, such as alternative adjacent land uses, buffers, surveillance, rigorous bylaw enforcement and resident education and stewardship. The reduction of encroachment by adjacent residential landowners requires an active, comprehensive set of policies, effective implementation, vigorous enforcement and monitoring.

Abstract

This research evaluated the extent of encroachment by neighbouring residential landowners into wooded parklands adjacent to their backyards. Field studies were conducted within the edges of 40 selected forests within six municipalities in Southern Ontario: Cambridge, Guelph, Kitchener, Mississauga, Oakville and Waterloo. These studies determined the effectiveness of several different types of edge treatment, such as fencing, municipal boundary marker, and no municipal boundary policies for limiting encroachment activities. In addition a content analysis review of official and secondary plans, and personal interviews with key municipal informants investigated municipal policies on encroachment.

The research found high levels of visible encroachment. 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% of their quadrats.

The unobtrusive measurement of encroachment activities within municipal forest edges indicated that when no boundary demarcation policy was implemented, high mean frequencies and intensities of all types of encroachment occurred, in addition to high mean maximum extents of encroachment. While both municipal fencing and boundary demarcation policies led to lower mean intensities, and in the case of fencing, lower mean maximum extents of encroachment, than sites with no boundary demarcation policy, encroachment intensities and extents were still significant.

In general, municipal policies were insufficient to address the edge-resident encroachment issue. When policies were in place, they were often not at a sufficiently authoritative policy level. Policies were often 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. When the municipalities were successful in implementing policies to prevent edge resident encroachment within natural areas adjacent to newly developing subdivisions; they infrequently implemented their policies for preventing encroachment within natural areas adjacent to established subdivisions.

The research concludes that current municipal policies are insufficient to meet the complexity and scope of the encroachment problem. Policy implementation that relies on simple boundary demarcation policies do not eliminate, or minimize residential encroachment. More complex boundary policies that include elements that reduce access, spatially separate, reduce forest encroachment, 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. Other policies are required, such as alternative adjacent land uses, buffers, surveillance, rigorous bylaw enforcement and resident education and stewardship. More rigorous enforcement of policy is necessary to reduce encroachment. The reduction of encroachment by adjacent residential landowners requires an active, comprehensive set of policies, effective implementation, vigorous enforcement and monitoring.

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1. Introduction

Historically, developers constructed housing within all types of environments, including forest fragments. Over time, in Ontario provincial, regional and municipal governments began to regulate the development process through land use planning to preserve forested natural areas and to protect them from the negative impacts of development. While substantial progress has been made in the protection of municipal natural areas and systems, impacts that follow housing development have the potential to degrade their social and ecological values.

The biophysical effects of human-dominated land uses on adjacent natural areas are referred to as "human-generated edge effects"(Matlack & Litvaitis, 1999). These include the alteration of forest chemical regimes due to urban storm water runoff (Davis, Weaver, Parks, & Lydy, 2003; Morley & Karr, 2002; Ontario Ministry of Natural Resources, 1987), and the alteration of vegetative communities due to "human activity effects" (Florgard, 2000; Littlemore & Barker, 2003; Matlack, 1993).

Human-generated edge effects are of particular concern where housing is placed adjacent to sensitive natural areas with relatively high native species diversity (Groom et al., 1999). Residents engage in activities within the forest, such as recreation, home and yard-related activities (Matlack, 1993). Studies demonstrate the degrading effects of these activities on forest vegetative communities, wildlife habitats, and on soil regimes in urbanizing landscapes (Florgard, 2000; Littlemore et al., 2003; Briffet, 2002). Others demonstrate negative effects on drainage and chemical regimes (Cox, Hendrickson, Skelton, & Suffling, 1996; Davis et al., 2003). Some human activities, such as residential garden extensions, can work to reduce the area of the forest or its area of interior habitat for both wildlife and human use. In certain instances, this could precipitate the extirpation of area sensitive species, such as some neotropical forest migratory bird species (Cox et al., 1996; Whitcomb et al., 1981).

Some municipalities demonstrate concern about unauthorized human activities and their effects within municipal forests, commonly referred to as "encroachment." These activities erode the recreational and aesthetic values of the forest. There are public safety issues should a resident or a resident's property be damaged due to such activities. For example, if a resident removes the vegetation on a steep forest slope adjacent to their property, the slope could collapse onto a passing resident or onto an adjacent resident's property. Municipalities may be liable for the damages (S. Turner, Director of Bylaw Enforcement, City of Kitchener; personal communication, October 5, 2005). However, few municipalities may have, or wish to devote, the resources to remove the encroachment, and restore the forest edge.

Municipalities are particularly interested in those human activity effects that arrive with those who reside immediately adjacent to the forest border. Visual evidence of the activities of this group of residents has led many municipalities to believe that this sector is responsible for a large proportion of the undesirable human activities that occur within public forests. The number and type of the more serious

encroachment activities of adjacent residents are included in some reports (D. Schmitt, Urban forest technologist, City of Kitchener, personal communication, September 7, 2005; T. Fleischmann, Manager of Forestry, City of Mississauga, personal communication, August 30, 2005).

Municipalities have developed many policies to protect municipal forest ecosystems for the long term, including policies to limit edge resident encroachment activities. However, little is known of the characteristics of these activities, or their significance in the long-term protection of municipal forest ecosystems. In addition, studies are lacking that describe municipal protection policies and evaluate their effectiveness for limiting undesirable edge-resident encroachment activities.

This research answers four research questions to determine whether municipal policies are effective in limiting edge-resident encroachment activities within suburban woodlands:

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?

To answer these four questions, three research objectives were achieved:

1) 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.

2) 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 by:

    2.1 determining if edge resident encroachment is occurring,
    2.2 identifying the types of residential encroachment activities,
    2.3 calculating the relative frequency and intensity of encroachment activities; and
    2.4 measuring the maximum distance of encroachment from the forest border

3) 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.

Four sections organize this report. Section 2 describes the research methods, outlining the protocols for each. Section 3 provides the results of the three research methods. Section 3.1 describes the policies contained within official and secondary plans aimed to protect natural areas and systems from encroachment. Section 3.2 deals with municipal residential encroachment policies, their implementation

and barriers to implementation as described by key informants within the municipalities. Section 3.3 outlines and discusses the results of the transect and quadrat sampling of the residential encroachment activities within the study areas. It focuses on the types, frequency, intensity and extent of residential encroachment activities under different municipal policies. Section 4 evaluates the municipal policies for limiting residential encroachment activities, through a consideration of the literature, the content analysis, the municipal interviews, and the transect and quadrat sampling of residential encroachment activities under the different implemented policies.

2. Methods

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, we 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 and three 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 two. 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 three. This research employs a mixed-method design, both qualitative and quantitative data collection, to achieve these objectives. A mixed-method approach provides a better understanding of the edge-resident encroachment issue.

Qualitative methods allow for a deeper, richer understanding of a phenomenon, particularly when little is known about it (Creswell, 2003). These methods were employed to identify encroachment goals, strategies, policies, their level of implementation and barriers to implementation within six Ontario municipalities: Cambridge, Guelph, Kitchener, Mississauga, Oakville and Waterloo. Interviews with 26 key municipal informants, approximately 70 minutes in length, provided an in depth view of staff

perceptions of encroachment activities, policies, and their implementation. People from six main groups within the municipalities were interviewed: 1) development planners, 2) environmental planners, 3) park planners, 4) forest and park managers, 5) bylaw enforcement managers, and 6) municipal real estate managers. The data was analyzed for themes and sub-themes of related information.

A content analysis of official and secondary plans complemented this method by ensuring the review of the most authoritative municipal policies. The official plans of all six municipalities were reviewed, in addition to three secondary plans within Cambridge, Waterloo and Kitchener. Natural heritage protection policies within these documents were analyzed according to the extent to which they met regional and provincial natural heritage policies. All of the analyzed 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 2.1 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 2.1: 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)

Quantitative methods were more appropriate for investigating the evidence of edge-resident encroachment activities within forest edges under different policies within the above six municipalities. 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 2.2 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 Tables 2.4 and 2.5 for summaries of the number of study sites by policy, boundary type and municipality.

Table 2.2 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

The unobtrusive measurement of encroachment activity traces was used as the methodology to: 1) identify the types of residential encroachment activities, 2) determine the relative frequency and intensity of encroachment activities, and 3) to determine the maximum distance of encroachment activities from the residential border.

This method was employed within two quantitative studies. An intensive study recorded the frequency and intensity of encroachment within each study site. A 'study site' was defined as the total study area within the forest edge behind one residence. Within the intensive study, each study area was 20.5 metres deep, but its width varied according to the width of the yard of the residence. A total of 55 samples were measured within each intensive study site. The samples were recorded along transects using quadrat sampling at intervals. The type and percentage cover of forest floor traces (evidence of encroachment activities and natural forest floor components) were recorded within eleven 1/2 metre squared quadrats along each of five transects running parallel to the residential boundary into the forest edge. An illustration of the sampling design is provided in Figure 2.1.

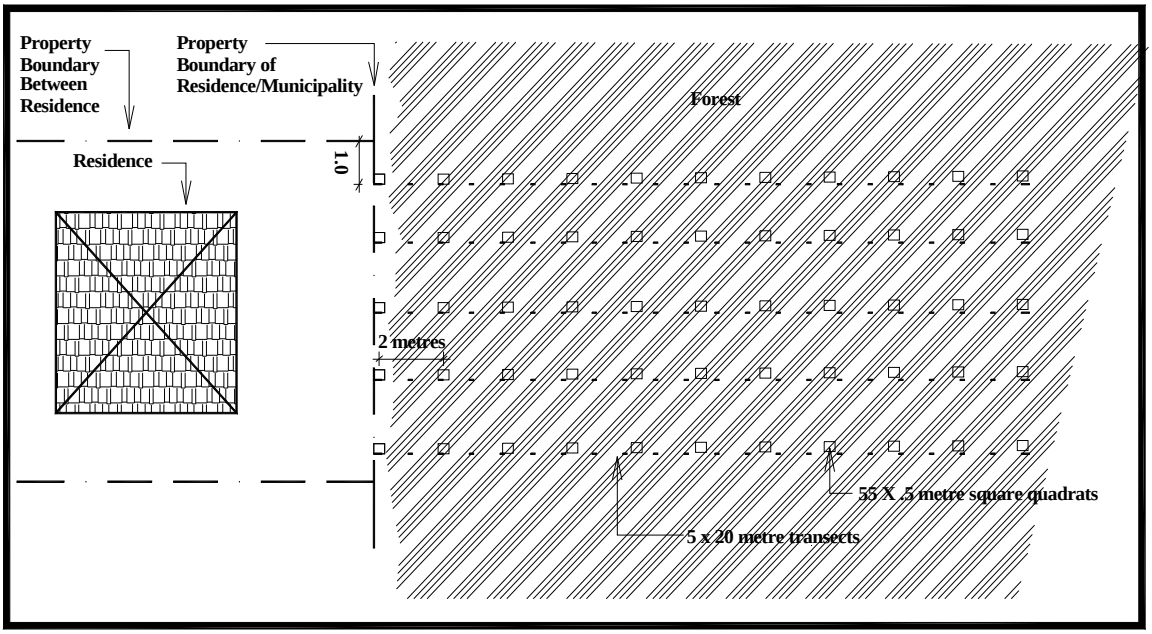

Figure 2.1 Intensive Sampling Method

The percentage covers of forest floor traces within the quadrats were recorded according to the Braun-Blanquet cover scale (Braun-Blanquet, 1932). For each forest floor trace, the scale assigns a number from zero (forest floor component is not present) to six (forest floor component covers 75 - 100% of the quadrat). An illustration of the Braun-Blanquet cover scale is provided in Figure 2.2.

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

Figure 2.2 Braun-Blanquet (1932) Cover Scale

The extensive study measured the furthest extent of encroachment activities by locating the encroachment component located furthest from the residential boundary and measuring its distance to this boundary using a measuring tape.

While an attempt was made to sample a large and equal number of study sites for each policy and boundary type within each municipality, it was found in the field that some policies and boundary types were more common than others. 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. Tables 2.3 and 2.4 provide summaries of the number of extensively and intensively-sampled study sites, forests, samples and transects per policy or boundary type, respectively.

Table 2.3 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)
Boundary Post	0	0	1 (1)	0	0	16 (4)	17 (5)
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 2.4 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 not in brackets is the number of study sites sampled. The number in brackets is the number of forests in which the study sites were sampled.
[2] The number not in brackets is the total number of samples taken in the study sites. The number in brackets is the number of transects sampled.

Encroachment trace types were categorized by an 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 is 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 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 & Marion, 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. This is important since it cannot be assumed that the samples are independent, which is an assumption of for all these statistical tests. 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.

3. Results

3.1 Municipal Official and Secondary Plan Policies on Encroachment

The content analysis found that the study municipalities do not recognize residential encroachment, or post development impacts in general, as significant problems at the official and secondary plan policy levels. Few official plans have goals dealing with protecting natural areas from residential encroachment activities, or from any of the impacts that follow development; and none of the municipalities had objectives that could serve as measurable indicators that they had achieved their goals. None of the municipalities had specific policies for either reducing the incidence of encroachment activities, or for resolving them after they had occurred. Although municipalities rarely mentioned the actual residential impacts of concern, some indicated that they would develop policies to protect their more sensitive natural areas from adjacent land use impacts. This indicates that there is an awareness of the natural area degradation resulting from adjacent land use activities; however, this has not yet translated into identifying the source of the degradation and establishing a course of action to address it. Municipal policy options focused 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 within 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 did 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 as relatively independent ecosystems. 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, reflect this assumption. Although an increasing number of studies indicate that the features and functions of urban natural areas become degraded following development, there is a general lack of monitoring by municipalities to assess the negative impacts of adjacent land use change and to evaluate protective policies.

Also the planning 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, & 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 an EIS (Environmental Impact Study) by a developer, at the watershed and subwatershed scales, through the preparation of plans by municipalities. Oakville was 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 are taking 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 municipalities more control over municipal planning by providing them with the knowledge, supported by evidence, to proactively plan an area and ensure that ecological systems are supported and protected. 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 monitoring is not being conducted. At the same time, a reliance on watershed/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 is 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 during 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 toward more intensive land uses and 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.

3.2 Municipal Policies for Limiting Encroachment

The interviews indicate that all interviewees and their municipalities were aware of the problem of residential encroachment into woodlands. Employees within environmental and parks planning, forestry, and parks operations were particularly concerned. They were concerned that encroachment activities will displace forest vegetation, reduce forest area and contribute to the spread of undesirable invasive exotic species. Some of these staff, in addition to bylaw officers, real estate managers, were also concerned about public safety issues and increased municipal liability. These latter groups were particularly concerned about the loss of parkland through successful resident adverse possession claims. These municipalities have now developed most of their land, and the vast majority of their natural areas already have established adjacent subdivisions. However, interviewees indicated that their policy tools to both prevent and resolve encroachments were only developed, refined, and formalized, in the last ten 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, the results indicated that they did not consider it significant relative to development and recreation impacts, or other planning and management issues. They are uncertain whether its effects are ecologically and socially significant, or whether one type of encroachment is significant relative to another. Although they see the direct impacts of edge resident encroachment within their forest edges, many were aware of the indirect impacts of the wider residential community encroachment on the forest, but feel they do not have the tools or the resources to address them.

This study and the content analysis clearly indicated that municipalities primarily protect natural areas through land use planning policies prior to development, rather than forest management policies post development. A majority of interviewees indicated that preventing and remediating encroachment activities post development is extremely difficult and resource intensive. In addition, this study indicated that encroachment behaviour is influenced by planning policies developed to protect forest edges from construction-related encroachment. These results clearly point to the importance of planning in the protection of natural areas post development, yet many of the development planners interviewed admitted

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 and construction because 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.

The lack of attention to the post development protection of natural areas is also evident in forest management. Many of the forest managers and ecologists interviewed indicated that the lack of active management within their natural areas have left many degraded. They indicated that within many municipalities 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 were restricted to maintaining recreational facilities and responding to the hazard-related concerns of residents. Proactive management occurred infrequently. Many of the forestry and park operations interviewees indicated that they were concerned about the effects of this lack of management on forest health. They argued that because they did not manage them properly, their current forest health issues were more significant than they would have been had they been managed. Interviewees indicated that this lack of management was not due to neglect, but to a widely held view that active forest management was unhealthy for these ecosystems - that they were better off being left to develop '"naturally." Forest managers and ecologists commented that this attitude was evident among residents living adjacent to forests who frequently objected when they had to remove or trim trees, particularly along the residential edge. Some said that it impeded their efforts to manage these forests properly and that they often avoided managing this edge as intensively to avoid conflicts with residents. They suggested that many, including planners, felt that they were protecting natural areas for the long term solely by preventing them from being developed into housing, and limiting construction impacts.

In light of this, they pointed out that encroachment impacts were just one of many of their concerns. They suggested that the significance of these activities needed to be assessed relative to the social and ecological values of the natural area and the goals of their communities. However, while the forest managers and ecologists within some of the municipalities indicated that 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 the staff necessary to conduct these plans.

Interviewees indicated that none of their municipalities, and few departments or individuals, had goals, objectives or strategies for addressing residential encroachment on adjacent forested parklands. While a majority indicated that the implicit municipal goal within their encroachment policies, or bylaws, was to eliminate encroachment activities, many stated that 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. Alternative strategies, introduced by recreation ecologists, to regulate recreation impacts in the larger remote natural areas, that include altering the way encroachment occurs, or when and where, at different spatial or temporal scales, were not considered by many interviewees. Most argued that following such strategies might indicate to residents that municipalities permit residential encroachment activities, and serve to encourage these activities among residents. Nevertheless, there were those who claimed that they consciously sought to address encroachment by controlling where it occurred through the implementation of buffers between the natural area and the residential edge. In addition, interviewees in Waterloo indicated that they implement a "Partners in Parks" program that, in effect, regulates how encroachment occurs by allowing residents to perform activities, such as gardening, within parks. However, most of these activities involve the establishment and maintenance of planting beds within park edges and entryways rather than the management of naturalized park areas. In addition, the Partners in Parks program was not developed to address encroachment with natural areas, but to beautify municipal parks. Nevertheless, this program points, again, to the importance of establishing encroachment goals, objectives and strategies in response to forest values and goals. Some types of encroachment, or interaction, within forests may be desirable, but forest managers and ecologists indicate that these types and levels of encroachment need to be established through the establishment of forest goals established in concert with surrounding communities.

The interview results indicated that the study municipalities have developed many policies to both prevent and resolve residential encroachment, largely within the last ten years. However, they have not been combined into an integrated approach to address 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 have focused their policies on establishing both physical and regulatory filters to protect forest edges from edge resident encroachment activities post development, at the scale of the forest/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 these elements can be spatially integrated to provide multiple filters to residential encroachment activities at the scale of the forest/residential border. Yet, the results indicate that these elements are being

established as separate boundary treatments. For example, in terms of edge encroachment boundary policies, boundary demarcation treatments are not being consciously developed in concert with buffers to address encroachment. In addition, forest managers and ecologists indicate that, in general, boundary treatments and regulatory policies are not being developed strategically, according to natural area values and goals, but comprehensively, to address encroachment within all natural areas.

The establishment of buffers adjacent to sensitive natural areas provide additional protection but, again, they are not being established to address residential encroachment. Figure 3.1 illustrates an example of a post development integrated boundary treatments within Waterloo for natural areas with cold-water streams. The treatment includes boundary demarcation and buffer policies to address residential encroachment, as well as grass strips and paths to meet recreation-related policy objectives.

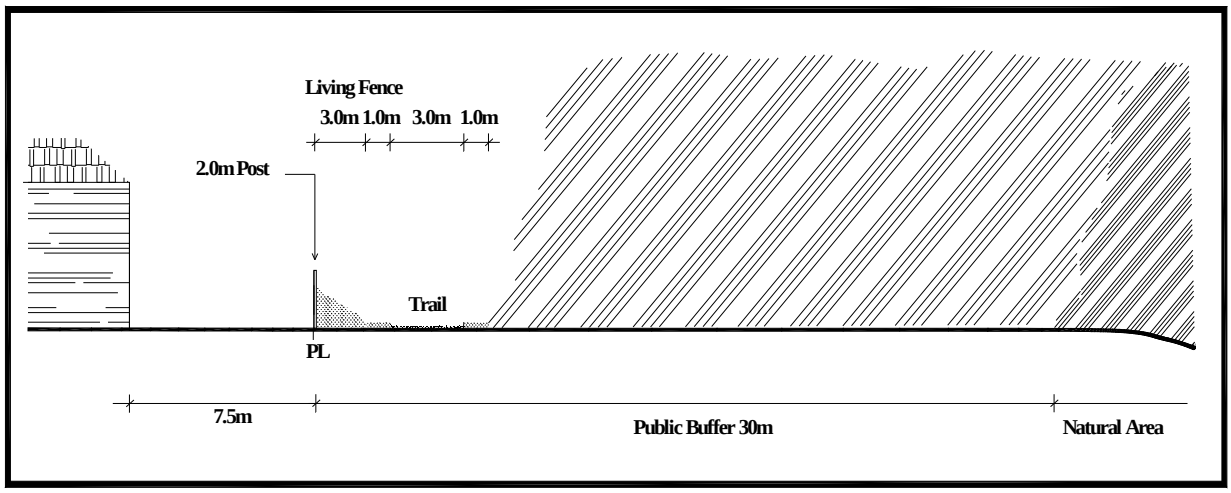

Figure 3.1 City of Waterloo integrated boundary treatment between new subdivisions and cold-water stream corridors

Boundary theory also indicates that filters function through time to protect adjacent land use values. Planning interviewees indicated that residential encroachment could be influenced by the impacts of development, such as construction encroachment, during subdivision development. They indicated that planners establish 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.

In terms of implementation, the results of this study indicated that preventative policies, such as physical boundary filters and resident education, were infrequently implemented in natural areas adjacent to established subdivisions. Interviewees indicated that a principal barrier to implementation was resident

resistance to new boundary demarcation treatments, particularly fences. In addition, they indicated that staff and council commitment to implementing these policies was insufficient, particularly in the face of resident opposition and competing forest management priorities. In addition, interviewees indicated that policies to resolve encroachment were also not being frequently implemented, but only in response to resident complaints. In most of the municipalities, the tools to enforce their resolution policies were in place, new policies had been developed, and bylaws updated, largely in the last five years. However, interviewees indicated that they lacked the resources, and in some cases the staff and council commitment, to implement these policies more frequently. Many interviewees indicated that they suspected that only a small proportion of the existing encroachments had been resolved through the implementation of these policies. In addition, many commented that indirect forms of encroachment, such as the flow of resident wastewater or herbicides and pesticides into the forest edge could not be addressed through the enforcement of their encroachment policies.

These results indicate the complexity of the encroachment issue, and the scale of the problem within most of these municipalities that have developed subdivisions adjacent to natural areas over the last 50 to 60 years without the policies in place to limit encroachment activities. They suggest that residential encroachment is a community-wide problem that cannot be solved merely through the implementation of municipal policies, and that community involvement is necessary. Spreading awareness and educating residents regarding this issue are important toward this end, yet interviewees indicated that resident education and stewardship policies were informal (consisting largely of departmental procedures or practices) and haphazardly established and implemented. Although many commented that resident education was important to long-term solutions to the encroachment issue, they were uncertain how to go about establishing and implementing these programs.

3.3 Edge Resident Encroachment Activities within Municipal Forests

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 (Figure 3.2).

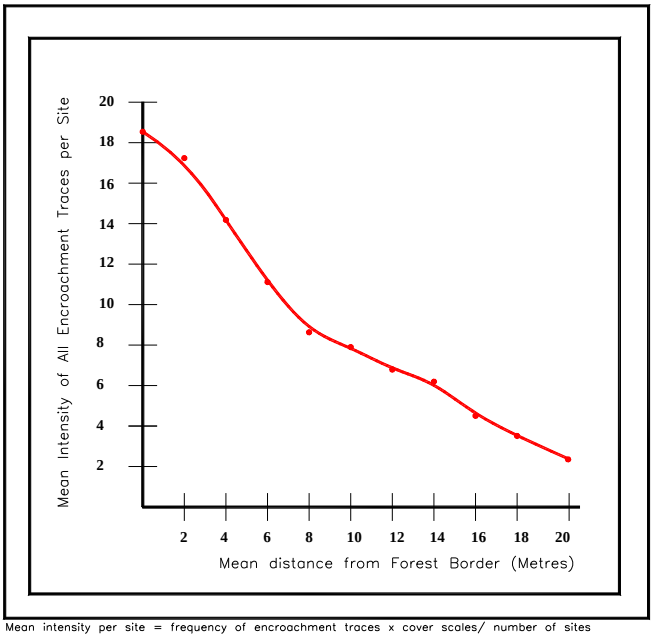

Figure 3.2 Mean intensity of encroachment with respect to distance from the forest border

Encroachment traces 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 (Figure 3.2)

These results support 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 towards the forest edge (Kolomogorov-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% 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 & Humphries, 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.

4. Evaluation

4.1 Are municipal policies sufficient?

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.

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.

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.

4.2 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.

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 encroachment. As a result, current boundary demarcation policies to address post development impacts are simplistic and 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.

5. Conclusions

The purpose of this research was to describe and then 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 4.1 summarizes this evaluation.

Table 4.1 Summary of evaluation of municipal edge resident encroachment policies

Steps	Methods	Key Results
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 1)	• 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 2)	• 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 (such as fences, grass strips, paths) 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 effective in limiting edge-resident encroachment activities	Integrate results of literature review, content analysis, social surveys, and unobtrusive measurement of encroachment traces (Objective 3)	• Current policies are 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 do not eliminate encroachment, or minimize it relative to other boundary types.

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