NATURAL HERITAGE SYSTEM DEFINITION & IMPLEMENTATION

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Provided By:
North-South Environmental Inc.
35 Crawford Crescent, Suite U5
P.O. Box 518, Campbellville, ON
L0P 1B0

North-South Environmental Inc.
Specialists in Sustainable Landscape Planning

Phase 3
Sustainable Halton Report 3.02

Halton Region
Prepared for Halton Region

Natural Heritage System Definition & Implementation
Sustainable Halton Report 3.02

Study Team

North-South Environmental Inc.
Mirek Sharp
Brent Tegler
Sarah Piett
Sarah Mainguy
Richard Czok

Region of Halton
Carolyn DeLoyde
Sarah Cannon
Ho Wong
Perry Vagnini
Anita Fabac
Anthony Campese
Chris Eden
Gianvito Monaco

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1.0 INTRODUCTION

Sustainable Halton is a project being undertaken by the Region of Halton to identify new urban areas and employment lands to accommodate the growth targets to 2031 as set out in the provincial Places to Grow Plan. A sustainable approach to accommodating growth is based on achieving a balance among environmental, social and economic issues. The Sustainable Halton Natural Heritage System (NHS) is intended to address environmental issues in a balanced manner using the best available science to achieve long term or "sustainable" environmental protection of natural heritage features and functions. The identification of the Sustainable Halton NHS is intended to provide direction for future urban and employment land uses and to provide certainty in the protection of the rich native biodiversity that exists within rural areas. Urban and employment land uses are more intensive than rural land uses and the associated environmental impacts on plants and animals are more severe where these new lands uses are proposed.

In Phase I of the Sustainable Halton project (then referred to as Durable Halton) a technical report was prepared describing, "Options for a Natural Heritage System in Halton" (North-South Environmental Inc. 2007; hereafter referred to as the "Options Report"). The Options report provided the following information:

- a rationale for a Natural Heritage System approach;
- described the key components of an NHS;
- provided a set of guiding principles for developing an NHS in Halton Region; and
- provided three options for a conceptual NHS for the Sustainable Halton project.

The purpose of the Options Report was to provide conceptual level NHS options that could be considered in a discussion and analysis of growth concepts which identified land for future development. Working at a conceptual level, the NHS Options Report did not develop precise boundaries for the three NHS options nor did it show the exact locations for ecological linkages. As the Sustainable Halton project progressed NHS Option 3: "Enhanced Ecological Integrity" was selected as the preferred NHS option for use in the development of Growth Concepts.

In Phase II of the Sustainable Halton project NHS Option 3, is referred to as the Sustainable Halton NHS and as a part of Phase II North-South Environmental has undertaken further development and refinement of the initial NHS OPTION 3 concept. As pointed out in the Options Report the conceptual NHS required further evaluation of alternatives, refinements and input from planners and the public. Using the Sustainable Halton NHS in Phase II the Growth Concepts have been reviewed through consultation with staff from the Region of Halton, Oakville, Burlington, Milton, Halton Hills, Niagara Escarpment Commission, Ministry of Natural Resources, Conservation Halton, the Hamilton Royal Botanical Garden and the general public. These reviews have provided important input to ongoing refinement of the NHS.

This report is a technical document presenting the results of work undertaken in Phase II of the Sustainable Halton project. The Phase II NHS report is intended to provide an understanding of how the Sustainable Halton NHS has been developed and to provide a framework to guide implementation of the NHS in the future. The implementation framework acknowledges that additional studies will be completed as part of future developments in Halton Region, such as Sub-watershed Studies or Secondary Plan studies. These more detailed studies will identify

precise or final boundaries of the NHS through field verification of natural features and analysis of ecological functions, including ecological linkage.

2.0 SUSTAINABLE HALTON NHS COMPONENTS

2.1 General Description of Sustainable Halton NHS

The Sustainable Halton NHS is a long range environmental planning effort intended to protect the habitat necessary to sustain native plants and animals over the long term. The NHS is of particular importance in the context of anticipated ongoing urban development in the Region, particularly within the Primary Study Area[1]. The Sustainable Halton NHS includes some areas of active agriculture in order to achieve the ecological goal and criteria as outlined below. It should be noted that the NHS is not intended to restrict agricultural practices or the development of agricultural infrastructure where it is required to maintain a sustainable and healthy rural agricultural community.

The Sustainable Halton NHS is based on the conceptual NHS Option 3 "Enhanced Ecological Integrity" developed in the Phase I study and achieves Halton's Planning Vision which states:

> *To maintain Halton as a desirable and identifiable place for this and future generations, certain landforms within Halton must be preserved permanently*." (R.O.P. Section 26)

The Sustainable Halton NHS forms an important part of the Regional Structure of Halton which is defined in the Official Plan as *The Urban System*, *The Rural System* and *The Greenlands System*. Following a "systems approach"[2], the Sustainable Halton NHS forms the Greenlands System which has the following goal:

> *The goal of the Greenlands System is to maintain as a permanent landform an interconnected system of natural areas and open space that will preserve areas of significant ecological value while providing, where appropriate, some opportunities for recreation (R.O.P. Section 114)*

The Sustainable Halton NHS will replace the Greenlands System currently in the Regional Official Plan by implementing the system approach as defined under R.O.P. Section 115. A systems approach reflects current science and is considered a more sustainable.

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[1]The Primary Study Area (PSA) is the study area for Sustainable Halton and includes the areas outside of existing urban boundaries and outside the area included in the Greenbelt Plan. It thus represents the area in which future urban expansion could occur. In Phase II the PSA has continued to be an area of greater focus for development of the NHS, however, NHS refinements have been made throughout Halton Region.

[2] *systems approach* considers the importance of maintaining and protecting ***ecological features*** in the environment such as woodlands, wetlands, and watercourses, *etc*., ***ecological functions*** of the environment such as water storage and water quality enhancement by wetlands, winter deer yards provided by dense cedar woodlands, amphibian breeding habitat in ephemeral forest ponds, *etc*. and ***ecological interactions*** that occur over varying scales of time and space such as animal predation and herbivory, the daily, seasonal and long term movement patterns of plants and animals, and the role of ecological disturbance mechanisms such as fire, wind, water, and disease, *etc*.

The Goal of Sustainable Halton NHS is:

> *To provide a high degree of confidence that the biological diversity and ecological function of the Region of Halton will be preserved and enhanced for future generations, through the creation of a Natural Heritage System consisting of substantial core areas connected by multiple linkages that enhance long-term ecological integrity.*

2.2 Step by Step Process for the Development of the Sustainable Halton NHS

The Sustainable Halton NHS is intended to reduce the risk of species loss and provide confidence that Halton's natural heritage can be sustained in the long term. The NHS is developed based on an understanding of the existing landscape matrix within Halton Region (Appendix 1) and Conservation Biology principles and research (Appendix 2) which provides guidance to the identification of NHS cores and corridors. The NHS for Halton provides:

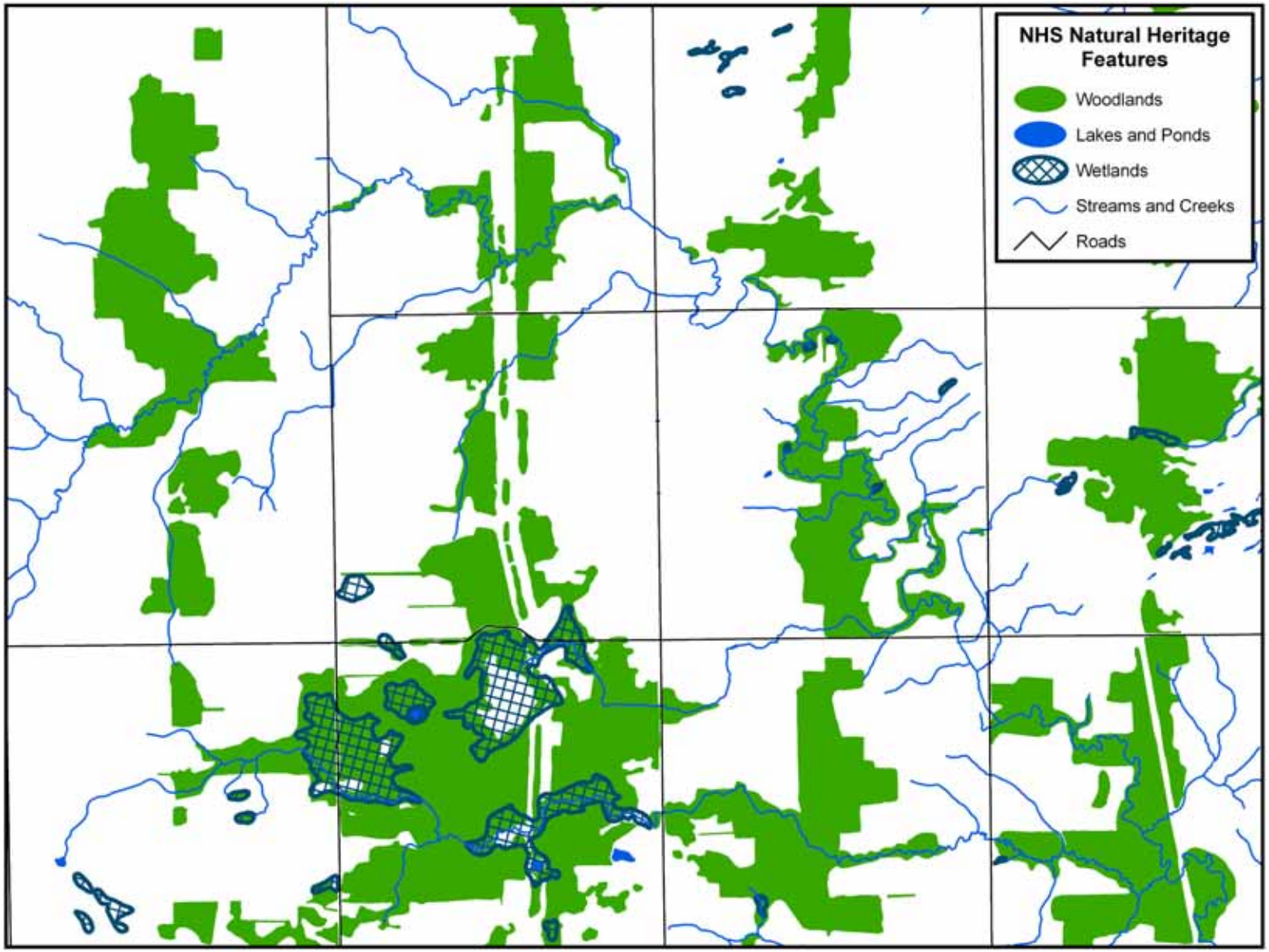
1) resilience through representation of multiple core areas with core area enhancements;
2) representation of very large core areas to protect centres for biodiversity within the main landscapes of Halton Region; and
3) functional ecological linkages among natural features, including multiple regional and local linkages and the identification of the need for wildlife crossings where major transportation corridors cross the NHS.

A step by step process is described below that summarizes the development of the Sustainable Halton NHS. Completing each step is an iterative process that may be influenced by the addition of new natural heritage information or by the review and commenting process that occurs as planners develop growth concepts and as public consultation meetings are held. The iterative process results in steps being repeated and this in turn leads to a refinement of the NHS. A series of conceptual maps that illustrate the development of a NHS have been prepared to illustrate each step. The actual data used in the development of the Sustainable Halton NHS is outlined in Appendix 3.

Step 1. Identify Natural Heritage Features - The natural heritage features remaining in the landscape to be mapped may include the following (Figure 1):

- areas of woodland;
- all wetlands;
- areas of meadowlands and thickets;
- known locations of significant species; and
- watercourses and water bodies

Figure 1: Conceptual Map of NHS Development – Step 1. Identify Natural Heritage Features



Step 2. Identify Core Areas, Centres for Biodiversity and Enhancement Areas – Within Halton Region natural heritage features consisting of woodlands, wetlands, watercourses and water bodies are present as fragmented patches embedded within a matrix that may be described as urban lands (residential, employment, and high density transportation) or rural lands (agriculture, rural estate, low density transportation). These natural heritage features constitute the building blocks that are protected within the NHS as Core Areas and Centres for Biodiversity together with associated Enhancement Areas that support important ecological features and functions (see Figure 3).

Core Areas may be identified as individual natural heritage features (e.g. woodlands, meadowlands or wetlands) or they may be identified collectively where two or more natural heritage features are in close proximity to one another.

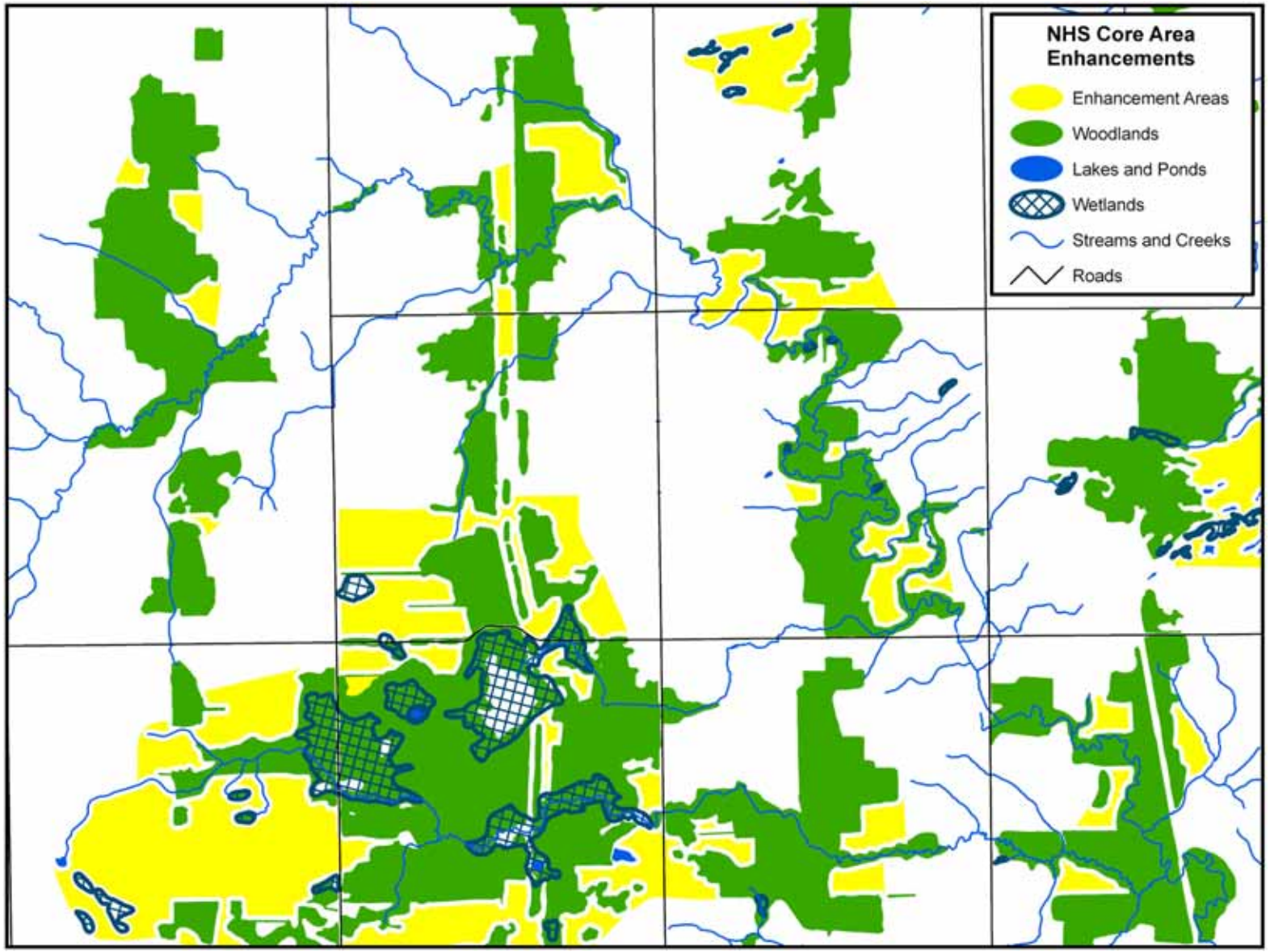
Enhancement Areas include lands that may be without obvious natural heritage features and include areas such as agricultural land, cultural meadow, and cultural thicket, *etc*. Enhancement areas contribute to the NHS by protecting and restoring critical ecological functions such as, ecological connectivity among natural area patches, surface water catchment areas for wetlands, minimum core area thresholds and improved core area shape that reduce edge effect and enlarge interior habitat.

Centres for Biodiversity are sensitive landscapes where there is a concentration of natural heritage features that collectively represent significant ecological features and functions capable of supporting native biodiversity over the long term.

The size thresholds used to guide the development of the Sustainable Halton NHS considered the following minimum core areas defined by Environment Canada (2004):

- ***Core Area Woodlands***: 20 ha
- ***Core Area Wetlands***: 10 ha for marsh/thicket and 20 ha for treed swamp
- ***Core Area Open Habitat***: 15 ha
- ***Centres for Biodiversity***: 200 ha

Figure 2: Conceptual Map of NHS Development – Step 2. Identify Core Areas, Centres for Biodiversity and Enhancement Areas



Step 3. Identify Ecological Linkages and Buffers – The identification of ecological linkages and buffers provides long term protection of the NHS from surrounding land use changes that may otherwise adversely impact ecological functions related to the movement of plants and animals within the environment or impact ecological features that make up the NHS (see Figure 3).

Ecological linkages are considered at two scales in the environment:
Regional linkage corridors ensure continuous linkage across the landscape, and as such they are wider in order to facilitate the long term movement of all plant and animals, in the very long term. The width of regional linkages is consistent with the linkages in the Greenbelt NHS.
Local linkage corridors connect isolated natural heritage features to the larger NHS. While they are narrower they are intended to accommodate the short and long term movement requirements of plant and animals over shorter distances.

Linkage corridors in the Sustainable Halton NHS meet the following guidelines:

- ***Regional Linkage***: 300 to 400 m width
- ***Local Linkage***: 60 to 100 m width

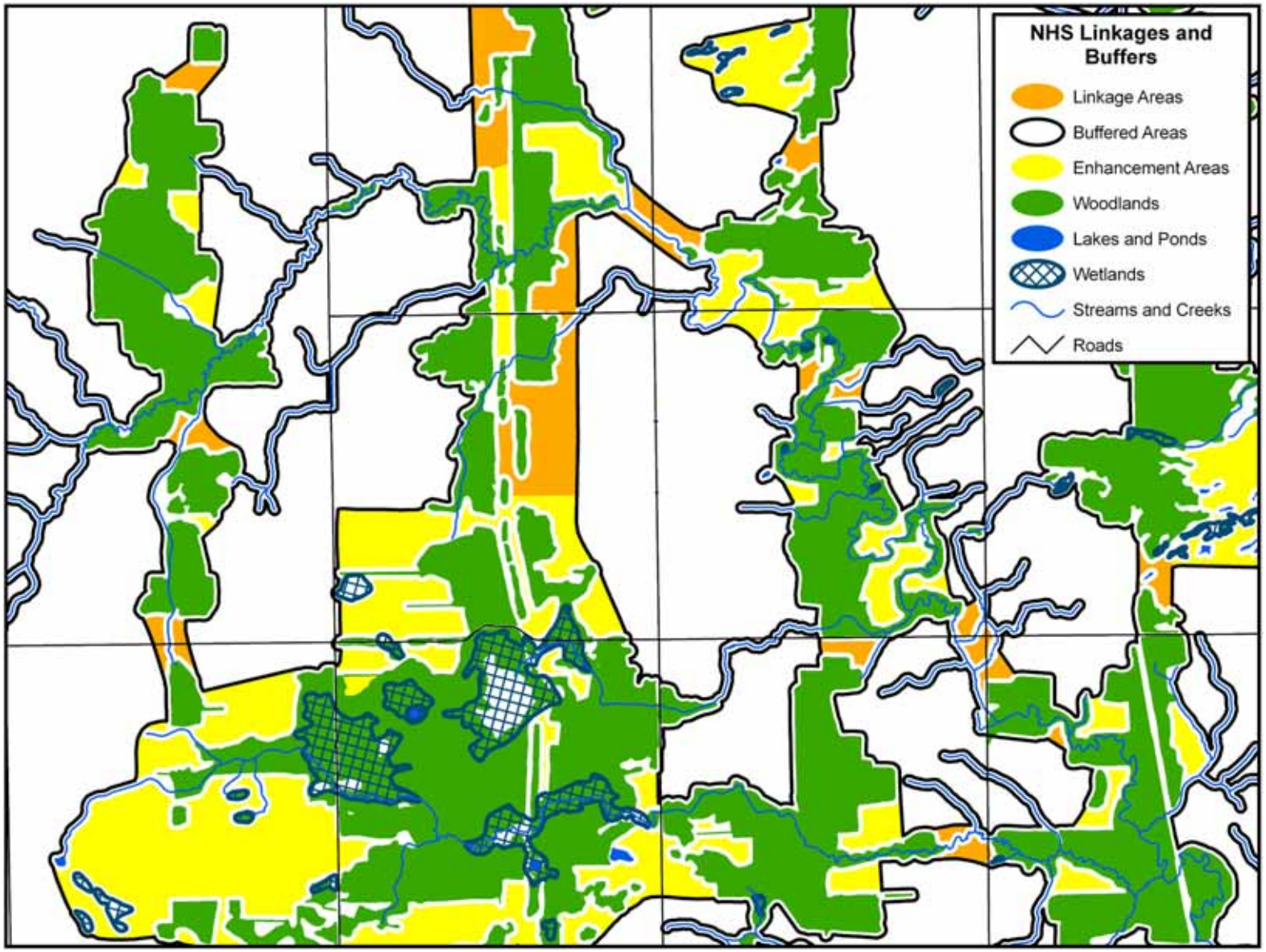
The Sustainable Halton NHS includes the following minimum buffers intended to protect natural heritage features as follows:

- ***Woodland Buffer***: 30 metres
- ***Wetland Buffer***: 30 metres

The Sustainable Halton NHS also includes buffers along watercourses based on the following criteria:

- all water watercourses located within the Regulatory Floodline have a 30 metre buffer on both sides
- watercourses located outside the Regulatory Floodline that are determined to provide an important ecological linkage function have a 30 metre buffer on both sides

Figure 3. Conceptual Map of NHS Development Step 3. Identify Ecological Linkages and Buffers



Step 4. **The Sustainable Halton NHS** – The step by step process discussed above identifies a NHS based on a "systems approach" that protects natural heritage features, ecological functions and the interactions which occur at local and regional geographic scales and over short and long term time frames (see Figure 4).

Within an urban system, the permitted land uses within the NHS are restricted to passive recreation that does not impact the NHS. Within a rural system passive recreation and as well as agricultural land uses are permitted provided they do not adversely impact the natural heritage features and functions of the NHS. In both urban and rural areas transportation and utilities infrastructure should only be permitted within the NHS where no other alternatives are available.

The key components that make up the Sustainable Halton NHS are as follows:

1. **Provincial Greenbelt NHS** – this provincially designated NHS extends across the northwest quarter of Halton Region and includes areas south of the Niagara Escarpment Plan (NEP) area, in particular areas along Bronte Creek, 16 Mile Creek and areas around the Georgetown and Glen Williams in Halton Hills (see report section 4.1). The Provincial Greenbelt NHS has been identified based on a "systems approach" and includes therefore similar areas identified for the Sustainable Halton NHS outside the Provincial Greenbelt, including core areas, core area enhancements, centres for biodiversity, watercourses, surface water features, linkages and buffers (see report sections 4.4 to 4.9).

2. **Niagara Escarpment Plan – Escarpment Natural Areas & Escarpment Protection Areas** – these provincially designated areas are considered the natural system connections within the Niagara Escarpment Plan area. Similar to the Provincial Greenbelt NHS there are areas that may be described as core areas, core area enhancements, centres for biodiversity, watercourses, surface water features, linkages and buffers (see report sections 4.4 to 4.9) included within these policy areas.

3. **Natural Heritage Features and Functions within Existing Urban Areas** –past planning exercises within the existing urban boundaries of Oakville, Burlington, Milton and Halton Hills have identified natural heritage features and functions for protection. These protected areas make up the Sustainable Halton NHS within the existing urban areas of Halton Region (see report section 4.3).

4. **Core Areas** – these areas are the remaining natural heritage features such as woodlands, wetlands and open meadowlands present within Halton Region. Core areas provide habitat that sustains native plants and animals, and thus form the building blocks for the Sustainable Halton NHS intended to protect native biodiversity (see report section 4.4).

5. **Core Area Enhancements** – are one or more core areas as defined above that individually or collectively have been enhanced through the addition of adjacent

supporting areas, such as agricultural lands, considered important to the protection of native biodiversity (see report section 4.5).

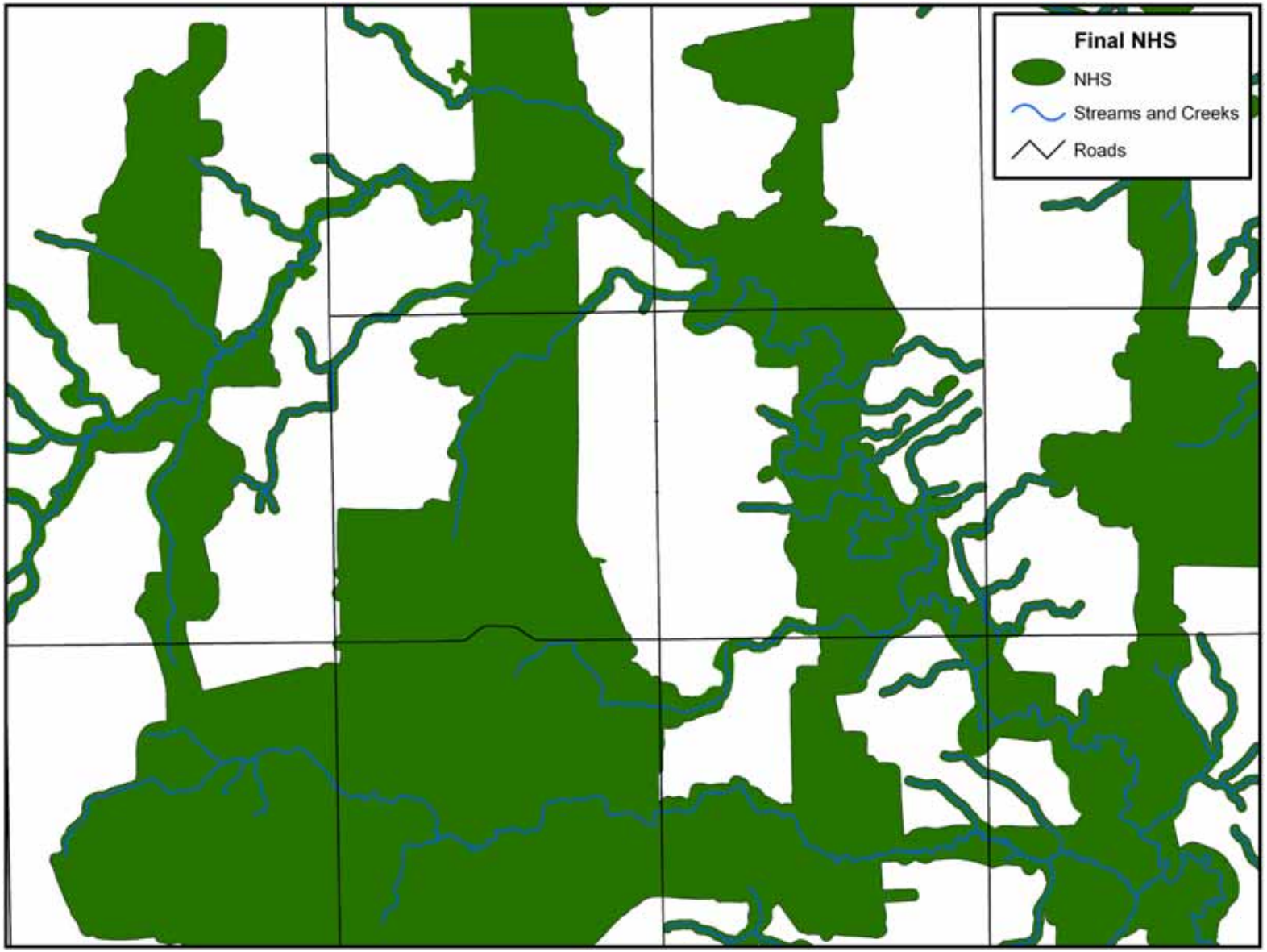
6. **Centres for Biodiversity** - are areas composed of multiple core areas and their core area enhancements that collectively form large ecological islands important to the long term protection of biodiversity native to Halton Region (see report section 4.6).

7. **Watercourses, Surface Water Features and Floodplains** – in addition to core wetlands the Sustainable Halton NHS also includes the aquatic features and functions of rivers, streams, ponds, lakes, Lake Ontario shoreline and floodplains (see report section 4.7).

8. **Linkages** - the Sustainable Halton NHS includes functional ecological linkages among natural heritage features that are considered important to meeting the short and long term movement requirements of plants and animals essential to the long term protection of native biodiversity (see report section 4.8)

9. **Buffers** – are included within the Sustainable Halton NHS to identify the minimum physical separation considered important for protecting natural heritage features and functions from adjacent land uses (see report section 4.9).

Figure 4: Conceptual Map of NHS Development Step 4. The Final Natural Heritage System



3.0 SUSTAINABLE HALTON NHS BOUNDARY ADJUSTMENT

As part of the Sustainable Halton planning process a NHS has been delineated based on the identification of a "system" of natural heritage features and functions intended to achieve the goal of long term protection and enhancement of native biodiversity. The boundary of the Sustainable Halton NHS is based on the identification of components available through a review of available digital geographic information that includes both natural heritage features and existing designated land use information from the Province, Region and Local Municipalities (Figure 5). The boundary of the Sustainable Halton NHS shown on Figure 6 is sufficiently accurate to provide direction for land use planning, whereby proposed land use changes within or adjacent (within 120 m) to the NHS trigger the requirement for the completion of environmental studies intended to ensure protection of the NHS and any boundary adjustments if necessary.

Within the rural areas of Halton Region located within the Provincial Greenbelt or Niagara Escarpment Plan area the boundary of the NHS is defined in large measure by the land use designation of this legislation (see report sections 4.1 and 4.2). Within the existing urban areas of Halton Region the NHS boundary is based on land use designations of the Local Municipalities, and there is generally a high degree of precision in the NHS boundary (see report section 4.3). Within rural areas outside the Provincial Greenbelt or Niagara Escarpment Plan area, the boundary of the NHS has been defined based on the known location of natural heritage features, core area enhancements, centres for biodiversity, watercourses, surface water features, floodplains, linkages and buffers as described below (see report sections 4.4 to 4.9).

Final adjustment of the Sustainable Halton NHS boundary will occur as part of future land use planning exercises. To ensure boundary adjustment is in keeping with the goal of the Sustainable Halton NHS a framework is necessary that guides the adjustment of final NHS boundaries. NHS boundary adjustment will occur in concert with the application of Smart Growth/Complete Community[3] development planning and decision-making that will integrate NHS boundary adjustments into detailed land use plans (*e.g.*, secondary plans). The preparation of detailed land use plans will allow adjustment of the NHS boundary to take advantage of additional natural heritage information and analysis that will be available from the associated detailed field studies. The NHS implementation framework is intended to improve land use planning decisions by providing some flexibility in making NHS boundary adjustments in the context of accommodating urban land uses that meet human needs while also achieving the NHS goal of long term protection of native biodiversity.

A fundamental question related to future adjustment of the Sustainable Halton NHS boundary is, "*how much flexibility is there in the location of the final NHS boundaries and where does any*

[3] "Smart Growth" and "Complete Communities" are terms used to describe forward thinking approaches to urban planning. They are characterized by compact, efficient, and environmentally sensitive patterns of development. They include a balanced mix of affordable housing, employment opportunities, public services and recreation. They are communities that are safe, walkable, public transit focused and which encourage healthy lifestyles and the protection of a healthy environment.

such flexibility occur?" Because the location of the NHS boundary relies on our current knowledge of varied natural heritage features and functions that undergo natural changes over time and because the NHS is based on several relevant policies (Provincial, Municipal, Conservation Authority), the degree of flexibility will vary throughout the NHS. In the report sections below the flexibility of each NHS component is discussed to provide for future boundary adjustments.

To ensure adjustment of the Sustainable Halton NHS is completed in the context of achieving the goal of long term protection and enhancement of native biodiversity, review of the NHS must always be undertaken in the context of a "systems approach". Taking a systems approach will ensure that the consideration of an adjustment of any one part of the Sustainable Halton NHS will undertaken through an examination of ecological features, functions and linkages at local and regional geographic scales and in the context of short and long term ecological needs. Thus the natural heritage features and functions associated any one site must always be examined in relation to the larger landscape and that where the NHS lies on two or more properties, this examination will require the cooperation of landowners and in some cases various government and/or conservations authorities.

The implementation framework for the Sustainable Halton NHS is based on distinguishing identifiable components that make up the NHS and determining the degree of flexibility of each component. The following steps outline how this is accomplished:

1. Classify the NHS into its component parts in order to document the underlying reason for identifying each section of the NHS;
2. Identify where an existing authority (e.g., policy or Plan) provides guidance on the location and/or limits of the NHS;
3. Determine the fundamental science-based drivers of the NHS that are the basis for selecting the location, size, width of the NHS boundary;
4. Based on the steps 1 to 3, articulate the degree of flexibility of the NHS boundary associated with each NHS component and establish a set of rules or guidelines for adjustment of the final NHS boundary; and
5. Identify the point in the development process and/or the type of study(s) that should be completed to adjust NHS boundaries.

Figure 5. Components that make up the Sustainable Halton NHS

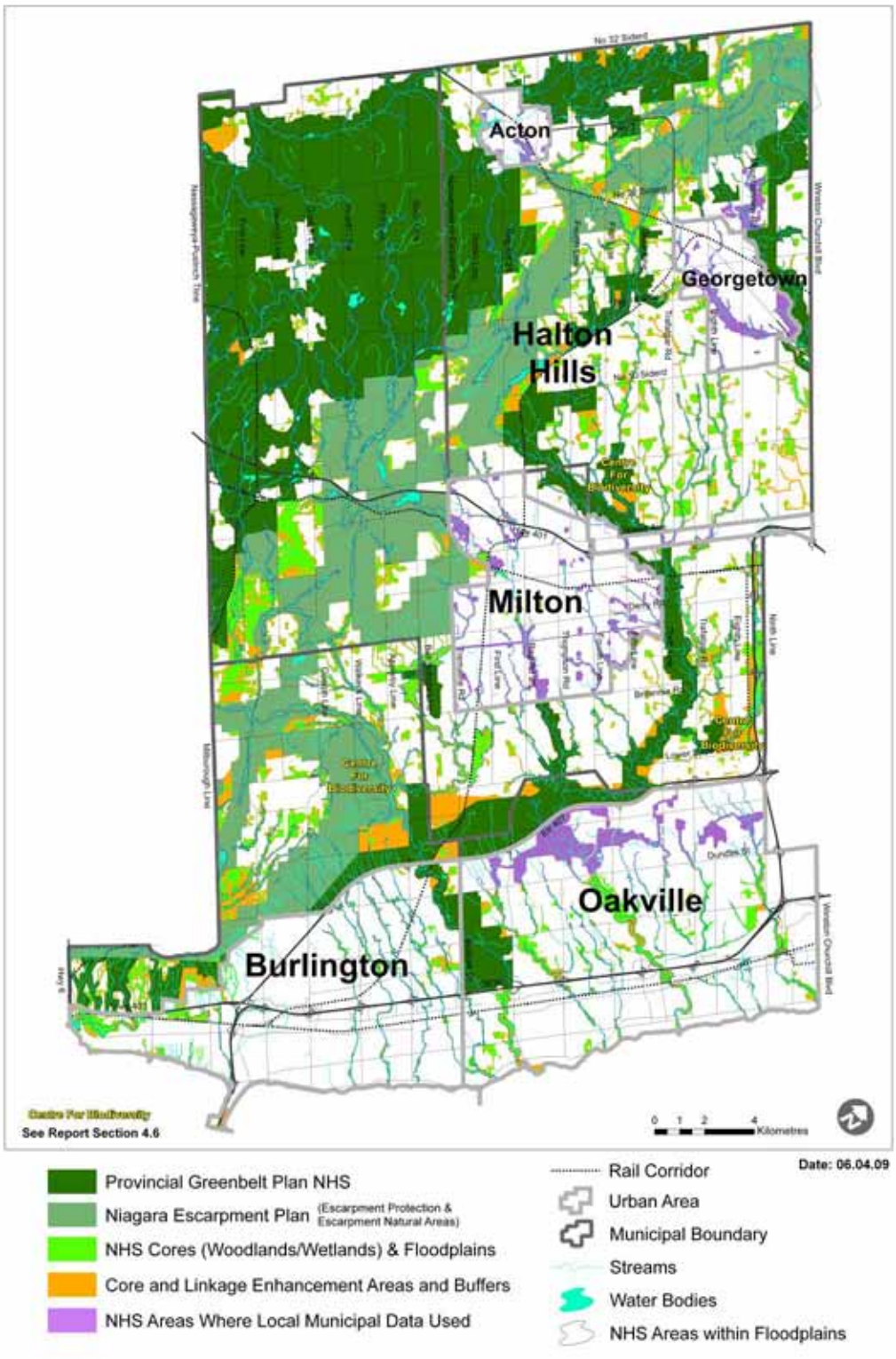
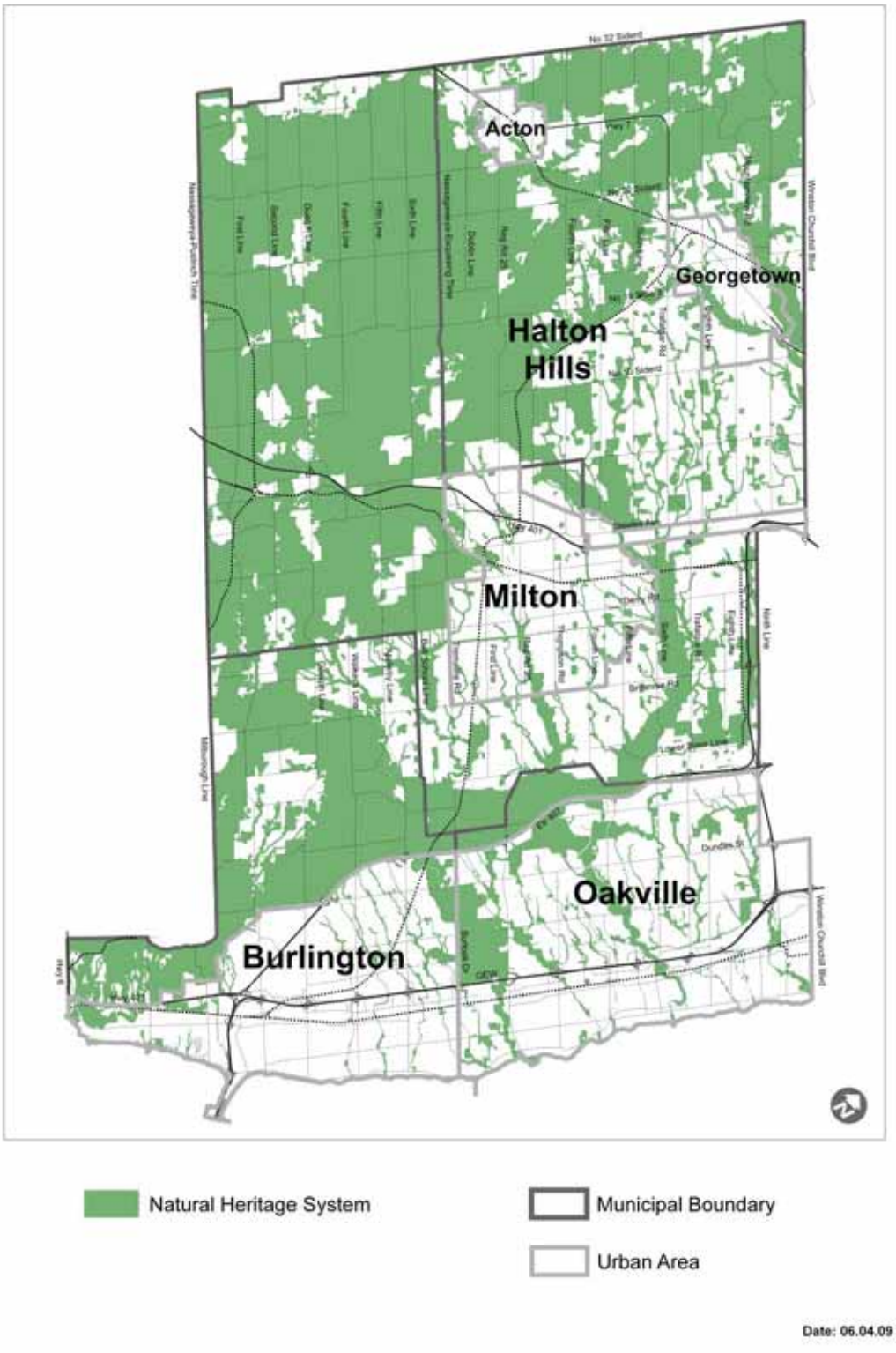


Figure 6. Sustainable Halton NHS



4.0 IMPLEMENTATION FRAMEWORK FOR SUSTAINABLE HALTON NHS

The Sustainable Halton NHS has been defined for the Region based on the best available ecological data (see Appendix 3). Within existing urban areas the natural heritage features and functions of the Sustainable Halton NHS are based in large measure on the urban land uses that are currently present and which surround the NHS. Within older urban areas the ecological features and functions of the NHS may be limited due to the small size of core areas, an absence of centres for biodiversity, a lack of core area enhancements, limited ecological linkage and minimum or no buffers of natural heritage features. Small, isolated natural heritage features within an urban landscape are unable to provide habitat of sufficient quality to sustain the majority of native biodiversity.

Within the remaining rural landscape of Halton the remaining natural heritage features co-exist with ongoing rural, largely agricultural, land uses. Over time a balance has been established between agricultural lands and the remaining woodlands, wetlands, open habitats and riparian areas that provide habitat which sustains the remaining communities that are relatively rich in native plants and animals. In rural areas the predominant agricultural land use has less impact on natural heritage features and functions than does the more intensive land use of urban areas. Rural stewardship of natural areas is often directed at further enhancing the ecological integrity of natural areas and increasing the sustainability of native biodiversity.

As such, the Sustainable Halton NHS defined within rural areas is intended to provide direction for potential future land use changes that would alter the existing balance of the natural heritage features and functions that are embedded within an agricultural landscape matrix. The Sustainable Halton NHS has been developed to ensure that should there be a change from rural to urban land use, a system of core areas, centres for biodiversity, core area enhancements, ecological linkages and buffers has been identified that is sufficiently robust to withstand the more intense ecological impacts associated with urban land use and thereby achieve long term protection of native biodiversity. The delineation and implementation of the Sustainable Halton NHS is most important therefore within existing rural areas where future land use changes may be proposed.

Within Halton Region there are a number of existing Provincial, Regional, Local Municipal and Conservation Authority designations that were used to guide development of the Sustainable Halton NHS and which may be used to guide future adjustment of NHS boundaries. Designations that considered for the Sustainable Halton NHS include:

- Provincial Greenbelt Plan Natural Heritage System
- Areas of Natural and Scientific Interest (ANSI)
- Provincially Significant Wetlands
- Provincially Significant Wildlife Habitat
- Niagara Escarpment Commission Escarpment Natural Areas
- Niagara Escarpment Commission Escarpment Protection Areas
- Conservation Authority Regulatory Floodlines
- Region of Halton Candidate Significant Woodlands
- Region of Halton Carolinian Canada sites

- Halton Regional Forests
- Region of Halton Environmentally Sensitive Areas
- Region of Halton Environmental Protection Areas identified in North Aldershot
- Halton Regional Waterfront Parks
- Local Municipal Greenlands

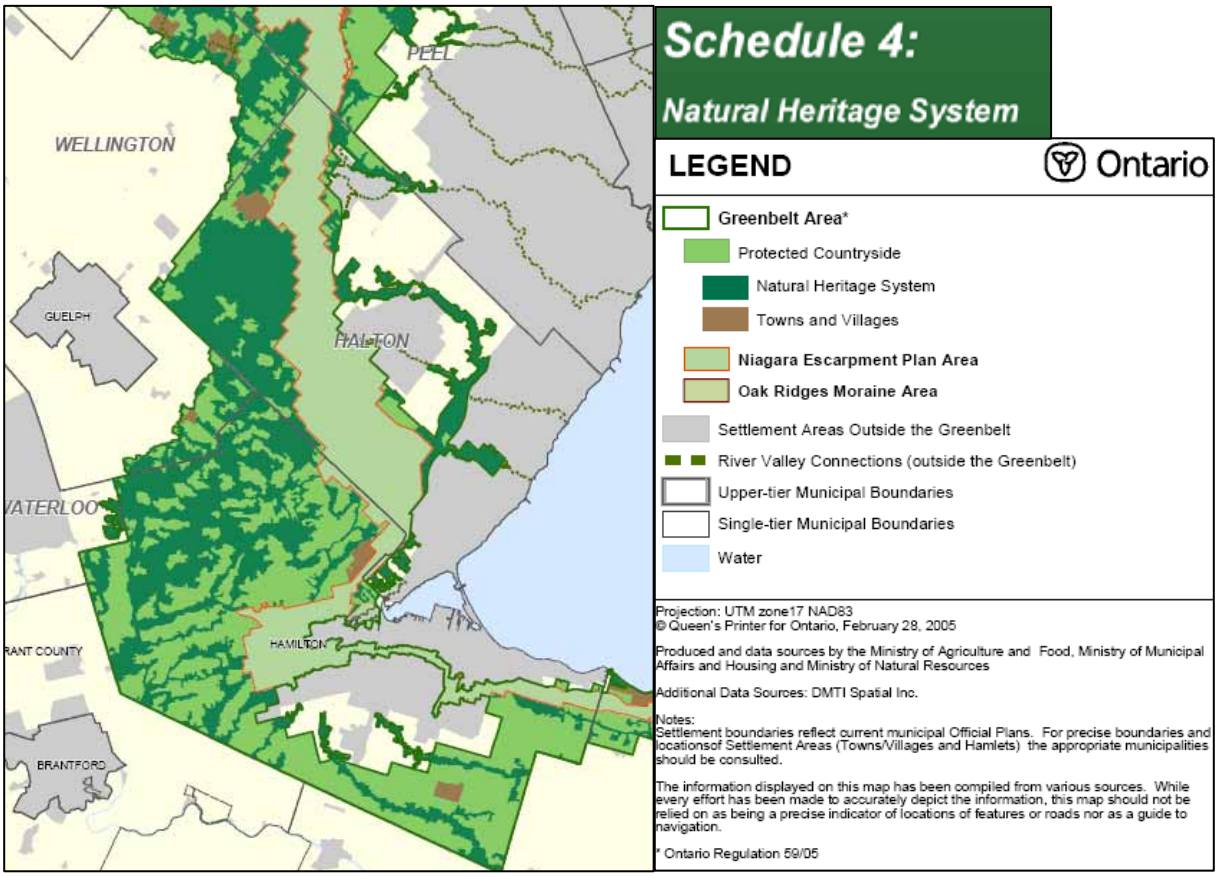
The implementation framework provides a description of key components that make up the Sustainable Halton NHS. Direction is provided in regard to the degree of flexibility (if any) in defining the final NHS boundaries and there is an outline of the relevant policy authority that applies to and guides implementation of each component. The identifiable component parts of the Sustainable Halton NHS that have been identified are as follows:

- Greenbelt Plan NHS
- Niagara Escarpment Plan, Escarpment Natural Areas and Escarpment Protection Areas
- Natural Features and Functions within existing Urban Areas
- Core Areas
- Core Area Enhancements
- Centres for Biodiversity
- Watercourses, Surface Water Features and Floodlines
- Linkages
- Buffers

4.1 Greenbelt NHS

Description
A large portion of Halton Region is located within an area regulated by the Greenbelt Plan (MMAH 2005) and the NHS identified by Greenbelt Plan forms a substantial part of the Sustainable Halton NHS (see Greenbelt Schedule 4 inserted below). The NHS identified within the Greenbelt is described as follows and this description complements the goal of the Sustainable Halton NHS:

> *The Natural Heritage System includes areas of the Protected Countryside with the highest concentration of the most sensitive and/or significant natural features and functions. These areas need to be managed as a connected and integrated natural heritage system given the functional inter-relationships between them, and the fact this system builds upon the natural systems contained in the NEP and the ORMCP. Together with the landscape surrounding the Greenbelt, these systems currently comprise, and function as, a connected natural heritage system.*



Flexibility

In regard to the Greenbelt NHS, the Greenbelt Plan policy states:

> *When official plans are brought into conformity with this Plan* [*i.e.* Greenbelt Plan], *the boundaries of the Natural Heritage System may be refined, with greater precision, in a manner that is consistent with this Plan and the system shown on Schedule 4.*

This policy is consistent with the implementation framework of the Sustainable Halton NHS, in that it is recognized new and more detailed information may become available during future development planning exercises and that this information may be used to refine NHS boundaries providing the original goal of the NHS is met. It should also be noted that there are instances where the limits of the Sustainable Halton NHS extends beyond the Greenbelt NHS boundaries to enhance ecological linkage among natural heritage features.

Existing Policy Authority

The Provincial Greenbelt Plan is the policy document that delineates this component of the Sustainable Halton NHS.

4.2 NEP Escarpment Natural Areas and Escarpment Protection Areas

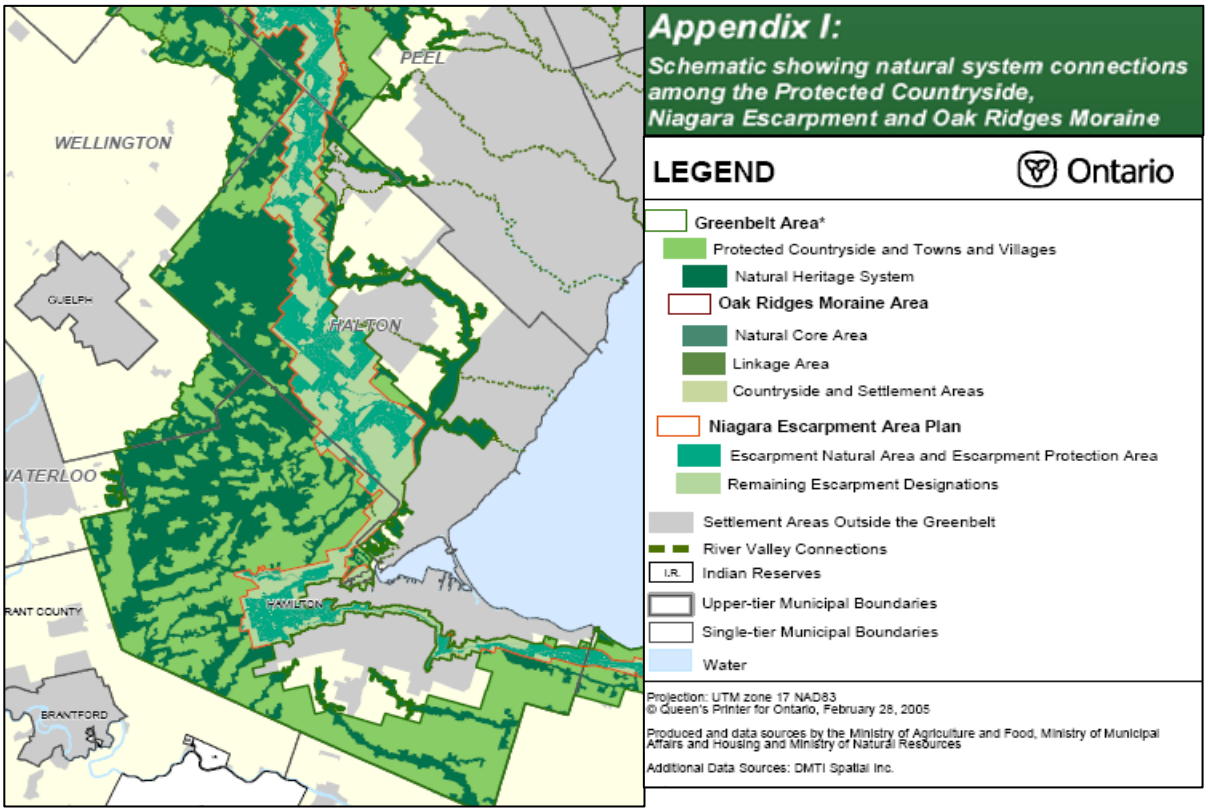
Description
A large portion of Halton Region is located within an area regulated by the Niagara Escarpment Plan (NEP) and the NEP identifies Escarpment Natural Areas and Escarpment Protection Areas that form a substantial part of the Sustainable Halton NHS (see Appendix 1 from the Greenbelt Plan inserted below). Escarpment Natural Areas and Escarpment Protection Areas collectively form a system of connected natural heritage features that complement the goal of the Sustainable Halton NHS. The NEP describes these areas as follows:

The NEP describes the features and policies associated with Escarpment Natural Areas and provides criteria for their designation as follows:

> *Escarpment features which are in a relatively natural state and associated stream valleys, wetlands and forests which are relatively undisturbed are included within this designation. These contain important plant and animal habitats and geological features and cultural heritage features and are the most significant natural and scenic areas of the Escarpment. The policy aims to maintain these natural areas.*
>
> ***Criteria for Designation***
> 1. *Escarpment slopes and related landforms associated with the underlying bedrock which are in a relatively natural state.*
> 2. *Where forest lands abut the Escarpment, the designation includes the forested lands 300 m (1,000 ft.) back from the brow of the Escarpment slope (e.g., Bruce Peninsula).*
> 3. *The most significant Areas of Natural and Scientific Interest (Life Science).*
> 4. *The most significant stream valleys and wetlands associated with the Escarpment.*

The NEP describes the features and policies associated with Escarpment Protection Areas and provides criteria for designation as follows:

> *Escarpment Protection Areas are important because of their visual prominence and their environmental significance. They are often more visually prominent than Escarpment Natural Areas. Included in this designation are Escarpment features that have been significantly modified by land use activities such as agriculture or residential development, land needed to buffer prominent Escarpment Natural Areas, and natural areas of regional significance. The policy aims to maintain the remaining natural features and the open, rural landscape character of the Escarpment and lands in its vicinity.*
>
> ***Criteria for Designation***
> 1. *Escarpment slopes and related landforms where existing land uses have significantly altered the natural environment (e.g., agricultural lands or residential development).*
> 2. *Areas in close proximity to Escarpment slopes which visually are part of the landscape unit.*
> 3. *Regionally Significant Areas of Natural and Scientific Interest (Life Science).*



Flexibility

In regard to the boundaries of Escarpment Natural Areas and Escarpment Protection Areas the NEP policy states:

> *The internal boundaries between designations within the Plan* [*e.g.* Escarpment Natural Areas and Escarpment Protection Areas],*… are less definite except where they are formed by such facilities as roads, railways, and electrical transmission lines. These internal boundaries, shown at a scale of 1:50,000, are not intended to be site specific and should not be used for accurate measurement. The exact delineation of designation boundaries on specific sites will be done by the implementing body through the application of the designation criteria (see Part 1) utilizing the most detailed or up-to-date information available and site inspections. Such designation boundary interpretations will not require amendments to the Niagara Escarpment Plan.*

Existing Policy Authority

The NEP is the policy document that delineates these components of the Sustainable Halton NHS.

4.3 Natural Heritage Features and Functions within Existing Urban Areas

Description
Within the existing urban boundaries of Oakville, Burlington, Milton and Halton Hills Greenlands have been identified through secondary plans. Where secondary plans are the approved land use plan the Greenlands identified will form the NHS within these areas. There remain some existing urban areas for which secondary plans are currently under development, within these areas there may be opportunities to enhance the Sustainable Halton NHS through the identification and protection of natural heritage features and ecological linkages based the systems approach used in this report.

Flexibility
Where a secondary plan has been approved and adopted by a Municipality there is very limited or no opportunity to add to the existing NHS as defined by the Greenlands in these plans. For those areas that do not have approved plans, there may be some flexibility in the identification of Greenlands that best support the Sustainable Halton NHS identified outside the existing urban boundaries.

Existing Policy Authority
Greenlands are protected through policies of the Provincial Policy Statement (2005), the Regional Official Plan (2006), Local Official Plans and Conservation Authority policies.

4.4 Core Areas

Description
Core areas are the remaining examples of natural heritage features such as woodlands, wetlands and open meadowlands present within the landscape of Halton Region. Core areas often exist as fragmented and isolated patches embedded within a predominantly agricultural or urban landscape. Core areas represent the reservoir of native biodiversity and the habitat that sustains this within Halton Region.

Cores areas included within the Sustainable Halton NHS have functional ecological linkages (see report section 4.8) and buffers (see report section 4.9) that ensure these areas contribute to the maintenance of habitat long term viability of of native biodiversity. Core areas also form the building blocks for core area enhancements and centres for biodiversity; the latter being NHS components that are important in mitigating the impacts of habitat loss, fragmentation and impacts from adjacent land uses.

Some core areas are defined through existing designations such as Significant Woodlands as defined by the ROP (2006) or Provincially Significant Wetlands as defined by the Ministry of Natural Resources using the Ontario Wetland Evaluation System. Core areas may also include other woodlands, wetlands and open habitat where these natural heritage features make an important contribution to the Sustainable Halton NHS within core area enhancements, centres for biodiversity, ecological linkages and in association with watercourses, surface water features, and floodplains (see further discussion of these NHS components below).

Flexibility
The flexibility associated with determining the boundary core features is generally very low. These features are generally remnants of larger natural features and their boundaries are usually well defined by adjacent land uses. In most cases such as wetlands and woodlands, the protocols for boundary determination are well established and will be determined as part of the current development process. The delineation of wetland boundaries is based on the Ontario Wetland Evaluation System and the delineation of woodland boundaries is based on areas meeting the definition of "woodland" as defined in the ROP.

Existing Policy Authority
There are a variety of planning documents which articulate the protection measures for core areas. Cores areas are protected through policies of the Regional Official Plan (206) and Provincial Policy Statement (2005), the Niagara Escarpment Plan and Act, Regional Official Plan (2006), Conservation Authority policies and the Greenbelt Plan (2005).

4.5 Core Area Enhancements

Description
Core areas enhancements are areas made up of individual and/or groups of natural heritage features (or core areas as defined above) that have been enhanced through the addition of adjacent supporting areas intended to increase the ecological resilience and function of the individual and/or groups of natural heritage features that make up a core within the NHS. Supporting areas may consist of meadowlands, early successional woodlands, or agricultural lands.

Some core area enhancements have been defined based on the boundaries developed in other natural heritage protection programs, including: Provincial and Regional Life Science and Earth Science Areas of Natural and Scientific Interest (ANSIs); Halton Region Environmentally Sensitive Areas (ESAs); Halton Region Waterfront Parks; Carolinian Canada Sites; Royal Botanic Gardens Cootes to Escarpment; and North Aldershot Environmental Protection Areas.

Core area enhancements are also defined based on one or more the following factors:

- achieving a minimum threshold size of a core area;
- grouping natural heritage areas that are likely to have important inter-dependent ecological functions;
- reducing the amount of edge of a core area by including embayments within cores;
- increasing the proportion of "interior" conditions (as defined by a 100 m buffer) within core areas; and
- including catchments critical to the quantity and quality of water sustaining core areas.

The size thresholds used to guide the development of core areas within the Sustainable Halton NHS considered the following minimum core areas defined by Environment Canada (2004):

- ***Core Area Woodlands***: 20 ha
- ***Core Area Wetlands***: 10 ha for marsh/thicket and 20 ha for treed swamp

- ***Core Area Open Habitat***: 15 ha
- ***Centres for Biodiversity***: 200 ha

Flexibility
There may be some flexibility in determining the final boundary of proposed core area enhancements providing the ecological intent and functionality of proposed enhancement is achieved. In determining core area enhancement boundaries existing natural heritage features should not be removed and flexibility should be restricted to those areas identified for enhancement. Examples of flexibility are as follows:

- if the intent of the enhancement is to increase the size of an existing 17 ha woodland to achieve a minimum 20 ha threshold for woodlands and if the proposed enhancement maximizes the amount of interior forest present, then it would not matter where the enhancement occurs, as long as these objectives are achieved;
- if the intent of the enhancement is based on improving the shape of core natural areas (*i.e.* minimizing the edge to interior ratio thereby maximizing the area of interior conditions and minimizing edge impacts); boundary adjustments that continue to achieve the proposed enhancement of core shape are acceptable;
- if the intent of the enhancement is to join or cluster one or more natural features and providing enhanced ecological linkage internally among features and externally to the larger NHS; boundary adjustment of these core area enhancements must continue to include and provide functional ecological linkage among all features; and
- if the intent of the enhancement is to include a catchment area for a wetland, boundary adjustments may be based on more detailed field information about a catchment area.

Existing Policy Authority
Core area enhancements is consistent with the PPS (2005) and the Regional Official Plan (2006) based on the fact these areas are necessary to maintain natural heritage features and to improve critical ecological functions necessary to sustain biodiversity within the Sustainable Halton NHS.

4.6 Centers for Biodiversity

Description
Centres for Biodiversity (CFB) are large (>200 ha) areas composed of multiple core areas and their core area enhancement areas that collectively form important ecological components of the Sustainable Halton NHS. CFBs are considered essential to achieving the objective of no further loss of plant and animal species in Halton Region by providing habitat that is of sufficient size, that is of high quality and diversity, and which is sufficiently well connected to provide a contiguous area capable of supporting a high proportion of native biodiversity. The CFBs will to the extent possible, include a wide range of environments intended to accommodate the needs of most native species by providing the variety of different habitats required to survive and complete their life cycles. For example, amphibians that breed in wetlands and forage/overwinter in uplands, raptors that nest/rest in woodland and forage within open habitats, deer that range over fields and woodlands in spring/summer/fall and overwinter within preferred wooded areas (deer yards), etc.

The best available natural heritage information has been used in locating CFBs to achieve representation of habitats characteristic of the distinct physiographic regions within Halton Region; one physiographic region being the area below the Niagara Escarpment and dominated by relatively flat areas and deeper clay soils on the Peel Plain and the other physiographic region being on and above the Niagara Escarpment dominated by rugged and hilly terrain and with till soils of variable thickness. CFBs have been located within areas that are relatively roadless and therefore natural habitats will remain less fragmented and they have also been located within areas that permit substantial ecological connectivity to the regional linkages identified for the Sustainable Halton NHS.

The location of CFBs is also based on a consideration of planning requirements related to the growth concepts, existing land use, the main transportation corridors currently present and those proposed within Halton.

Flexibility
There is some flexibility in the overall location of CFBs and there may be substantial flexibility in the adjustment of some areas of their boundaries, although conservation biology and nature reserve design should be applied. These principles include:

- protect the remaining natural heritage features present in the landscape;
- minimize the edge to interior ratio by ensuring edges are not convoluted with large embayments allowing other land uses to intrude in to the CFB or extensions of the CFB surrounded by other land uses. Hence the overall shape should be approximately round, square, or rectangular (not a long and narrow rectangle);
- maintain robust (>300 m) internal and external linkages among natural heritage features within CFBs and to natural heritage features within adjacent areas of the Sustainable Halton NHS;
- the CFB should contain a range of habitats such as terrestrial and aquatic, and/or riparian and uplands, slopes and bottomlands, and/or woodland, open lands (meadow, prairie, savannah, thicket), and wetlands.

Existing Policy Authority
The policy basis for the CFBs stems from direction provided in the Basic Position in the current Regional Official Plan Section II (2006). This section outlines a vision for planning in Halton that places an emphasis on the maintenance of a Halton as a "*desirable and identifiable place for this and future generations*". The Basic Position introduces the concept of "*Landform Permanence*" as essential to achieve this and identifies Landform Permanence as "*… Halton's fundamental value in land use planning …*". In the context of Halton's Planning Vision, Landform is meant to include the range of biotic and abiotic features that compose the regional landscape. It consists of the features that define Halton's cultural and natural identity and serve to distinguish it from neighbouring municipalities. This identity includes the Region's biological diversity, the plants and animals that occur here and the habitats that are needed to ensure their persistence. "Permanent", means forever, and thus Landform Permanence includes the need to maintain the Region's biological diversity forever. The inclusion of CFBs within the Sustainable Halton NHS is essential to achieve this.

The concept of CFBs is also consistent with direction in the PPS (2005). Policy 2.1.2 notes that "*The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems should be maintained, restored or, where possible, improved* …" (our underscore for emphasis). The proposed CFBs would provide substantial improvement of ecological function and biodiversity with the Sustainable Halton NHS.

4.7 Watercourses, Surface Water Features and Floodplains

Description
The Sustainable Halton NHS utilizes the most up to date information provided by each Conservation Authority in relation to watercourses, surface water features and floodplains. In some areas this data may be updated through the completion of more detailed field studies and this is discussed in greater detail below under the heading of *Flexibility*.

Watercourses: The Sustainable Halton NHS includes all watercourses located within Conservation Authorities' Regulation Limit. In some cases, watercourses located outside the regulation limit have also been included based on an important ecological linkage function provided by watercourses that link natural heritage features such as woodlands and wetlands.

Surface Water Features: The Sustainable Halton NHS also includes surface water features such as lakes, ponds and the Lake Ontario shoreline.

Floodplains: Floodplains are areas that perform critical hydrologic functions of water detention, storage and conveyance and when in a natural state are biologically rich, often forming diverse ecological communities with multiple ecological functions.

Flexibility
For cold-water and cool-water systems, there is little flexibility. These streams are generally more sensitive to impact and are of higher quality and it is preferable that they not be moved or re-aligned.

There may be greater potential for flexibility for steams with a warm-water thermal status. Field studies may determine some streams are headwater swales with no defined channel, intermittent flow and limited ecological function. The inclusion of certain headwater streams within the NHS may consider factors such as the longer water conveyance detention time provided by swales, the ability to facilitate infiltration and the ecological linkage function provided by intermittent watercourses. In some cases it may be determined that it is only necessary to maintain the hydraulic function of the watercourse and that this can be accomplished while moving and/or consolidating the watercourse as part of a stormwater management plan. The re-location of such watercourses and the maintenance of hydraulic function would be determined through consultation with the relevant Conservation Authority.

In determining the feasibility of re-aligning or consolidating watercourses, their ecological linkage function should be a primary consideration. If these watercourses provide an important

ecological linkage function within the NHS, such as connecting headwater wetlands and downstream riparian woodlands, these linkage function should be maintained and this may limit some of the flexibility of some stream re-alignments and provide direction for subsequent restoration strategies.

All watercourses located both within and outside the NHS will continue to be shown on NHS mapping and it is recommended all watercourses be evaluated in the field, whenever additional studies are undertaken (*e.g.*, sub-watershed studies, secondary plans, EIS). The final decision regarding the inclusion of any particular watercourse may be made through future studies such as Subwatershed Study, Secondary Plan Study or Environmental Impact Study in collaboration with Municipal governments and Conservations Authorities.

The flexibility of the NHS boundary defined by floodlines will be limited, but there are instances where detailed studies can be used to refine floodlines with review and approval by the Conservation Authority. In older urban development areas there may be some floodlines that include existing built areas consisting of residential, commercial and employment land uses. Where floodlines are within built areas the Sustainable Halton NHS boundary should be delineated to exclude built areas where there is no possibility of future ecological restoration. In areas where detailed studies have not yet been completed to accurately determine the location of floodlines, there may be some flexibility in determining the final NHS boundary defined by floodlines; this flexibility must however be determined through the completion of detailed hydrology studies in collaboration with the Conservation Authority. Notwithstanding the results of an analysis of floodlines, other associated factors such as linkage, the presence of natural heritage features and core area enhancements should always be considered in determining the flexibility of the NHS boundary.

Existing Policy Authority
The protection of streams, surface water features, floodplains, valleylands and the direct and indirect fish habitat associated with these areas is supported by the federal Fisheries Act, the PPS (2005), Conservation Halton policies and Halton Region O.P.

4.8 Linkages

Description
The protection of functional ecological linkages among natural heritage features is a fundamental ecological principle of the Sustainable Halton NHS that is critical to maintaining ecological integrity at a landscape scale that provides long term protection of native biodiversity. The landscape of southern Ontario is described as a "fragmented landscape", referring to the fact that natural heritage features often exist as isolated patches surrounded by other land uses. Within a rural agricultural landscape species movement among isolated patches may not be severely restricted if hedgerows are present, fields remain fallow some years and patches are relatively close to one another. Within an urban landscape species movement among isolated patches will be severely limited by inhospitable habitat, barriers and the threats present. The Sustainable Halton NHS identifies local and regional functional ecological linkages required to meet the

daily, seasonal and long-term movement requirements of species that are considered essential to the long term protection native biodiversity.

The width of regional linkages may in some cases be based on maintaining consistency with linkages in the Greenbelt NHS or linkages to Escarpment Protection Areas and Escarpment Natural Areas. For example, in an area where the Greenbelt provides linkage of 400 m wide the Sustainable Halton NHS will maintain a similar width to maintain a wide continuous regional linkage corridor. A minimum width of 300 m is used where a linkage is intended to include habitat for interior demanding species; this is based on the assumption that in the long term linkages will become wooded and a 300 m linkage will include a 100 m core of interior habitat with 100 m wide buffers on either side. For local linkages, the width used when mapping the NHS considered the width of the "face" of the features being connected, to provide the best possible movement opportunities for species between two features. The following provides a guideline for a minimum linkage width to consider; longer linkage distances should consider wider linkages width to enhance the ecological functioning of linkages:

- *Regional Linkage*: 300 to 400 m width
- *Local Linkage*: 60 to 100 m width

One of the principles used in the design of linkages is based on the value of providing multiple connections among habitat patches. Because not every linkage will be used by all species at all times, providing multiple linkages in the NHS increases the likelihood plant and animal movement and migration will occur meeting the short and long term needs various species such as re-populating habitat patches following a local extinction, providing greater assurance plants and animals will be able to adapt to changing climate conditions, and to mitigate against unforeseen changes that may eliminate one or more linkages.

It is also recognized that linkage must address the substantial barriers to wildlife movement caused by major highways such as Highways 401, 403, and 407, Dundas Street, and Highway 7. Where major highways fragment the Sustainable Halton NHS suitable locations that have the potential to restore ecological linkage through the creation or enhancement of wildlife overpasses or underpasses should be considered a priority for future restoration efforts.

Every effort should be made to direct new or upgraded transportation and utility infrastructure away from the Sustainable Halton NHS. However, where such infrastructure is proposed within the Sustainable Halton NHS mitigation measures should be proposed to maintain or where possible enhance existing wildlife linkage functions as part of infrastructure development.

Flexibility

There may be substantial flexibility in the location and/or adjustment linkage boundaries in some cases. For all linkages, the location must be based on providing ecologically functional connections that maintain a consistent width (i.e., "bottlenecks" or narrowing of the NHS will adversely impact the ecological function provided by a linkage and should therefore be avoided). However, in some cases an entire linkage could be shifted one way or another providing the ecological function is maintained. In cases where a linkage is centered on a feature, it is important that the feature continue to be included within the linkage, and this may in turn limit the degree of flexibility in moving the linkage. Where a linkage is associated with a

watercourse, it may be possible to move the watercourse feature and the associated linkage function, to a new location within the landscape. Where two or more linkages have been defined within the NHS, these linkages should not be regarded as "optional linkages"; while the location of individual connections may be flexible, the number of connections should remain the same.

Existing Policy Authority
The inclusion of ecological linkages within the NHS is consistent with the PPS (2005) which recognizes linkages between and among natural heritage features and areas, surface water features and ground water features should be maintained, restored and where possible improved. Linkage is a fundamental component of a systems approach to natural heritage protection supported by the Region's OP.

4.9 Buffers

Description
Buffers provide an ecological protection function of natural heritage features by providing a. physical separation from a feature and an adjacent land use. Some of the related functions may include the following:

- a barrier that reduces access into a natural heritage feature such as related to predation by dogs and cats, invasion of exotic species, or human intrusion;
- a zone of protection for the elements of the feature along its outer edges such as tree root compaction and damage from construction activity
- a safety zone such as a tree fall zone next to a woodlot
- an area for wildlife to carry out part of their life cycle such as water fowl nesting next to a wetland
- a vegetated zone to help provide water quality controls for overland flows before reaching the feature such as active, exposed construction areas next to a feature
- a vegetated zone that encloses a water catchment sustaining flow volumes important to sustain an adjacent feature
- a vegetated zone to help control overland flow so as to reduce possible problems such as erosion on valley slopes
- an area to provide for wildlife movement

Scientific literature has reported on a variety of buffer width based on factors related to topography, sensitivity of features, and magnitude of impact from adjacent land use, etc. The Sustainable Halton NHS identifies the following minimum buffer widths:

- a minimum 30 m buffer for all woodlands and wetlands
- a 30 m buffer on either side of all streams

Flexibility
There is low flexibility for the minimum buffer widths to be applied from the edge of the feature being protected. Field studies are required to make a precise determination of the location of a feature such as a wetland or woodland. The delineation of wetland boundaries is based on the Ontario Wetland Evaluation System and the delineation of woodland boundaries is based on areas meeting the definition of "woodland" as defined in the ROP. A woodland edge is

generally defined by the "dripline" defined by the canopy of edge trees. It should be noted that in some cases more detailed studies may recommend a buffer width greater than the minimum 30 m buffer width defined here in order to protect natural heritage features and functions.

The buffer applied to streams is intended to be applied from the stream bank as defined by the bankful width. In some cases streams may be defined based on a meander belt width, in these cases the 30 m buffer should be applied to the edge of the meander belt. It should also be noted that there may be some flexibility in the location of some watercourses and that as part of a development approval process a stream may be re-located if approved by the appropriate authorities (Conservation Authority, Department of Fisheries and Oceans, Municipal governments); following stream re-location and restoration, a 30 m buffer width should be applied to the stream bank of the re-located stream.

Existing Policy Authority
The need for protection of lands adjacent to natural heritage features is supported by the PPS (2005), Conservation Halton policies, Greenbelt (2005) policies, NEP policies and Halton Region OP policies that acknowledge adjacent lands may provide supporting ecological functions for natural features.

4.10 Physical Implementation

The Sustainable Halton NHS has been mapped to include the components as described above based on the best available information (see Appendix 3). One map has been prepared to show individual components that make up the Sustainable Halton NHS (Figure 5) and a second map has been prepared to show the Sustainable Halton NHS as single integrated system (Figure 6).

The flexibility discussed above in relation to each of the NHS components recognizes new and more detailed information will assist in making final Sustainable Halton NHS boundary adjustments. Subwatershed Studies, Secondary Plans and Block Plans involve environmental studies that can provide new and more detailed information that may be used to confirm natural heritage features and functions needed to make final Sustainable Halton NHS boundary adjustments. Future planning exercises and their associated environmental studies should consider the following:

- future studies that include spring, summer and fall field inventories of plants and animals can provide important data to assist in the decision-making process regarding the Sustainable Halton NHS boundary;

- future planning exercises that take in to account Smart Growth principles will provide the best opportunities to protect the Sustainable Halton NHS in balanced sustainable development;

- future planning should make every effort to avoid fragmentation of the Sustainable Halton NHS when considering new infrastructure development such as servicing, transportation and transit to achieve maximum protection of the Sustainable Halton NHS;

- where new development is proposed Low Impact Development and Best Management Practices should be implemented to reduce adjacent land use impacts on the Sustainable Halton NHS; and

- Halton's Greenlands Securement Strategy (GSS) which represents, in part, a protocol for expenditures made under the Halton Green Fund to support the continuous enhancement of environmental quality in Halton Region should consider the Sustainable Halton NHS as a focus for lands to be considered by the GSS program.

- Within the rural area, agricultural land use and the Sustainable Halton NHS coexist; the NHS is not intended to restrict agricultural practices or the development of agricultural infrastructure where it is required to maintain a sustainable and healthy rural agricultural community (see Section 2.1).

APPENDIX 1: NATURAL HERITAGE SYSTEM CONCEPTS

APPENDIX 1: NATURAL HERITAGE SYSTEM CONCEPTS

The following sections provide context and background for the Sustainable Halton NHS.

Character of the Pre-European Landscape in Ontario

In developing an NHS intended to protect the diversity of native plants and animals the plant communities that support them, it is useful to consider the natural environments that characterized the Region of Halton prior to European settlement. If the Greenlands System is to achieve the protection of native biodiversity, it must include some of these features and functions that were present in the past, because it was these conditions that supported the rich and diverse species and ecosystem diversity that existed in pre-settlement times. This vision is not intended to represent the intended end point of the NHS. It is not possible, and perhaps not even desirable, to turn the clock back and try to re-create a pre-settlement landscape. However, it is important to have a sense of what the former landscape was like, and thus provide perspective for the proposed Options

The Character of Ontario's Pre-European Landscape

Woodland was the prevalent vegetation cover in eastern North America prior to European settlement (Braun 1950), covering approximately 90% of southern Ontario (Riley 1999). The woodlands were largely unbroken, with only small openings from natural disturbances such as fallen canopy trees, small areas of blowdown, and occasional understorey fires. These pre-settlement woodlands were structurally diverse with "supercanopy" older growth trees, (mostly white pine) that pierced and rose above the more continuous, shade-tolerant canopy. Beneath the main canopy there was a sub-canopy of trees, as well as tall and short shrubs, forbs and grasses and ground layers of mosses, liverworts and low herbs. The lofty canopies created cathedral-like spaces beneath them. An idea of what it would be like to walk in such woodlands is provided by an early traveller:

"The grand forests present a more striking appearance than anything else to the eye of one just arrived from the Old World. No one entered their shadows or tread their long-drawn vistas of tall grey stems, spanned by over-arching roof of dark leaves, without the idea of a vast cathedral involuntarily rising in the mind. Like ruined columns, huge prostrate trunks lie strewn around, some but newly fallen, others moss-grown and verdant, with creeping plants; while many show only a dark line of decayed vegetable mould, the last and rapidly disappearing vestige of their former stateliness." (King. 1866., as cited in Larson *et al.* 1999)

Of interest in this quote, is the observation of the various states of decay of fallen deadwood, some acting as host trees to mosses and other woodland plants, some almost fully decayed and noticeable only as a "dark line of decayed vegetable mould". These are characteristics of what we now recognize as "old growth" woodlands, and are a necessary structural feature for capturing the biodiversity of native woodlands.

Not only were the woodlands expansive, but they were older and, therefore, contained much bigger trees. David Douglas, traveling through Ontario in the 1820s, wrote:

"… on the banks of the Detroit River, from Amherstburgh [sic] *to the junction of the Thames with the St. Clair in Upper Canada, and on the opposite banks, in Michigan Territory, on a deep alluvial rich black soil, these trees* [referring to white oak (*Quercus alba*)] *frequently measure from 20 to 25 feet in circumference* [approximately 195 to 240 cm in diameter] *at 8 feet from the ground, and are from 80 to 100 feet high* [24 to 30 metres]" (Douglas 1914 as cited by Fox and Soper 1954).

Similarly,

"One tulip tree near Kingsville yielded six thousand board feet of lumber. Chestnut trees have also been known to equal this… A giant walnut in Metcalf township locally know as 'King of the Forest' measured thirty-six feet in circumference [approximately 350 cm] *one foot above the roots with very little loss of size in the first twenty feet."* (Ontario Lands and Forests 1963, as reported in Larson *et al.* 1999)

These pre-settlement woodlands supported a very different fauna from the small woodland patches that characterize much of the current landscape in southern Ontario. Top predators such as wolf and cougar were present and black bear were common throughout southern Ontario. Lady Simcoe wrote in her diary, *"Near the [Don] river we saw the track of wolves, and the head and hooves of a deer"* (Robertson 1911, pg. 213)

It is important to note that the Region was not 100% woodland prior to settlement. There were also scattered patches of open prairie and savannah-like ecosystems scattered across southern Ontario, reaching at least as far as the Rice Lake Plains near Peterborough. There is evidence that the extreme southwest corner of Halton supported savannah and/or prairie communities, thus the source of the name "Plains Road", reflecting the fact there were open plains in that part of the Region.

The picture of the pre-settlement woodland with its multi-layers and giant canopy trees provides a worthwhile perspective when identifying a NHS in Halton Region (and elsewhere). The woodlands present within natural areas today which we perceive to be mature ecosystems with "interior woodland", do not fulfill the same ecological roles or provide the high biodiversity which existed in the undisturbed, old-growth woodlands that dominated southern Ontario just 200 years ago. Our current perception that areas of southern Ontario are "well-wooded" because they have 30% or more woodland cover is misguided, because it does not reflect the continuous natural woodland cover of the original landscape. When viewed from this perspective, all of the remaining natural areas within southern Ontario are important to some extent.

Influence of Surrounding Landscape Matrix

Natural Heritage Systems are an approach to preserving biodiversity and ecological function within developed landscapes. The area surrounding the NHS, which is referred to as the "landscape matrix", has an impact on remnant natural systems, and will therefore influence the design of a NHS. The landscape matrix may support a variety of other land uses which have varied impacts on natural features. Generally speaking, agricultural landscapes impose fewer impacts on the natural environment than urban development and are, therefore, more compatible

with Natural Heritage Systems in most cases. The other land uses which form the landscape matrix may be supportive or detrimental to the objectives of biodiversity protection and maintenance of ecological function, depending on their compatibility with natural systems.

An agricultural landscape matrix can be supportive of an NHS particularly when Best Management Practices (BMPs) and/or an Environmental Farm Plan (EFP) are implemented. With appropriate management, supportive aspects may include the more natural distribution of surface water, minimized impacts to infiltration and ground water, and better opportunities for the movement, migration and dispersal of plants and animals within the landscape. This movement through the agricultural landscape may utilize agricultural fields, hedgerows and/or protected riparian corridors.

However, agricultural land uses can also result in significant negative impacts to an NHS. For example there are direct impacts when wetlands and woodlands are removed to facilitate agricultural land use or when livestock are permitted to trample, feed and defecate in natural areas. There is also the potential for numerous indirect impacts such as alteration of the natural water balance due to installation of tile drains; reduced infiltration and increased runoff caused by soil compaction; depletion of surface and groundwater resources from irrigation and the creation of drainage ditches; and a reduction in air and water quality due to agricultural fertilizer and pesticide inputs, and erosion.

Areas where the landscape matrix includes aggregate extraction are generally seen as potentially the most detrimental to an NHS. This is due to the direct impacts associated with aggregate extraction that results in the complete removal of native vegetation cover and soil, the significant alteration of natural topography, reduction of surface and ground water quality and impacts to hydrological regimes. These changes may have indirect impacts on wetlands, woodlands and other natural features as well as other indirect impacts due to noise, dust, light and vibration. Nonetheless, the environment has a tremendous capacity to recover from impacts, and with an increasing knowledge of restoration ecology, areas of aggregate extraction may be supportive to a NHS through the strategic staging of extraction and the timing, intensity and type of rehabilitation following extraction.

Within urban areas, consisting of residential, commercial and industrial land uses and the supporting infrastructure of roads and highways, the landscape matrix is significantly less supportive of an NHS than an agricultural matrix. Urban land use impacts include the creation of impervious surfaces (roads, parking areas, roof tops, compacted lawns, *etc.*) that alter timing, quantity and quality of surface and ground water flows. Urban lands are far less permeable to wildlife movement than agricultural landscapes. For example, roads, buildings, fences, *etc.* constitutes substantial barriers to the movement of plants and animals and offer little habitat to support and conceal wildlife as it attempts to move among remnant natural features. Urban lands also result in many indirect impacts to protected areas within an NHS such as the introduction of non-native plants and animals, pets that harass and kill native wildlife, soil compaction and erosion from trampling, motorized recreational vehicles and mountain bikes, dumping of refuse and garden waste, noise, light, contamination of surface water, *etc.* The provision of significant buffers and functional ecological linkages are critical to mitigating the impacts associated with the more intensive impacts of urban land uses.

These varied impacts from the landscape matrix need to be considered during the development of an NHS. Where an NHS is anticipated within an urban area, it will likely need to be more robust with respect to the size of core areas, buffers against remnant features and connecting habitat, than where an a NHS is located within an agricultural landscape. However, even within a non-urban matrix, an NHS needs to provide cores and connections consisting of natural habitat in order to accommodate species intolerant of agricultural landscapes, if native biodiversity is to be protected and enhanced.

Functional Linkages

The NHS approach to natural heritage protection is based on recognition of the many substantial and critical interactions that occur within natural, healthy ecological landscapes. These interactions are complex and occur at a variety of spatial (geographic) and temporal scales. For example, on a daily basis animals may move between protected areas that offer cover and protection from predators and areas where they forage; seasonally aquatic insects may emerge from a wetland and forage in upland habitat where they may also perform an important pollination function for plants; tree frogs and some salamanders move annually from breeding ponds to upland over-wintering sites; and, over the long term the movement and dispersal of organisms results in the exchange of genetic material among populations, thereby contributing to the genetic health, adaptation and evolution of species. A fundamental objective of an NHS is to provide functional ecological linkages in order to maintain natural interactions of plants and animals in the landscape.

The aspects essential to consider in creating successful ecological linkage are the width and length of linkage corridors, the habitat quality within linkage corridors, the redundancy of linkages and the creation of habitat nodes along linkage corridors. Generally the habitat must be of high quality and suitable for the species intended to move through a linkage. This is what is meant by a linkage being "functional". As the length of the corridor increases the width must also increase. It may be important to provide habitat nodes along the linkages to provide refuge for wildlife as it moves through the corridor, thereby providing an area where wildlife can forage and rest in a more protected habitat before completing their movement through a corridor. For species that may take more than one generation to move between major habitat cores, this may require sufficient resources to support overlapping populations along the length of the linkage. Redundancy of linkages increases the probability of a plant or animal finding a linkage for movement within the landscape. It also mitigates against future changes (*e.g.*, climate change) that may destroy or compromise one ecological connection.

Core Areas

The ability to protect the full range of native species diversity increases as the size of core areas increases, and as their shape becomes more regular (circular or square). Core areas that fall below certain size thresholds are incapable of providing suitable habitat for a large number of species that require large areas of habitat. These are frequently referred to as "area-sensitive" species. This is largely attributed to environmental conditions along the edges of cores (edge effects) that create light levels, soil and air moisture levels, ambient wind and temperature that

are significantly different from conditions that characterize the "core interior". Edge effects have been shown to penetrate 100 to 300^{+} metres into a forest patch. Thus to obtain one hectare of "interior conditions" buffered by the minimum 100 edge, requires a circular patch size of approximately nine hectares. However, one hectare of interior habitat provides insufficient habitat for the many area-demanding species common to southern Ontario. Nor does it begin to provide representation of our natural heritage, considering the historic landscape of near continuous forest cover that characterized the vegetation prior to European colonization (see section 4.1). Moreover, many species require a range of habitat conditions in which to survive, thus requiring cores containing a mosaic of habitats. Lastly, long term (indefinite) sustainability of biodiversity requires a landscape capable of supporting many populations of individuals to allow for normal ecological events of extinction and re-colonization, to facilitate evolution and speciation, to allow for response to widespread impacts such as climate change, and to support species near the top of the food chain that require extensive prey bases.

A recent study by Environment Canada (2004) examined the ability of various patch sizes to provide habitat for native species. The report suggests patch sizes to sustain various animal groups for a variety of ecosystems, two examples are provided below.

Treed Swamp Wetland:

- areas 100 to 400 ha in size provide habitat for all forest-dependent bird species though many populations may be small and will therefore rely on other areas of similar size to ensure long term viability;
- areas > 1000 ha in size provide habitat for some forest-dependent mammals but most will still be absent; and
- areas > 10,000 ha are considered fully functional ecosystems, however, these areas may still be of inadequate size for some large mammals such as gray wolf or bobcat

Upland Forest:

- areas 50 to 75 ha in size will support some area-demanding bird species;
- areas 100 ha in size will support approximately 60 percent of area-demanding species; and
- areas > 200 ha in size will support approximately 80 percent of area-demanding species.

It is apparent that a NHS must include some core areas of considerable size, much larger than have generally been protected in most urban and agricultural landscapes of southern Ontario. In many cases there are no individual remnant natural areas that meet the size requirements outlined above, especially on the well-developed Peel Plain that stretches west from Toronto, and includes that area of Halton below the escarpment lands. As such, a NHS must create large core areas, preferably by combining several existing natural features located in close proximity, combined with the long term ecological restoration of the intervening lands to a natural state. Similar to linkages, redundancy of large core areas is also important to the protection of biodiversity.

APPENDIX 2: SOME KEY HABITAT PARAMETERS FOR PRESERVING NATURAL HERITAGE FEATURES IN FRAGMENTED LANDSCAPES

Appendix 2: Some Key Habitat Parameters for Preserving Natural Heritage Features in Fragmented Landscapes

Key habitat parameter	Location	Study variable	Rationale	Source
25-125 m riparian corridor	Central Pennsylvania, with residential and agricultural habitats along stream	Breeding bird species richness and abundance	• Bird species sensitive to disturbance do not occur unless an undisturbed corridor >25 m wide from each bank was present. Protecting at least 25 m of riparian habitat provided both dispersal and breeding opportunities for avian communities. • 45% reduction of birds in agricultural areas that did not have fencerows approximately 100 m from the stream. • Naturally vegetated riparian corridors >125 m were needed to support the full complement of bird communities that approached reference conditions	Cronquist and Brooks 1993
Successional and wooded buffers (width not a factor)	Southeastern Minnesota agricultural and wooded landscape	Stream temperature (effects on brook trout populations)	• Successional buffers (grasses and forbs) provide as much shade as wooded buffers in streams with width less than 2.5 m. • Successional buffers also tend to be less eroded, have less exposed bank • Mosaic of successional and wooded buffer areas is recommended	Blann and Nerbonne 2002
20-50 m wide riparian buffer strips	Clearcuts/forest in Newfoundland	Breeding bird guilds	• Riparian buffer strips of this width were used by a relatively abundant and diverse assemblage that included species from a variety of habitat guilds • Even very wide buffer strips (>100 m) may not provide adequate interior forest conditions and could act as ecological traps, compelling these species to breed in areas where nest predation is high	Whitaker and Montevecci 1999
150 trees/ha interspersed with mixed habitats, conifers and food-producing species	Converted railroad ROW in southeast Nebraska	Breeding and migrating bird species richness	• In intensively cropped areas, limited habitat patches or corridors may be the only suitable nesting habitat available for many species and, during migration, the only available stopover sites with appropriate food and cover resources • Railroad rights-of-way in conversion to recreational trails can sustain a wide variety and abundance of birds where they are observed easily by birders and other trail users, affording educational opportunities.	Poague et al. 2000
Successional corridors though forest	Northwestern Pennsylvania	Plant species richness and vegetative cover	• Utility corridors serve as refugia for non-native species, not as foci of non-native invasion	Rubino et al. 2002
>10 ha successional areas	Eastern United States	Richness of forest mammal species	• Richness of forest predators (such as bobcats) depends on mammals of successional habitat such as lagomorphs • A variety of seral stages will support a diverse mammal community	Litvaitis 2001
100 m riparian strip	Bottomland hardwoods, Altamaha River, Georgia	Neotropical migratory breeding bird communities	• Forest corridors of about 100 m width should be sufficient to maintain functional assemblages of the six most common species of breeding migratory birds. • Functional forested corridors assimilate nutrients and organic matter, hasten the degradation of persistent pesticides and decrease the bioavailability of heavy metals.	Hodges and Krementz 1996
10-30 m vegetated buffer strips	North America	Stream temperature	• Empirical evidence that these widths have been shown to effectively maintain stream temperatures	Osborne and Kovacic 1993

Key habitat parameter	Location	Study variable	Rationale	Source
9-45 m vegetated buffer strip	North America	Sediment load in overland flow	• Fairly narrow strips of riparian vegetation can reduce sediment input to surface water (though efficiency dependent on many factors)	Osborne and Kovacic 1993
10-50 m vegetated buffer strips	North America	Surface and subsurface nutrient load	• Fairly narrow forested buffer strips remove nitrate from surface runoff and groundwater (though efficiency dependent on many factors)	Osborne and Kovacic 1993
39 m grass vs. 16 m forested buffer strips	Eastern Illinois	Phosphorus and nitrate-N	• Forest buffer strips are better than grassed at removing nitrate-N in subsurface groundwater, but forested buffer less effective at retaining P.	Osborne and Kovacic 1993
Urban riparian strip 60-150 m wide	Florida	Density and richness of breeding birds	• Neotropical migrants are sensitive to habitat areas and widths, species begin to be eliminated at 60 m.	Smith and Schaefer 1992
40 m forested riparian strip	Agricultural landscape, North America	Occurrence of red-eyed vireos	• Minimum forested riparian strip width supporting this species is 40 m	Stauffer and Best 1980
Forest fragments 1-3 ha	St. Croix river valley Minnesota	Bird migrant species and numbers	• Diverse array of forest fragments (1-3 ha) may serve an important role to stopover migrants, for feeding, • Nearctic deciduous woodlands may have higher levels of invertebrate food resources available during migrant passage than at other times of the year	Winker et al. 1992
Fields larger than 15 ha, with at least 50 m from "edge" (in this case forest or hedgerow)	Illinois agricultural land	Grassland-dependent bird species	• Grassland birds present in fields only >15 ha in size, appears to be a function of amount of "interior" habitat (areas away from woody cover where predators could be hiding)	O'Leary and Nyberg 2000
>10-15 m riparian buffer	Riparian corridors in Swedish forests	Target bryophye species	• 10-15 m is insufficient buffer to preserve bryophytes from logging impacts	Hylander et al. 2002
Corridors of trees along streets	Fragmented urban parks and wooded streets in Spain	Breeding bird density	• Even corridors as narrow as those along wooded streets serve as "overflow" habitat for species that density-dependent species	Fernandez-Juricic 2001

Key habitat parameter	Location	Study variable	Rationale	Source
Corridor quality is an important element of connectivity	Model based on demographics in northern latitudes (North America)	Population dynamics of *Peromyscus leucopus*	• Any connection between two isolated patches is better than no connection in terms of persistence and population size at equilibrium • Metapopulations with exclusively high quality corridors between patches have a larger population size at equilibrium • Increasing the number of high quality corridors between patches has a positive effect on the size of the metapopulation while increasing the number of low quality corridors has a negative effect • The addition to a metapopulation of a patch connected by low quality corridors has a negative effect on the metapopulation size	Henein and Merriam 1990.
Large habitat patches have large benefits, small habitat patches have supplemental value depending on connections and quality	Phoenix, Arizona	Various functions	Important variables are • patch: size and type, vegetative structure and diversity, patch context, naturalness index • Corridor: content analysis, corridor size and type, vegetative structure and diversity, corridor context, naturalness index • Network: mesh density/naturalness, matrix utility, circuitry and connectivity.	Cook 2002
Riparian buffers	Clinch and Powell River Basin, Virginia and Tennessee	Fish index of biotic integrity, mussel species diversity	• Protection and enhancement of naturally vegetated riparian corridors, better controls of urban runoff, and reintroduction of threatened and endangered species may help sustain native fish and mussel populations • Riparian buffers may not be sufficient to address losses in species diversity due to past cumulative effects of urbanization	Diamond and Serveiss 2001
Large core areas (over 100-500 ha)	Urban Sweden	Red-listed bird species	• Forest size is the dominating predictor of these species	Mortberg and Wallentinus 2000
Buffers should be made "impermeable" as possible using dense vegetation	North America	Bird species richness	• Use dense, simple structured vegetation for buffers	Marzluff and Ewing 2001
Buffer quality (not just width) is important for protecting stream quality	Minnesota	Invertebrate and fish assemblages	• The ability of grass buffers to maintain streambank stability and low sediment content in stream substrates suggests they may be a viable riparian management option	Nerbonne and Vondracek 2001

Key habitat parameter	Location	Study variable	Rationale	Source
Corridor quality is important for small mammal movement	Ottawa, Ontario	chipmunks	• Fencerows with tall trees and a woodland structure preferred movement corridors	Bennett et al. 1994
10 to 30 m from high water mark	Vermont	Streamside plant species	• To include 90% of the streamside plant species need a minimum corridor width of 10 to 30 m from high water mark	Spackman and Hughes 1995
75-175 m from high water mark	Vermont	Bird species	• To include 90% of bird species, need minimum corridor width of 75-175 m	Spackman and Hughes 1995
Below or just above high water mark	Vermont	Mammal species	• Use of stream corridors by most mammal species occurred below or just above the annual high water mark	Spackman and Hughes 1995
Stream corridor	Colorado	Peromyscus maniculatus	• Survival unaffected by corridor width, continuity or vegetation variables	
Quality of stream corridor incl. Diverse habitats	Illinois	Reptile and amphibian species richness	• Wider (>1000 m) corridors were no better than narrow corridors (100 m) at supporting greater numbers of reptiles and amphibians. • Proximity to core area and local habitat heterogeneity best explained species richness • Lack of upland habitat, lack of fishless pools, and reguilar inundation of remaining riparian habitat inhibit many species from occurring consistently through the corridor	Burbrink et al. 1998
Large grassland area (12 ha minimum)	Illinois	Richness of grassland bird species	• Minimum area requirements vary from 12 ha for grasshopper sparrows, 55 ha for northern harriers, 65 ha for upland sandpipers, 75 ha for Henslow's and savannah sparrows	Walk and Warner 1999
Grassland area of 200 ha	Maine	Diversity of grassland bird species	• Upland sandpipers reached 50% incidence at sites of 200 ha • Grasshopper sparrows reached 50% incidence at 100 ha • Vesper sparrows reached 50% incidence at 20 ha • Savannah sparrows reached 50% incidence at 10 ha	Vickery et al. 1994
Even narrow corridors (mean 31 m) can have a useful function of providing habitat for rodents and fragmentation-tolerant bird species	Dense residential development and coastal sage scrub fragments in California	Rodents and birds	• ROW (highway strips) serve as habitat for 9 species of rodents. In fact, density of many rodent species in highway strips was as great as density in habitat fragments. • Species richness of habitat-tolerant bird species was similar in ROW and habitat fragments, species richness of fragmentation-intolerant bird species declined in ROW compared with habitat fragments	Bolger et al. 2001

Key habitat parameter	Location	Study variable	Rationale	Source
Minimal requirements for area-sensitive species are 5 to 55 ha	Agricultural land in Illinois	Grassland birds	• Area-sensitive species included grasshopper sparrow (30 ha), Henslow's sparrow (55 ha), bobolink (50 ha), savannah sparrow (40 ha) and eastern meadowlark (5ha) • Some species that appear area-sensitive may be vegetation sensitive, including upland sandpiper (high percentage of live vegetation), field sparrow (short grass, tall vegetation), sedge wren (dense, short, heterogeneous vegetation)	Herkert 1994
Large grasslands	Review of grassland studies	Grassland birds	• Some small grassland species favour patches of grassland far in excess of their territory size, e.g. savannah sparrow, grasshopper sparrow, Henslow's sparrow, bobolink. • Other species area requirements are uncertain because some studies may be confounded.	Johnson 2001
100 m wide riparian buffer strips	Clear cuts in boreal forest, Alberta	Frequency of bird movements	• Even in forested landscapes dispersing juveniles use riparian buffer strips for protection from predators • Adults breed in buffer strips	Machtans et al. 1996
0.5 m wide corridors	Norway: meadows in devegetated matrix (controlled experiment)	Root voles	• Corridors allowed reproductive females to transfer between habitat patches	Aars and Ims 1999
High quality corridors that maximize interior connections over peripheral connections	Modelling study	Small mammal metapopulations	• Corridor quality and arrangement will influence metapopulation dynamics in a landscape of interconnected patches. • Landscape with a greater ratio of peripheral to interior patches will support smaller metapopulations • Number of corridor connections in a landscape does not influence population size unless it also alters the peripheral:interior patch ratio.	Anderson and Danielson 1997.
10-20m buffer strip of rough vegetation	Netherlands	Surface N and P	• A 10-20 m buffer strips with rough vegetation retains the majority of surface N and P, through retaining sediment-bound nutrients and contaminants, exchanging dissolved nutrients at the soil litter surface • Most subsurface inflows also retained.	Vought et al. 1995
75 m to 275 m buffer strip adjacent to turtle habitat		Freshwater turtles	• Fresh water turtles may require areas as wide as 275 m adjacent to wetlands to ensure protection of 100% of nest sites • 75 m buffer sufficient to protect 90% of nest sites	Burke and Gibbons 1995.

Key habitat parameter	Location	Study variable	Rationale	Source
20 - 60 m distance from forest edge		Physical edge effects (wind, light, decreased litter moisture, increased vapor pressure deficit, decreased humidity, increased shrub cover	• Physical edge effects have been found within 20-60 m of the forest edge, depending on aspect • Drying winds and sunlight penetrate further into south-facing edges than north facing edges	Matlack 1993 Fraver 1994
25-35 m from amphibian spawning sites	Maine	Pond-spawning amphibians	• Depth of edge effects conservatively estimated to be between 25-35 m for pond-spawning amphibians	Demaynadier and Hunter 1998
60 m from forest edge	Roanoke Basin, North Carolina	vegetation	Vegetation responses along edge-to-interior gradients in mixed hardwood forests of the Roanoke River basin are estimated to penetrate to 60 m on south-facing edges	Burke and Nol 1998
100 m from forest edge	Various locations in eastern North America	birds	Edge effects can be noted to 100 m from forest edge	Gates and Gysel 1978 (not found), Ranney et al. 1981 (not found), Temple 1986 (not found), Burke and Nol 1998
5 km from reserve boundary		vegetation	• Serious edge effects (including problems related to heavy use my humans and domestic animals) occur anywhere within 5 km of a reserve boundary	Brown et al. 1987.
300 to 400 m upslope of road crossing over stream, 30-500 m downslope	Massachusetts	Physical stream alteration	• Channelized portions of streams tend to occur from 30 to 400 m upslope and 30-500 m downslope of roads	Forman and Deblinger 2000
Effects on stream course 200-1500 downstream of road: average road effect zone 300m	Massachusetts	Physical effects of roads on streams	• Road salt and contaminants measured at distances of 200 to 1500 m • Roadside exotic invasion measured to 120 m • Forest interior birds: 600 m • Grassland birds: hundreds of m	Forman and Deblinger 2000
70 m into forest	Delaware	Sociological edge effects	• Sociological edge effects penetrate up to 70 m into forest from edge	Matlack 1993

Key habitat parameter	Location	Study variable	Rationale	Source
30 m buffer width on streams (from edge)	Review article	Biotic indices (invertebrates)	• Highest biotic indices found where at least 60% of the riparian buffer zone upstream of the sampling point was at least 30 m wide, • lowest (<20) where less than 50% of the buffer was that wide	Horner et al. 1998
22 cm above mean annual water level fluctuation	Review article	Plant species richness	• Hydroperiod (inundation period, depth, frequency, duration) is a major determinant of wetland character. • Plant species richness declined with increased mean annual WLF in the scrub-shrub zone. • No emergent areas had more than 14 spp if WLF exceeded 22 cm • 30% of the areas with WLF <22 cm had at least 16 spp. • in addition to urbanization level, a key determinant of the biological condition appears to be the integrity of the riparian area available to buffer the aquatic community, in some measure, from negative influences.	Horner et al. 1998.
10-50 m buffer from water's edge		Diffuse pollution control	• For control of diffuse pollution require 10 m buffers for small ditches and streams >50 m for large rivers.	Haycock and Muscutt 1995
10 m buffer strip from stream edge	Netherlands	Removal of N and P	• 10 m wide buffer strip removed 75% of nitrate • 10 m wide buffer strip removed 65-95% of phosphorus	Vought et al. 1995
buffer strip 15 m to 46 m from stream bank on flat ground	Indiana	Removal of sediment	• 50 foot strip of bluegrass removed 46% of sediment (most N and P are attached to sediment, removal of non-sediment contaminants is much less effective with buffer strips) • 150 foot buffer with 3% slope reduced sediment by 90% • slopes >10% are too steep to allow significant detention of runoff and sediment	Palfrey and Bradley undated
16-25 m	Not noted	Stream temperature	• Maximum angular canopy density (maximum shading ability) is reached within a width of 80 feet, with 90% of the max reached within 55 feet	Palfrey and Bradley undated
46 m on both sides of centre line, 15 m beyond floodplain, whichever is greater	Harford Co., Maryland	Transition zones (food, cover, travel routes, roosting sites,	• Examples of recommended buffer areas around 3rd order streams	Palfrey and Bradley undated
3 x canopy height or 15 m + 1.2 m for each 1% increase in slope, whichever is greater	Harford Co., Maryland	Protecting various stream functions	• Examples of recommended buffer areas	Palfrey and Bradley undated
50 ft + 4 x percent slope, in feet	Virginia	Protecting various stream functions	• Examples of recommended buffer areas	Palfrey and Bradley undated

Key habitat parameter	Location	Study variable	Rationale	Source
30 m from high water line of waterbodies	California	Protecting various stream functions	• Example of recommended buffer areas	Palfrey and Bradley undated
30-100 m of riparian buffer		beaver	• Clallam County Critical Area Code recommendations	
67-93 m	Washington	Small mammals	• Clallam County Critical Area Code recommendations	Johnson 1999
100 m	Washington	Large mammals	• Clallam County Critical Area Code recommendations	Johnson 1999
75-200 m buffer from riparian edge	Washington	birds	• Clallam County Critical Area Code recommendations	Johnson 1999
20-50 m into forest edge	Review article	Physical edge effects air moisture, vapor pressure deficit, air temperature, light, soil moisture, chmical substances)	• Empirical measurement of these variables	Murcia 1995
15-150 m into forest edge	Review article	Tree stem density, basal area, canopy cover, subcanopy cover, understory cover, liana density, seedling density, plant/seedling growth, canopy damage, mortality	• Empirical measurement of these variables	Murcia 1995
Width of buffer zones needed to protect woodland neotropical breeding species largely undetermined	Eastern North America (review article)	birds	• Review of urban-rural landscape gradients and what affects them	Friesen 1998

Key habitat parameter	Location	Study variable	Rationale	Source
Restriction of edge development is critical to bird diversity; is related to housing density	Missouri Ozarks	Abundance of forest interior migrant species	• Forest edge type is a more important landscape feature affecting species composition in a forest matrix than forest patch size	Nilon et al. 1995
Important to protect breeding and post-breeding habitats together	Putnam co. Florida	Pond-breeding amphibians	• Distance and directional component of buffers required	Dodd and Cade 1998
Importance of protecting small, temporary wetlands	North America	Pond-spawning amphibians	• Small temporary wetlands need to be incorporated into protected areas	Semlisch 2000
Landscape planting can affect the number of urban bird species using an area	Phoenix, Arizona	Urban bird species	• Structural design of a given area (number and type of trees planted) probably plays a primary role in affecting the distribution of most bird species in urban environments • Regardless of land use designation, landscape design and management of an area may strongly influence whether an area is attractive to a given bird species	Hostetler and Knowles-Yanez 2003
Differences between non-forested and forested streams can be complex	Urbanizing areas along Delaware River, southeastern Pennsylvania	Water quality, benthic algae, benthic macroinvertebrates, fish	Preliminary results (after 1 year of 3 year project): • No clear relationship between water quality and urban development • Non-forested reaches have lower diversity, lower evenness and greater biomass than forested reaches • Greater total biomass and number of fish individuals in non-forested stream reaches than in forested stream reaches	Hession et al. 2000
Buffer zones can be set using the flight initiation distance of wildlife species	Australia	Flight initiation distance of shorebird species	• Flight initiation distance is species-specific	Blumstein et al. 2002
Restrict housing density in areas with sensitive species	Urban habitats in Tucson, Arizona		• Housing density best explains variation in species richness • Retaining or replanting native vegetation becomes increasingly important to many bird species as housing density increases • Riparian areas positively influence species richness for native breeding birds • Reduction of native ground cover will likely reduce or eliminate native birds dependent on it	Germaine et al. 1998.

Key habitat parameter	Location	Study variable	Rationale	Source
Birds are the best indicators of landscape condition within near vicinity of small stream riparian wetlands, fish best indicator of broader landscape patterns	Upper Mississippi, Lake Superior, St Croix River, Minnesota	Birds, amphibians, fish	Shrub carr vegetation, bird and fish diversity and richness generally decreases with increasing cultivation of the landscape Amphibian abundance decreases and fish abundance increases as the proportion of open water and rangelands increases Bird diversity and richness increase with forest and wetland extent in the landscape Shrub carr vegetation, amphibians and birds are influenced by lad use at small landscape scales (500 and 1000 m), fish respond to land use at larger landscape scales (2500, 5000 and the catchment)	Mensing et al. 1998

APPENDIX 3: DESCRIPTION OF REGION OF HALTON MAPPING METADATA

Appendix 3: Description of Region of Halton mapping metadata

Data Layer	Source	Comments
1. VTE Species	• No data used in current analysis	• Not used as a layer to generate NHS • Policy driven protection
2. Floodlines	• Grand River Conservation Authority • Conservation Halton • Credit Valley Conservation	
3. Wetlands	• All Conservation Authority Wetland information • MNR Wetlands	• includes evaluated and unevaluated wetlands
4. Provincially Significant Lake Ontario & Burlington Bay Shoreline	• Original source unknown	• Follows physical shoreline based on 2007 Orthophotography
5. ESA	• Region of Halton GIS data files	• Based on ESA consolidation report
6. Parkway Belt	• Parkway Belt – Open Space overlay	• Open space designation used only
7. ANSI	• Source data from MNR	• Includes Provincial, Regional and Candidate Earth Science and Life Science ANSIs
8. Carolinian Canada Sites	• Region of Halton GIS data files	• revisions required based on urban development
9. Regional Significant Woodlands	• MNR woodland layer	• Application of Halton ROP criteria to identify candidate significant woodlands
10. Regional Forest	• Region of Halton GIS data files	•
11. North Aldershot EPA	• Region of Halton GIS data files	•
12. NEC Escarpment Natural Area and Escarpment Protected Area	• MNR data files	•

Data Layer	Source	Comments
13. Waterfront Parks	• Region of Halton GIS data files	•
14. Greenbelt NHS	• From Province	• as per Provincial Greenbelt Plan 2005
15. Streams & waterbodies	• Data from Conservation Authorities	•
16. Conservation Halton Park	• Conservation Halton	• The *Glenorchy Conservation Area* (Oakville)
17. Enhancements	• North-South Environmental map review	•
18. Local Municipal OP Land Use designations	• Local Municipal GIS data files	• Greenland - protected open space data defined by local municipalities used to define NHS within urban areas