Middlesex Natural Heritage Systems Study

A study to identify Natural Heritage Systems in Middlesex County

2014

Prepared by

Upper Thames River Conservation Authority

in cooperation with Middlesex County Conservation Authorities

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North Thames River Valley near Plover Mills. *Photo by Cathy Quinlan*

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Executive Summary

The 2014 Middlesex Natural Heritage Study (MNHSS 2014) evaluated the significant terrestrial (land) resources of the county using scientific methods and Geographic Information Systems (GIS) modeling.

Chapter 1 introduces the importance of the natural heritage systems planning, including policy rationale and a history of natural heritage planning in Middlesex County and the nearby counties of Huron and Oxford. The study scope is discussed, including the study area (geographic Middlesex), work plan and general limitations of the study.

Chapter 2 describes how the various components of the county's natural heritage system were defined and mapped. Using a variety of base mapping layers developed by the Middlesex County Conservation Authorities, the first step was to identify and delineate the smallest unit of vegetation – the *Vegetation Community*. Eighteen types of Vegetation Communities were delineated. The Vegetation Communities were then lumped into seven broader categories called *Vegetation Groups* including woodlands, thickets, meadows, water features, connected vegetation features and watercourse bluffs and depositional areas. Three Vegetation Ecosystems were defined: terrestrial, wetland and aquatic. The final step consisted of delineating Vegetation Patches, which are a mosaic of one-to-many abutting *Vegetation Groups*. Chapter 2 concludes with a summary of mapping results. In summary, there is 20.1% vegetation cover in the study area broken down as follows: 15.8% woodland cover, 1.0% thicket cover, 2.5% meadow cover, 0.7% water feature cover, and <0.1% connected vegetation feature cover. Wetland cover (comprised of woodland, thicket and meadow groups) is 3.5%. Environment Canada's targets for sustainability are 30% vegetation cover and 6-10% wetland cover.

Chapter 3 describes the 15 criteria used to identify significant natural heritage features and functions in the study area. Two types of criteria were developed: criteria for *Vegetation Groups* and criteria for Vegetation Patches. Three criteria are difficult to map and will have to be evaluated as part of the site specific field work needed for a Development Assessment Report (DAR). Each criterion is described, providing rationale, application/mapping rules and modeling results in terms of how many Vegetation Communities, Groups or Patches meet each criteria.

Chapter 4 summarizes the results of the criteria model. Patches meeting one or more criteria are deemed significant in this study. Maps showing the patches that meet one or more criteria for significance are provided for the study area (geographic Middlesex) as a whole and for each local municipality. Approximately 19.7% of the study area is in significant natural feature cover. This translates to 78.5% of patches (2749 of 3502) being identified as significant, representing 98.8% of the patch area. A comparison with the 2003 Middlesex Natural Heritage Study is provided.

Chapter 5 provides recommendations for the implementation of this science-based study. A number of land use planning related recommendations are provided along with additional stewardship and education recommendations.

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Aerial view of narrow woodlots in Middlesex County. *UTRCA photo*

1.0 Background

1.1 Purpose of the Middlesex County Natural Heritage Systems Study

The Middlesex Natural Heritage Systems Study (MNHSS) addresses the need for information on the state of the county's natural areas and systems. The study provides a landscape level assessment of natural heritage features and functions. It builds on the 2003 Middlesex Natural Heritage Study (MNHS) (UTRCA 2003), which was a leading-edge study at the time.

The identification of significant natural features in southwestern Ontario is an important undertaking. Environment Canada (2013) identified that human activities, such as agriculture, urban development and associated infrastructure, have resulted in the loss or degradation of over 70 per cent of the naturally vegetated areas in Southern Ontario. In some areas this reduction is greater. The remainder of these naturally vegetated areas tends to exist in unconnected patches across the landscape. It has also been found that in addition to the loss of naturally vegetated areas, intensive land use activities have also contributed to degraded water quality conditions in many streams and lakes.

The Province of Ontario provides policy guidance to municipalities on matters of provincial interest in the Provincial Policy Statement (PPS). The PPS (2014) includes the following general directives for municipalities related to planning for natural heritage:

> ***Excerpt from the 2014 PPS (page 22)***
>
> **2.0 Wise Use and Management of Resources**
> Ontario's long-term prosperity, environmental health, and social well-being depend on conserving biodiversity, protecting the health of the Great Lakes, and protecting natural heritage, water, agricultural, mineral and cultural heritage and archaeological resources for their economic, environmental and social benefits.
> Accordingly:
> **2.1 Natural Heritage**
> 2.1.1 Natural features and areas shall be protected for the long term.
> 2.1.2 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, recognizing linkages between and among *natural heritage features and areas*, *surface water features* and *ground water features*.
> 2.1.3 *Natural heritage systems* shall be identified in Ecoregions 6E & 7E1*,* recognizing that *natural heritage systems* will vary in size and form in *settlement areas*, *rural areas*, and *prime agricultural areas*.

Note: Middlesex County is fully within the area identified as being in Ecoregions 6 E and 7E in the PPS 2014

The MNHSS (2014) is a science based study which uses high quality ortho-imagery and geographic information system (GIS) modeling to identify natural vegetation patches in the County that are considered to be "significant." In this context, significant is referring to the PPS (2014) definition of significant (see text box below).

Excerpt from the 2014 PPS (pages 48, 49)

Significant means

a) in regard to wetlands, coastal wetlands and areas of natural and scientific interest, an area identified as provincially significant by the Ontario Ministry of Natural Resources using evaluation procedures established by the Province, as amended from time to time;
b) in regard to woodlands, an area which is ecologically important in terms of features such as species composition, age of trees and stand history; functionally important due to its contribution to the broader landscape because of its location, size or due to the amount of forest cover in the planning area; or economically important due to site quality, species composition, or past management history. These are to be identified using criteria established by the Ontario Ministry of Natural Resources;
c) in regard to other features and areas in policy 2.1, ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or natural heritage system;

Criteria for determining significance for the resources identified in sections (c)-(e) are recommended by the Province, but municipal approaches that achieve or exceed the same objective may also be used.

While some significant resources may already be identified and inventoried by official sources, the significance of others can only be determined after evaluation.

The MNHSS (2014) incorporates the most current information available from the Ministry of Natural Resources (MNR) to identify areas that meet components of the PPS definition of significant. The MNHSS method is intended to be a local approach to identifying elements of the natural heritage system as contemplated in second last paragraph of the definition.

The MNHSS provides mapping of the natural heritage system for the County of Middlesex and the City of London. The PPS (2014) defines the natural heritage system as follows:

> ***Excerpt from the 2014 PPS (page 45)***
>
> ***Natural heritage system:*** means a system made up of *natural heritage features and areas*, and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include *natural heritage features and areas*, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue. The Province has a recommended approach for identifying *natural heritage systems*, but municipal approaches that achieve or exceed the same objective may also be used.

Agriculture is the dominant land use in the County of Middlesex and in the area of the City of London that is located outside of the Urban Growth Boundary. The working agricultural fields can provide linkages between natural heritage features and areas and these linkages may be utilized in different ways depending on the cropping patterns or the time of year. The MNHSS does not attempt to map all of these potential system linkages but rather acknowledges that the agricultural landscape can provide linkages. Given the size of the study area, the predominantly agricultural land use and that land use change is anticipated to be limited, the MNHSS maps the natural heritage system at the county level of scale.

In cases where land use change is anticipated, the potential impact of the land use change on system linkages must be considered. For example, if agricultural land is proposed to be converted to urban development, the system linkages that would have been provided in the working agricultural landscape may be disrupted or eliminated by the post development urban landscape. In such cases it is necessary that natural heritage system linkages be studied at an appropriate level of detail and that system linkages be provided as part of the planning approval process.

For the area of London that is within the Urban Growth Boundary, the MNHSS provides a broader systems context within which existing urban development exists and new urban development may be planned.

1.2 The 2003 Middlesex Natural Heritage Study (MNHS)

The County of Middlesex has taken steps to identify and protect natural heritage features. The 2003 Middlesex Natural Heritage Study (UTRCA 2003) was led by the Conservation Authorities and completed for the County of Middlesex. Various partners participated in the project. The study has produced a solid information and policy basis to protect and rehabilitate the County's woodland and wetland features and systems. The 2003 MNHS had the following goals:

1. To increase understanding of the County's natural heritage features and systems (e.g. woodlands, wetlands, aquatic systems such as streams and rivers, threatened or endangered species, etc.).
2. To develop land use planning information and policy, at both the County and local municipal levels, in order to identify, protect and enhance the natural heritage features and systems.
3. To encourage and facilitate private stewardship and public education.
4. To strengthen links between natural areas and protect the relationships between plant and animal communities.

The study area did not include the City of London or the three First Nation Reserves.

The 2003 study was a pilot project for the Carolinian Canada Big Picture Project and the Ministry of Natural Resources Ecological Land Classification System. The study involved analysis of existing information along with new botanical information for private property that was collected as part of the study. This information, combined with a detailed review of the ecological literature, lead to the development of a set of landscape criteria which were then modelled using Geographic Information System (GIS) technology.

To run the model, existing air photography and satellite imagery was used to create vegetation and watercourse information. The 2003 study provides a baseline for future comparison, a natural heritage systems map with a focus on woodlands, landscape criteria for considering woodland significance and a policy discussion to assist with implementation. The MNHS, 2003 can be accessed at the following link: http://www.thamesriver.on.ca/MNHS/MNHS.htm

The MNHS (2003) was accepted by Middlesex County Council. The current Middlesex County Official Plan relies on the MNHS (2003) to define significant woodlands and the Conservation Authorities have worked with the County to develop DAR guidelines and patch confirmation criteria to assist with implementation.

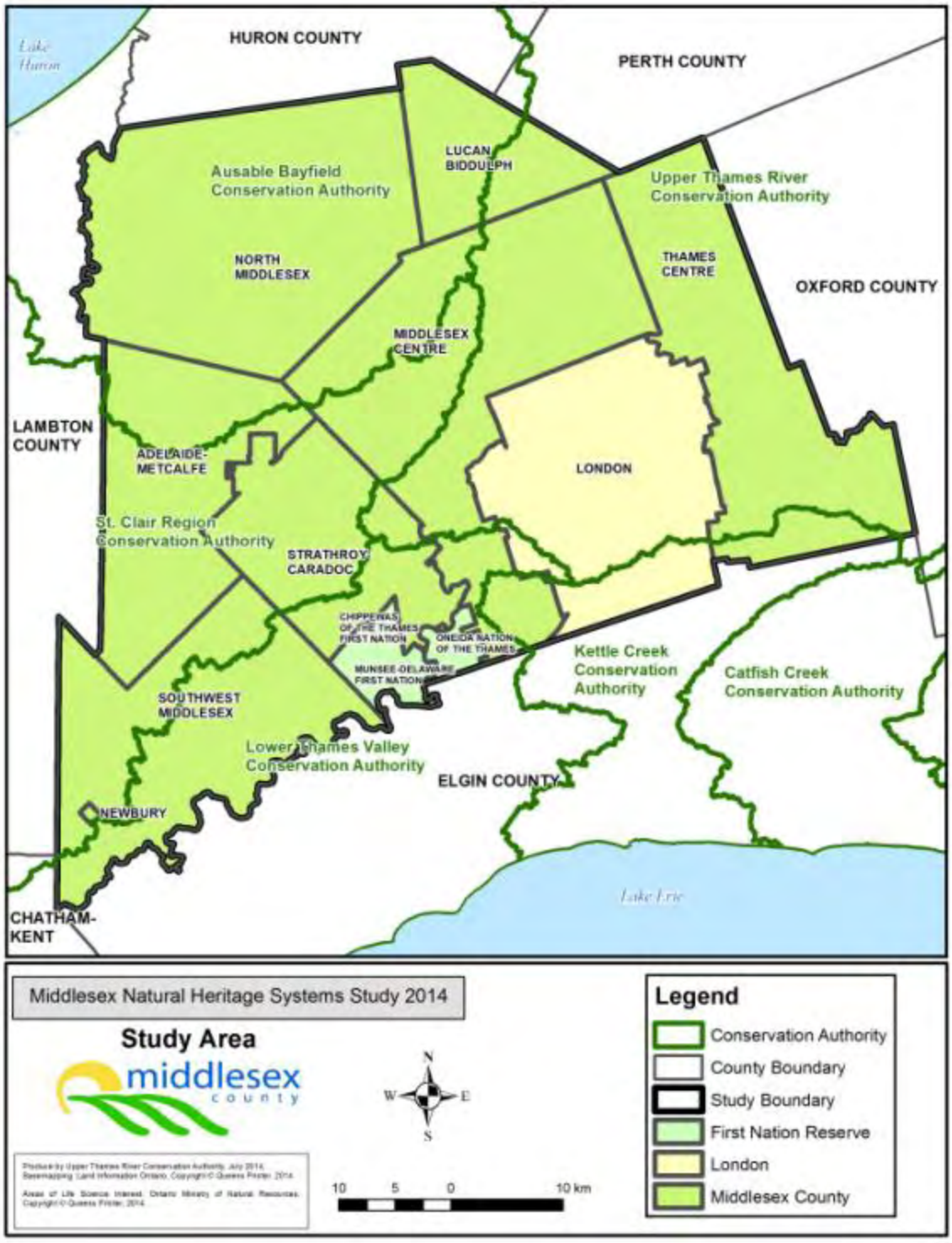
The science method developed through the MNHS (2003) has been built on over the years through other natural heritage studies. The Oxford County Natural Heritage Study (ONHS, 2006) followed a similar landscape approach methodology. The ONHS broadens the approach beyond wooded areas to include flood plain meadows and other elements of the natural heritage system. The ONHS was received by the County of Oxford and subjected to a third part peer review. The basic approach was validated through the peer review and minor adjustments were made to some criteria. The County of Huron is nearing completion of a study that builds further on the peer reviewed ONHS. Refinements to the methodology for the Huron study have been made to incorporate the ONHS peer review results and also to refine the vegetation mapping methodology and to incorporate the Lake Huron shoreline and large river valley ecosystems.

1.3 Study Area

A map of the study area is shown in Figure 1. The study area includes the corporate County of Middlesex, the City of London and the three First Nation Reserves: Oneida Nation of the Thames, Chippewas of the Thames First Nation and Munsee-Delaware First Nation. This area includes part of five Conservation Authority watersheds, also shown on Figure 1. The three First Nation reserves were included in the mapping of the Vegetation Patches and in the significance analysis as they are part of the natural heritage system of the study area. They are not included in the implementation recommendations other than that it is recommended that the County share the results of the mapping and analysis with First Nations for their consideration.

Meadow habitat at Komoka Provincial Park. *Photo by Cathy Quinlan*

Figure 1. County of Middlesex showing member municipalities, Conservation Authority boundaries, City of London and First Nation Reserves.



1.4 Project Governance, Committees and Peer Review

Steering Committee

Since this work was essentially an update to the 2003 MNHS, the methodology was somewhat streamlined. The project was guided by a Steering Committee with representatives from the following:

- County of Middlesex
- Local Municipalities
- The City of London
- Ausable Bayfield Conservation Authority
- Kettle Creek Conservation Authority
- Lower Thames Valley Conservation Authority
- St. Clair Region Conservation Authority
- Upper Thames River Conservation Authority
- Ministry of Natural Resources

The Steering Committee approved the final project proposal and oversaw the fulfillment of project time lines and deliverables. Any significant changes to project methodology or timing were approved by the Steering Committee. The Upper Thames River Conservation Authority oversaw project coordination.

Technical Committee

A Technical Committee was established to assist with developing the Landscape Criteria for the updated MNHSS. The main work of the Technical Committee was completed through participation in a one day workshop in the fall of 2012.

Individuals with expertise in ecology, biology, geographic information systems and planning from 19 organizations were invited to participate on the Technical Committee:

- County of Middlesex
- Municipality of Thames Centre
- Municipality of Strathroy-Caradoc
- The City of London
- Middlesex Conservation Authorities
    - Ausable Bayfield Conservation Authority
    - Kettle Creek Conservation Authority (could not attend)
    - Lower Thames Valley Conservation Authority
    - St. Clair Region Conservation Authority
    - Upper Thames River Conservation Authority
- Maitland Valley Conservation Authority
- Ministry of Natural Resources
- Carolinian Canada
- Ducks Unlimited Canada
- Nature Conservancy of Canada (could not attend)
- Western University / Thames Talbot Land Trust

- Staff from neighbouring counties
    - Oxford County
    - Lambton County
    - Perth County

At the workshop, there was a detailed review of the landscape criteria developed for the Huron Natural Heritage Study (the most current study) and confirming or adjusting them to be applied to the updated MNHSS. The workshop was well attended and provided excellent feedback. UTRCA staff conducted further literature searches and edited the report.

Peer Review

The project was subjected to a technical peer review by a qualified third party expert at two stages in the process. First, the Peer Reviewer was asked to review the technical information and assumptions that were made by project technical staff to develop the draft MNHSS methodology and significance criteria. The Peer Reviewer provided detailed comments that were used to refine the study methodology and the preliminary GIS model was run to generate mapping. The Peer Reviewer was provided draft outputs from the model and additional comments were provided. This second set of comments from the Peer Reviewer were reviewed and incorporated into the final project methodology.

Dorchester Swamp. *Photo by Cathy Quinlan*

1.5 Statement of Limitations (Scope)

The methodology for this study involves using the best available vegetation information from digital mapping layers and current landscape ecology literature to develop landscape criteria for significance (e.g., size, proximity). Several limitations are noted in this section.

1.5.1 Mapping Limitations

The base mapping layer is based on spring colour 2010 aerial photography (ortho-imagery). The 2014 MNHSS maps only the boundaries of the natural features in existence in 2010 as seen on the 2010 ortho-imagery. Base mapping layers are manually interpreted through an on-screen process. The *Vegetation Community* information is derived by the colour and patterns seen on the photography. Misinterpretation of certain features may occur. As well, the mapping layer is only accurate to the date and season that the air photo was taken.

Although the boundary of some natural heritage features will have changed from 2010 to present, it is important to use a base layer from a single point in time that is consistent across the county so that it can be used for future comparisons. The Ecological Site Assessment Process and/or associated DAR will verify any changes to the boundaries of the natural features.

Another limitation with mapping features that are developed and maintained by dynamic processes (e.g., old field succession) is that they are more likely to change over a shorter period of time than features that are more stable (e.g., mature woodlands).

For many of the ecosystem functions and derived services, it is not possible or appropriate to delineate clear spatial boundaries between natural heritage features. Often these boundaries are dynamic in both space and time, depending on seasonal patterns of rainfall and/or land use. Dynamic processes include geomorphology (e.g., bluff development), natural disturbances such as fire, wind erosion, flooding, plant succession (e.g., meadow to thicket to woodland), and anthropogenic disturbances (e.g., cattle grazing, drainage changes, deforestation, etc.).

1.5.2 Watercourse Layer

To accommodate budget constraints, the watercourse layer was not updated and therefore was not incorporated as a component of the natural heritage system for this study. Instead, Vegetation Communities adjacent to any major watercourse were identified as significant for their riparian functions. Through project development and peer review, the authors feel that this layer is an important element of the natural heritage system and encourage the County to update the watercourse layer and verify the classification of municipal drains under the Municipal Drain Classification Project (Department of Fisheries and Oceans Canada 1999), especially coldwater areas and other small watercourses. It should be noted that fish habitat is a natural heritage feature identified under Section 2.1 of the PPS, so all potential fish habitat (i.e., open watercourses) should be identified.

1.5.3 Connectivity and System Linkages

Ecological connectivity is a fundamental conservation biology principle that is scientifically defensible, yet difficult to identify given the dynamic nature of the landscape and the species within it (Rodewald 2003). Given the complexity of defining linkages and sustainability in an agricultural landscape, where it could be argued that the majority of farm fields are part of the system, the MNHSS does not attempt to identify current or future linkages between patches or across agricultural fields or neighbourhoods or along unvegetated stretches of watercourses since the concern over loss of connectivity is not as great as it is for urban areas.

Instead, Chapter 5 outlines recommendations for areas where there is a conversion of land use that affects the porosity of the landscape and the ability for species to move between features. The recommendations consider the site as a part of the overall system and must demonstrate there is no impact on the loss of connectivity and linkages between the features defined in this study. The analysis of the loss of agricultural land to other uses must characterize and prioritize these linkages according to factors such as the presence of threatened and endangered species, proximity to other features, application of the Carolinian Canada Big Picture corridor rules, etc. As well, several significance criteria deal with proximity between Vegetation Communities and Patches.

This study evaluates what is significant, but does not attempt to analyze whether the natural heritage features are in the best location, nor does it build an ecologically sustainable ecosystem.

1.5.4 Features Identified through DARs

For features dependent on Development Assessment Reports (DARs) to identify them, mapping will not be comprehensive in the County Official Plan nor in the township Official Plans. Planners need to be informed that some features can only be identified through site inventory and ensure that the DAR considers all features, whether mapped or not. These features include:

- Significant Wildlife Habitat,
- Groundwater Dependent Ecosystems and
- Watercourse Bluffs and Depositional Areas.

Deciduous woodland in Southwest Middlesex. *Photo by Cathy Quinlan*

2.0 Mapping Guidelines

2.1 Assemble Digital Vegetation Layers (Base Mapping Layers)

Before evaluation criteria for significance can be applied to the natural heritage features of the County, it is necessary to develop a method to define and delineate these natural heritage features and systems. This is an important step as the delineation of natural heritage features will affect the application of some criteria (e.g., size and nearest neighbor calculations).

Photo interpretation techniques using 2010 South Western Ontario Ortho Photography (SWOOP) as a backdrop were used to prepare a detailed and comprehensive mapping product of the natural heritage features in Middlesex County.

The natural heritage features were defined using a minimum scale of 1:2,000. The work was prepared in partnership by various conservation authorities, building on earlier work prepared for the 2003 MNHS as outlined in Table 1.

Table 1. Digital Mapping Layer Development by CAs for the 2003 MNHS and 2014 MNHSS

	2003 MNHS	**2014 MNHSS**
Product →	Digital layer of Woodlands and Wooded Wetlands	Mapping update to include digital layers of Woodlands, Wetlands, Watercourses, Water Bodies, Thickets and Meadows
Upper Thames River	**UTRCA** developed the layer using a patchwork of 2000 black and white ortho-imagery combined with older paper mapping and some satellite imagery for areas not covered by the 2000 air photos	**UTRCA** updated the layer using 2010 colour imagery
Lower Thames River	Data acquired digital layer from OMNR and verified using colour Infared imagery and contact prints	**UTRCA** updated the layer using 2010 colour imagery
Ausable Bayfield	**ABCA** developed the layer using a patchwork of 1999 black and white ortho-imagery combined with older paper mapping and some satellite imagery for areas not covered by the 1999 air photos.	**ABCA** updated the layer using 2010 colour imagery
Sydenham	Data acquired digital layer from OMNR and verified using colour Infared imagery and contact prints	**SCRCA** updated the layer using 2010 colour imagery
Kettle Creek	Data acquired digital layer from OMNR and verified using colour Infared imagery and contact prints	**UTRCA** updated the layer using 2010 colour imagery

2.2 Delineation of Digital Vegetation Layers

Air photo interpretation enables coarse level identification of *Vegetation Communities* without a site visit. All digital vegetation layers (a compilation of Conservation Authority and MNR data as described in Section 2.1) were corrected to reflect the 2010 colour ortho-imagery. For the UTRCA and ABCA watersheds, the vegetation had been corrected to the 2006 photography prior to this study for other purposes. In these areas, a comparison between 2006 and 2010 could provide additional information about the changes that occurred in natural heritage over that time. In the LTVCA, SCRCA and KCCA watersheds, only the woodlands and wooded wetland areas were previously updated to 2006 imagery. All other *Vegetation Communities* were interpreted and created from 2010 imagery.

Natural heritage in Middlesex County is comprised of a hierarchy of four vegetation layers or components described in detail in this chapter and shown in the schematic below. The smallest unit of delineation is the *Vegetation Community*. *Vegetation Communities* are lumped by type into *Vegetation Groups*, which are then lumped into Vegetation Ecosystems (see Table 2). Contiguous *Vegetation Groups* are lumped into Vegetation Patches. The graphic below illustrates how the layers are put together.

Land ownership boundaries do not impact the creation of *Vegetation Communities*, Groups, Ecosystems and Patches. For example, any given Vegetation Patch could be under the jurisdiction of many landowners.

The metadata for Vegetation Patch and Group is included in Appendix F. The metadata for *Vegetation Community* is included in Appendix G.

Vegetation Layers in the MNHSS

Vegetation Community
smallest unit
18 types
↓
Vegetation Group
grouping of Vegetation Communities
7 types
↓
Vegetation Patch
grouping of contiguous Vegetation Groups

Vegetation Communities and Ecosystems

Vegetation Community
18 types
↓
Vegetation Ecosystem
grouping of Vegetation Communities
3 types

Table 2. Relationship between *Vegetation Communities*, Groups and Ecosystems

Vegetation Community **(18 types)**	***Vegetation Group*** **(7 types)**	**Vegetation Ecosystem (3 types)**
Deciduous Woodland	Woodland	Terrestrial
Mixed Woodland	Woodland	Terrestrial
Coniferous Woodland	Woodland	Terrestrial
Mature Plantation	Woodland	Terrestrial
Deciduous Swamp	Woodland, Wetland	Wetland
Mixed Swamp	Woodland, Wetland	Wetland
Coniferous Swamp	Woodland, Wetland	Wetland
Plantation Swamp	Woodland, Wetland	Wetland
Upland Thicket	Thicket	Terrestrial
Young Plantation	Thicket	Terrestrial
Young Plantation Swamp	Thicket, Wetland	Wetland
Wetland Thicket	Thicket, Wetland	Wetland
Meadow Marsh	Meadow, Wetland	Wetland
Upland Meadow	Meadow	Terrestrial
Connected Vegetation Feature	Connected Vegetation Feature	Terrestrial
Watercourse Bluff and Depositional Areas	Watercourse Bluff, Bar or Beach	Terrestrial
Water bodies	Water Feature	Aquatic
Major Watercourses?	Water Feature?	Aquatic?

2.3 *Vegetation Communities*

The smallest unit mapped in Middlesex County, the *Vegetation Community*, is a unit of vegetation normally visible and consistently interpreted on remotely sensed images. *Vegetation Communities* are internally homogenous and distinguishable at a 1:2,000 scale by the dominant types of plant forms that characterize the *Vegetation Community*.

The *Vegetation Communities* must be at least 0.5 ha and 30 m wide to be included (length is the longer direction and width is the shorter). This minimum width was chosen to ensure the protection of the roots of some of the tree species. Tree roots often extend out from the core of the tree to a distance of at least the height of the tree, and the average height of a tree in Middlesex County is 30 m. Vegetated areas 20 to 30 m wide are considered connecting features (e.g., hedgerows), not woodlands. Linear treed areas <20 m wide are considered windbreaks and are not mapped or included in this study, though it is understood that wind breaks do provide many benefits to the environment including protection from soil erosion. For consistency, the 30 m width was chosen as the minimum width for thickets and meadows as well as woodlands.

A Minimum Mapping Unit (MMU) of 0.5 ha was used as the minimum size of an isolated *Vegetation Community*. The ELC (Lee et al., 1998) uses 0.5 ha since vegetation features <0.5 ha are too small to be visible on air photos or to map. Land cover classifications commonly use a MMU of 0.5 ha to 1 ha for large scale county level maps, and 10 to 100 ha for very small scale regional maps.

Exceptions to the 0.5 ha MMU rule in this study include:

i) ***Connected Vegetation Features.*** These features do not have a minimal area associated with them, but they do have to be > 20 m in length and 20 to 30 m in width.
ii) ***Provincially Significant Wetlands.*** Some evaluated wetland communities are smaller than 0.5 ha and are retained as part of the natural heritage system.
iii) ***Artifacts of Mapping***. *Vegetation Communities* smaller than 0.5 ha in size are identified if they are either: 1) surrounded by *Vegetation Communities* or 2) connect two or more *Vegetation Communities* that are greater than 0.5 ha. *Vegetation Communities* less than 0.5 ha do not, by themselves, become a *Vegetation Group*, but they are included in the Vegetation Patch to maintain shape and size of the Vegetation Patch (see Figure 3).

Vegetation Communities in Middlesex County were mapped and updated following the manual on-screen digitizing procedures outlined in the Southern Ontario Land Resources Information System (SOLRIS) Image Interpretation Manual (OMNR 2004), with the following three exceptions:

i) ***Human Disturbance*** − Vegetated and non-vegetated features maintained by human disturbance, such as agriculture, pasture, aggregate operations, orchards, and impervious land uses, are not identified in this study.
ii) ***Structures*** − Buildings or structures less than 20 m in width are considered part of the surrounding natural feature (i.e., there is no hole carved out of the natural feature).
iii) ***Roads*** − All municipal roads separate *Vegetation Communities* regardless of their width. However, later, when *Vegetation Communities* are put into *Vegetation Groups*, clustering rules apply (see Section 2.4).

Note: Features such as agricultural fields, water bodies and watercourses <20 m wide are also considered part of the surrounding natural feature (i.e., they do not cause a break in the *Vegetation Community*), as per the SOLRIS manual.

Eighteen types of *Vegetation Communities* were delineated in Middlesex County. Table 3 provides a description of each *Vegetation Community* including how they are identified and the ELC equivalent. The ELC code name descriptions are provided in Appendix A.

In the ELC, woodland and forest are different types of habitat, where woodlands have 35-60% tree cover and forests have >60% tree cover. In this study, the word woodland is used instead of forest to be consistent with the PPS.

Marsh vegetation (Joe-Pye weed and cattails) around a pond in London. *Photo by Cathy Quinlan*

Table 3. Definition and Attribution of the 18 *Vegetation Communities*

Vegetation Community	Description and Methods uses for Identification on Imagery	ELC Equivalent (Appendix A)
1. Deciduous Woodland	- Comprised of tree species that lose their leaves at the end of the growing season and are capable of reaching heights of several metres (typically 20-30 m). - Individual deciduous trees have a billowy texture on air photography. If the image is taken when trees are not in leaf, individual trees have a translucent appearance such that tree trunks can be seen through the branching canopy.	FOD
2. Mixed Woodland	- Comprised of a combination of coniferous and deciduous tree species scattered throughout the *Vegetation Community* where each plant type comprises greater than 25% but less than 75% of the canopy.	FOM
3. Coniferous Woodland	- Comprised of > 60% cone-bearing tree species capable of reaching heights of several metres. - Individual trees have a conical shape with a pointed top.	FOC
4. Mature Plantation	- Comprised of either deciduous or coniferous (or mixed) tree species - Boundary distinguishable by at least one edge with a linear line - Most often started off as rows of conifers, and then the area filled in with deciduous trees. - At maturity, individual tree or rows of trees are not clearly discernible at 1:2,000.	CUP
5. Deciduous Swamp	- Deciduous woodland with a more open canopy (indicating lower tree vigor) located in an OMNR or CA identified wetland area. - Common in Middlesex.	SWD
6. Mixed Swamp	- Mixed woodland with a more open canopy (indicating lower tree vigor) located in an OMNR or CA identified wetland area.	SWM
7. Coniferous Swamp	- Coniferous woodland with a more open canopy (indicating lower tree vigor) located in an OMNR or CA identified wetland area. - Treed bogs, a type of coniferous wetland, are uncommon and often have a pond or low open thicket at the centre.	SWC
8. Plantation Swamp	- A mature plantation with a more open canopy (indicating lower tree vigor) located in an OMNR or CA identified wetland area. Not common in Middlesex. - Trees are usually conifers.	CUP
9. Upland Thicket	- Comprised of 25 to 60% tree or shrub cover (i.e., woody plants that are not capable of reaching heights of several metres). - Less than 20% standing water.	TPW, CUT, CUW

10. Wetland Thicket	- A thicket *Vegetation Community* that is either found along a watercourse, has greater than 20% standing water, or is located in an OMNR or CA identified wetland area. - Tree cover is either: i) between 10% - 25%, or ii) is less than 10% and shrub cover is greater than 25%. - Dark water tones interspersed throughout	SWT, FET, FES, BOT, BOS
11. Young Plantation	- Comprised of deciduous and/or coniferous tree types, although most are coniferous. - Boundary distinguishable by at least one edge with a linear line - Individual tree or rows of trees discernible at 1:2,000. - Does NOT include Christmas tree farms, fruit orchards, or other tree cash crops.	CUT, CUW
12. Young Plantation Wetland	- A young plantation *Vegetation Community* located in an OMNR or CA identified wetland area where individual trees or rows of trees are discernible at 1:2,000. Trees are usually conifers.	CUT
13. Upland Meadow	- Comprised of grasses or forbs where less than 25% of the canopy is comprised of woody plants. Trees or shrubs often widely scattered	TPO, CUM
14. Meadow Marsh	- A meadow *Vegetation Community* located in an OMNR or CA identified wetland. - Fens and open bogs are uncommon wetland types in Middlesex County. They are not distinguished from marshes in the mapping layer, but should be distinguished when conducting DAR site specific surveys. - Non-treed wetlands must be at least 30 m wide to be included.	FEO, BOO, MAM, MAS, SAS, SAM, SAF
15. Water Bodies	- Comprised of a body of standing water at least 20 m wide adjacent to another *Vegetation Community*. Can include a: • man-made pond associated with construction or extraction (e.g., aggregate pit), • reservoir created by a dam or barrier, • natural pond within a wetland or a natural water feature such as a kettle lake, or • sewage lagoon found in/on the outskirts of an urban area. - Appears as a flat plain surface on air photos; may show patterns of wind disturbance, floating aquatic vegetation, or cloud reflections.	OAO
16. Major Watercourse	- A linear feature >1 km long and mostly >20 m wide and contains flowing water at least for part of the year. - Delineated as a polygon using bankful width as seen on aerial photography flown in the spring. - See Section 2.4.5 for more details	OAO
17. Connected Vegetation Feature	- A linear feature comprised of woody plants that connects two or more *Vegetation Communities*, often called a hedgerow - Length is >20 m and width is >20 m but <30 m. See Section 2.4.6 - Considered one feature as long as there are no gaps >20 m. - Often located between farm fields.	--
18. Watercourse Bluff and Depositional Areas (Bars, Beaches)	- Bluffs: Areas of mostly bare soil along a watercourse or on steep slopes not being actively cultivated. - Bars, Beaches: Appears as a visible sediment depositional area along bends of watercourses and along creeks and streams. - Not currently mapped	BBO, BBS, BBT, BLO, BLS, BLT, CLO, CLS, CLT, TAO, TAS, TAT

2.4 *Vegetation Groups*

Each *Vegetation Community* is assigned to broader *Vegetation Groups*. Seven types of *Vegetation Groups* were delineated in Middlesex County:

1) Woodland
2) Thicket
3) Meadow
4) Wetland (contains woodland, thicket and meadow)
5) Water Body Feature
6) Connected Vegetation Feature, and
7) Watercourse Bluff and Depositional Area.

Vegetation Groups are comprised of a mosaic of one or more *Vegetation Communities* within 20 m of each other (see Figures 2 and 3).

Figure 2. Illustration of two woodland *Vegetation Communities* (Deciduous Woodland and Deciduous Swamp) forming a Woodland Group

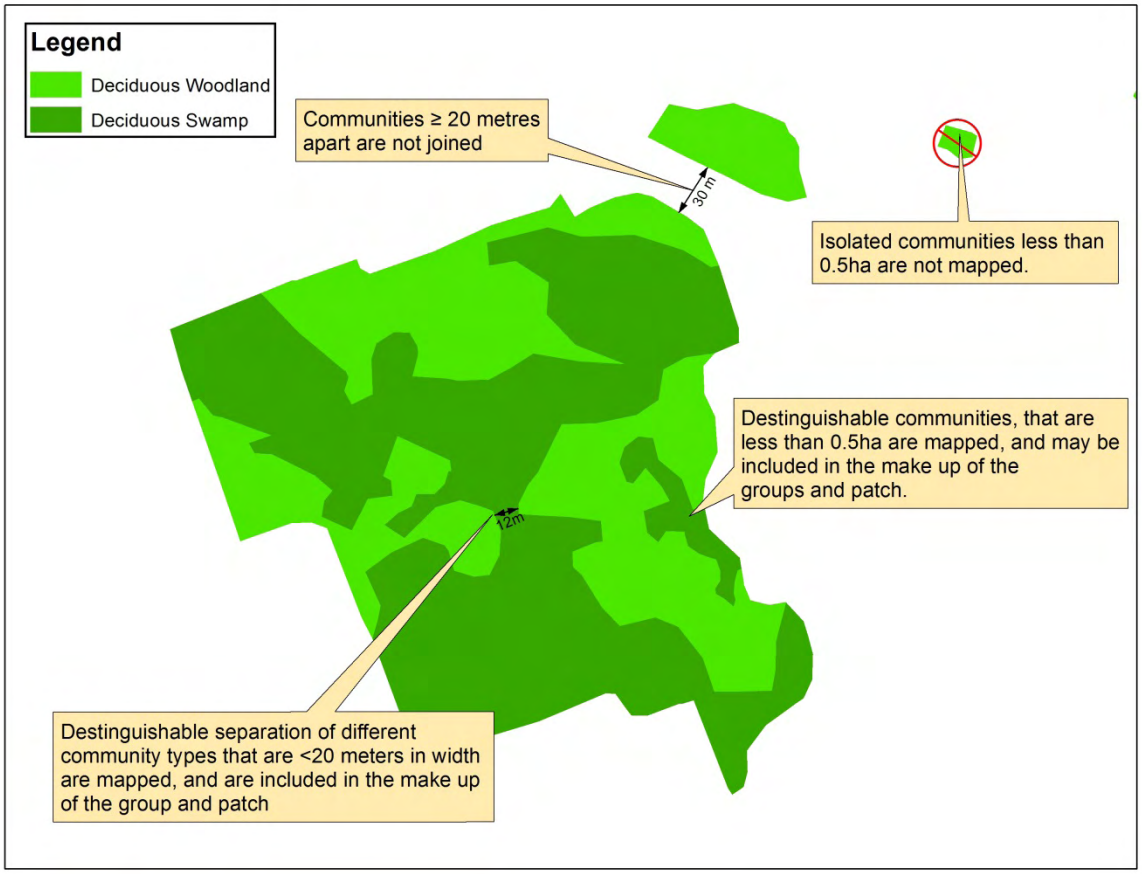


Figure 3. Illustration of how small and large *Vegetation Communities* are combined into *Vegetation Groups* and Patches

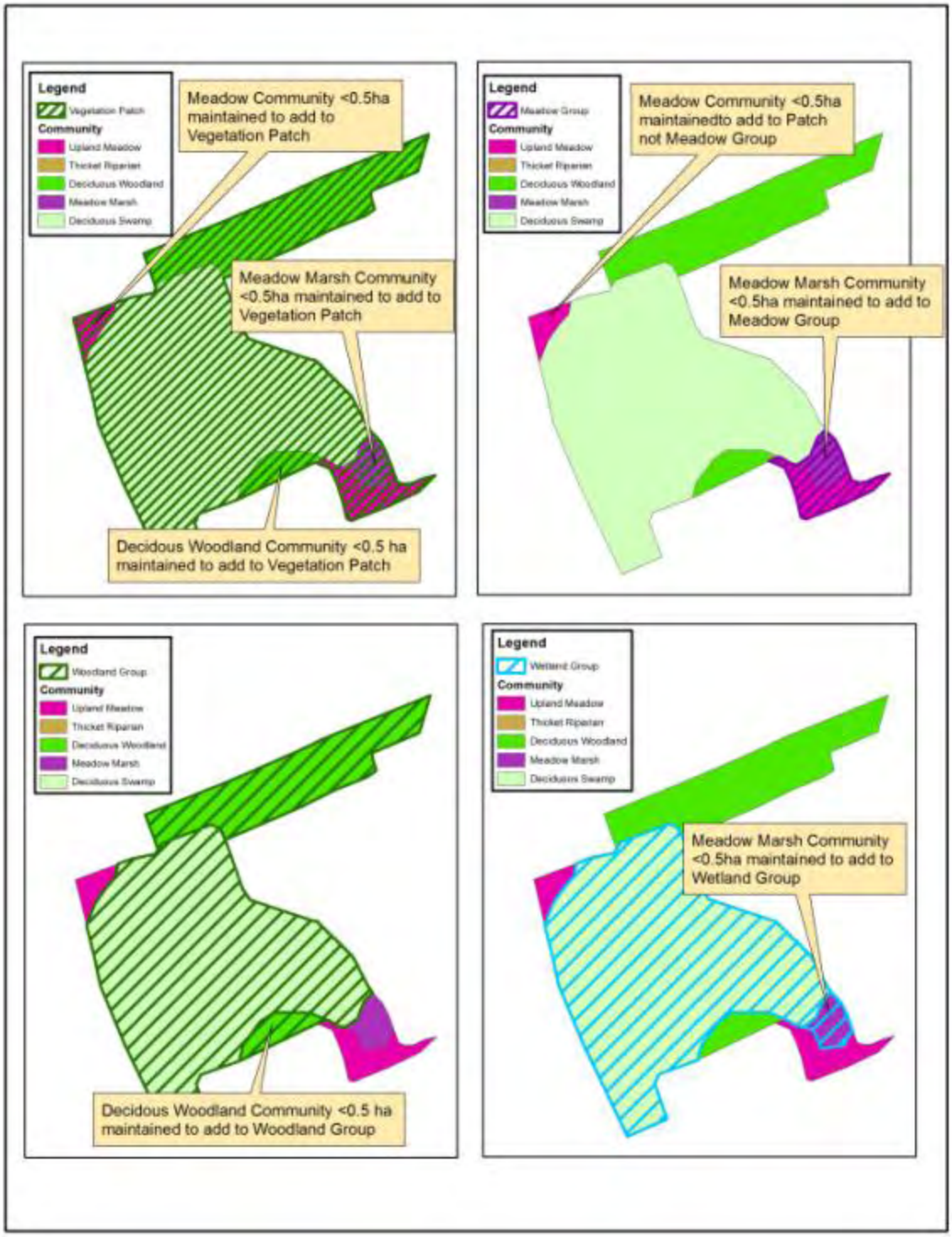


Table 3, shown earlier, presents a comparison between the *Vegetation Groups* identified in this study to the ELC *Vegetation Community* Series level (Lee et al. 1998). Appendix A contains more details. There are four main differences.

- The ELC distinguishes whether the vegetation is the result of an anthropogenic (cultural) process or a natural process. However, it should not be assumed that a cultural feature is not significant. Cultural, disturbed or successional natural features can have significant ecological functions and could be identified as Significant Wildlife Habitat (SWH). Therefore, it is important to consider any ELC communities classified as cultural for their potential to provide important ecological functions by comparing the community description with criteria in the Significant Wildlife Habitat Technical Guide. Thus, there is no distinction in the MNHSS 2014 as to whether the vegetation was influenced by natural or anthropogenic (cultural) processes.

- The ELC defines Open Water bodies as >2 m depth and Shallow Water bodies as <2 m depth. Since depth of water bodies cannot be determined from aerial photos or remotely sensed data, these two features are combined into a single open water feature.

- The key factor in distinguishing wetlands from water bodies and other aquatic components in the ELC is the presence of >25% emergent or woody vegetation cover. For this study, water bodies did not contain any water tolerant herbaceous or woody plants.

- The ELC distinguishes thickets, woodlands and forests. The ELC lists two types of woodlands, Tallgrass Woodland (TPW) and Cultural Woodland (CUW), with a tree cover of 35% to ≤60%. Both these woodland types are rare in the Middlesex area. For the MNHSS, these ELC woodlands were lumped in the thicket *Vegetation Community* because of the low tree cover. As well, the ELC defines forests as habitats with >60% tree cover. The MNHSS calls them woodlands to be consistent with the PPS wording. See Appendix A for more details.

2.4.1 Wetland *Vegetation Group*

Fluctuation of water levels and the presence of water tolerant herbaceous and woody plants distinguish wetlands from water body *Vegetation Communities*. The wetland *Vegetation Group* is comprised of seven wetland *Vegetation Communities*, four treed wetlands (swamps) and three un-treed wetlands (thicket, marsh, young plantation swamp):

1) coniferous swamp
2) deciduous swamp
3) mixed swamp
4) plantation swamp
5) wetland thicket
6) meadow marsh
7) young plantation wetland

The wetland layer for Middlesex was derived from OMNR Evaluated Wetlands and Conservation Authority Unevaluated Wetlands. A description of the methods used in each case is included in Appendix B.

2.4.2 Woodland *Vegetation Group*

The Woodland *Vegetation Group* is comprised of eight *Vegetation Communities*, of which four are terrestrial/upland and four are wetland:

1) coniferous woodland (terrestrial/upland),
2) deciduous woodland (terrestrial/upland),
3) mixed woodland (terrestrial/upland),
4) mature plantation (terrestrial/upland),
5) coniferous swamp (wetland),
6) deciduous swamp (wetland),
7) mixed swamp (wetland) and
8) plantation swamp (wetland).

Mature plantations and plantation swamps are included as part of the woodland *Vegetation Group* as they are key components to the ecosystem. Mature plantations are old enough that the original tree rows (usually conifers) are not very visible on the ortho-imagery because a diversity of other tree species (usually deciduous) have moved in. Plantation swamps are communities where trees have been planted in an area recognized as a wetland (evaluated or unevaluated) and the trees are full size or taller than shrub height.

Plantations, like natural forests and woodlands, contribute to the net removal of carbon dioxide from the atmosphere, produce oxygen, modify wind and temperature, remediate soil pollution and structure and provide wildlife habitat. Landowners often plant trees into a plantation or block planting to retire land from agriculture and begin the process of natural succession towards mature forest/woodland.

2.4.3 Thicket *Vegetation Group*

The Thicket *Vegetation Group* is comprised of four *Vegetation Communities*, two terrestrial/upland and two wetland:

1) upland thicket (terrestrial/upland),
2) young plantation (terrestrial/upland),
3) wetland thicket (wetland), and
4) young plantation wetland (wetland).

Thickets are usually early successional communities dominated by shrubs, young trees or stunted mature trees. Upland thickets usually develop on abandoned fields, for example, and succeed to woodland much more quickly than wetland thickets that tend to be found in very areas too wet for trees. Wetland thickets may also succeed to swamp if the wetland slowly fills in. Thickets along watercourses may be maintained even longer as flooding and ice scour knock trees back. Young tree plantations are called thickets when the trees are still short (e.g., shrub height).

Table 3 provides definitions for each thicket *Vegetation Community*. Thicket *Vegetation Communities* must be at least 30 m wide and 0.5 ha to be included.

2.4.4 Meadow *Vegetation Group*

The Meadow *Vegetation Group* is comprised of two *Vegetation Communities*, one terrestrial/upland and one wetland:

1) upland meadow (terrestrial/upland), and
2) meadow marsh (wetland).

Table 3 provides a description of the defining meadow habitat features. Meadows are short, open *Vegetation Communities* dominated by grasses and broad-leaved herbaceous plants and a scattering of shrubs and trees. Many meadows in Middlesex County are old fields of cultural origin (e.g., abandoned or retired farmland) and will, in time, succeed to thicket then forest/woodland. However, meadows along watercourses may be more permanent as the frequent flooding and ice scour keeps trees and shrubs from establishing. Meadows must be at least 30 m wide and 0.5 ha to be included. Pastures were not included in meadows since they are often heavily grazed and are part of the farm cycle.

2.4.5 Water Body Feature *Vegetation Group*

A Water Feature *Vegetation Group* is comprised of two *Vegetation Communities*:

- permanent water bodies (>20 m wide and 0.5 ha in size) and
- major watercourses (>20 m wide and >1 km long).

Permanent water bodies include natural and man-made ponds ≥20 m wide and ≥0.5 ha in size without any vegetation cover. Water features do not have any tree, shrub or emergent vegetation.

Short stretches of major watercourses that are <20 m wide are included as part of the major watercourse to maintain continuity. However, when a watercourse is <20 m wide for 1 km or longer, it no longer becomes a major watercourse and becomes part of the surrounding *Vegetation Group*.

2.4.6 Connected Vegetation Features *Vegetation Group*

The Connected Vegetation Features *Vegetation Group* is comprised only of the Connected Vegetation Features *Vegetation Community*.

Connected Vegetation Features are narrow *Vegetation Communities* consisting of trees and/or shrubs and are sometimes called hedgerows or shelterbelts. They are an important component of the natural heritage system because they provide corridors for wildlife movement as well as wildlife habitat, and may include remnants of vegetation present prior to disturbance (e.g., forest remnants). While more common in the past, many of these features have been or are being removed in the agricultural landscape to increase field size.

Section 7.3.2 of the NHRM (OMNR 2010) recommends establishing a minimum width to these features to exclude relatively narrow linear treed areas (e.g., windbreaks) when delineating Woodland *Vegetation Groups*. Recognizing that breaks < 20 m are too small to separate Woodland *Vegetation Groups* (OMNR 2010), the width of a connected vegetation feature was defined as being greater than 20 m but less than 30 m in width.

Note: The Natural Heritage Reference Manual recommends that where the size threshold is 4 ha for woodland significance in a given planning area, a hedgerow is defined as <40 m wide. In the MNHSS, to account for both the minimum width and animal movement, connected vegetation features must connect two or more natural heritage features and be > 20 m in length.

2.4.7 Watercourse Bluffs and Depositional Areas (Bars or Beaches)

This *Vegetation Group* is part of the terrestrial/upland Vegetation Ecosystem and consists of very open and generally active geomorphic sites including beach bars, cliffs and talus slopes, all of which represent unique and sometimes significant habitats for animals and plants. Watercourse bluffs usually occur on steep slopes on an outside meander where active erosion takes place preventing the long-term establishment of vegetation. Deposition areas occur where sediment is deposited, producing beach-like areas along watercourses. They are generally open or unvegetated because of fluctuating water levels and water flow action. Bluffs and Depositional Areas are often used by burrowing animals as well as Bank Swallows.

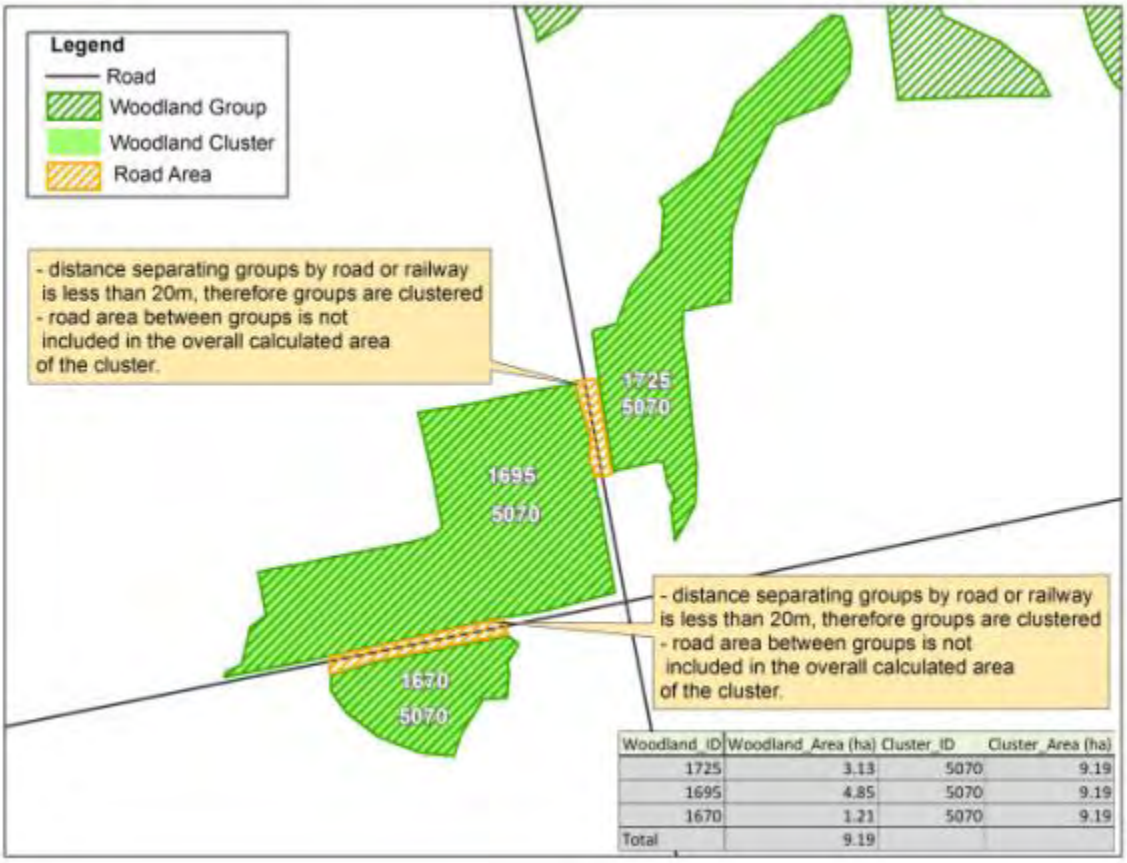
The dynamic nature of watercourses means these features are constantly being altered and recreated. These features are generally quite small and because of the vertical nature of Bluffs, they not very visible on ortho-imagery. Thus, most watercourse bluffs and depositional areas are not mapped currently and will need to be identified through field studies as part of the Ecological Site Assessment Process and recorded in the Development Assessment Report (see Chapter 5). These features do not have to meet a minimum size for mapping standards.

2.4.8 Clustering around narrow Roads and Railroads

As stated in Section 2.3, roads and railroads 20 m or wider separate *Vegetation Communities* and *Vegetation Groups* (i.e., the canopy must be separated by at least 20 m). Where roads/railroads are <20 m wide, the vegetation is not broken, but an extra step in the mapping is needed so that the area of the road is not included when vegetation area measurements are calculated, as per the Natural Heritage Reference Manual (OMNR 2010). This step is called clustering and the methodology is as follows (see Figure 4 example):

- A unique identification number is assigned to each *Vegetation Group* (1725, 1695, 1670 in Figure 4).
- A unique cluster identification number is assigned to each clustered *Vegetation Group* (5070).
- Clustering was applied to the *Vegetation Groups* before modeling the significance criteria.
- Criteria that measure area were applied to the entire clustered *Vegetation Group* (5070), then the area of the road was subtracted.
- The remaining significance criteria were applied to the clustered *Vegetation Groups* (5070).

Figure 4. Illustration of clustering *Vegetation Groups* (1725, 1695, 1670) around narrow roads into one Woodland Cluster (5070)



Woodland_ID	Woodland_Area (ha)	Cluster_ID	Cluster_Area (ha)
1725	3.13	5070	9.19
1695	4.85	5070	9.19
1670	1.21	5070	9.19
Total	9.19		

2.5 *Vegetation Patches*

A Vegetation Patch is a mosaic of one or many different abutting (or <20 m apart) *Vegetation Groups* (see Figure 5).

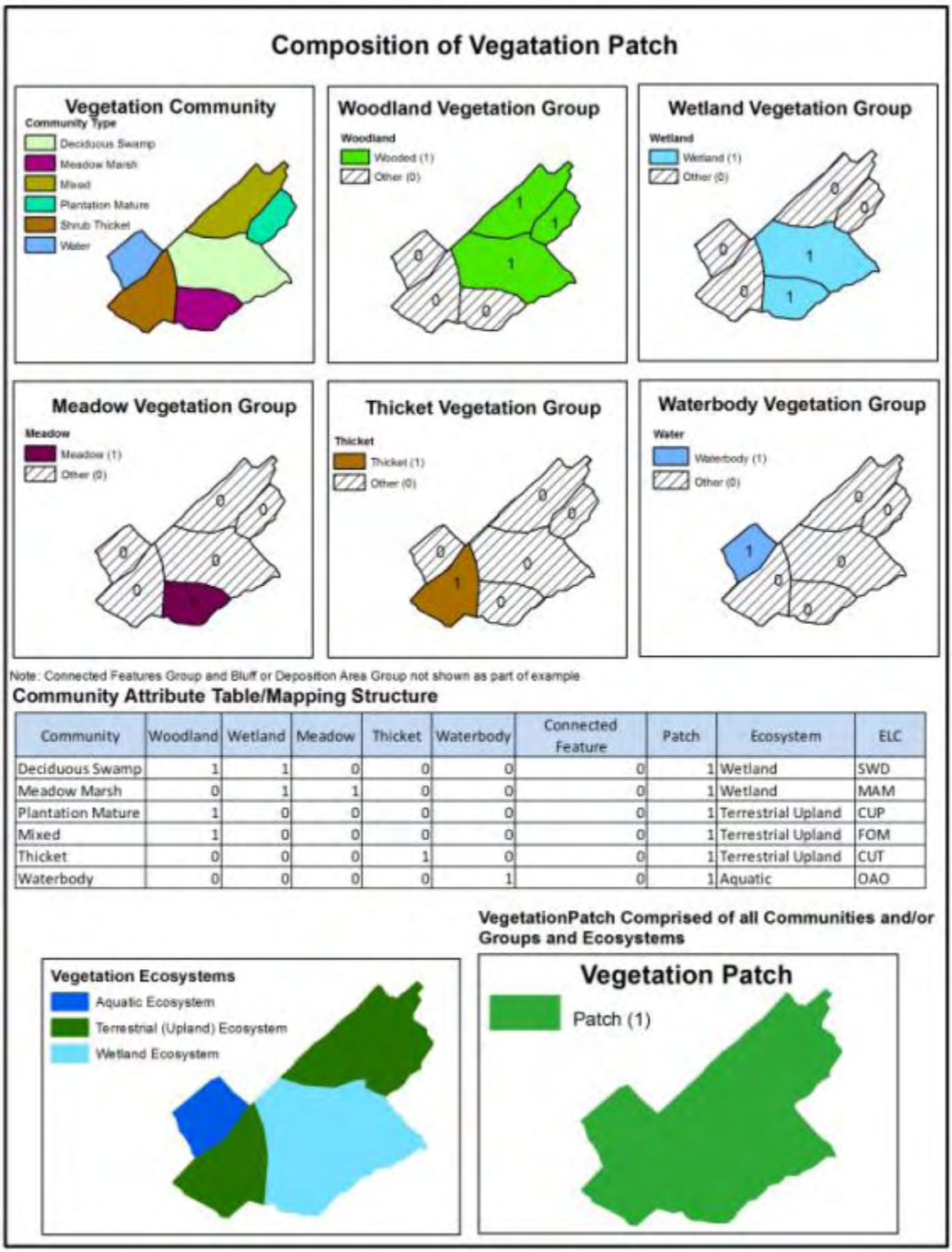
As with *Vegetation Groups*, roads >20 m wide separate *Vegetation Patches*. However, where roads <20 m wide separate patches, they are clustered. Clustering is applied to the *Vegetation Patches* before modeling the significance criteria. Since the NHRM does not calculate the area of a road when determining size and interior (OMNR 2010), area criteria will be applied to the entire clustered Vegetation Patch less the area of the road. The remaining significance criteria will be applied to the clustered *Vegetation Patches* and include the road and railroads as part of the Vegetation Patch (Figure 4).

A Vegetation Patch digital layer was created with unique number attributes assigned to each Vegetation Patch:

- the unique identification number to each Vegetation Patch, and
- a unique cluster identification number for clustered Vegetation patch(s), groups are connected to each other based on the 20m separation rule when divided by roads or railways.

Aerial photo of a large wetland/woodland patch near Dorchester. *Photo by UTRCA*

Figure 5. Illustration of the composition of a Vegetation Patch made up of different *Vegetation Communities*, Groups and Ecosystems



Note: Connected Features Group and Bluff or Deposition Area Group not shown as part of example

Community Attribute Table/Mapping Structure

Community	Woodland	Wetland	Meadow	Thicket	Waterbody	Connected Feature	Patch	Ecosystem	ELC
Deciduous Swamp	1	1	0	0	0	0	1	Wetland	SWD
Meadow Marsh	0	1	1	0	0	0	1	Wetland	MAM
Plantation Mature	1	0	0	0	0	0	1	Terrestrial Upland	CUP
Mixed	1	0	0	0	0	0	1	Terrestrial Upland	FOM
Thicket	0	0	0	1	0	0	1	Terrestrial Upland	CUT
Waterbody	0	0	0	0	1	0	1	Aquatic	OAO

2.6 Vegetation Ecosystem

The 18 *Vegetation Communities* belong to one of three Vegetation Ecosystems:

- terrestrial,
- wetland and
- aquatic.

Vegetation Groups can belong to one or more Vegetation Ecosystem (see Table 4). For example, woodland, thicket and meadow *Vegetation Groups* include both wetland and terrestrial *Vegetation Communities*. The only time Vegetation Ecosystems are used is for Criteria 13 on habitat diversity.

Terrestrial Vegetation Ecosystem

Terrestrial Vegetation Ecosystems occur where soil moisture is scarce for at least some point in the growing season. Terrestrial Vegetation Ecosystems are distinguished from wetland or aquatic Vegetation Ecosystems by:

- a lower availability of water and the consequent importance of water as a limiting factor.
- greater temperature fluctuations on both a diurnal and seasonal basis
- greater availability of light and gases (including carbon dioxide for photosynthesis, oxygen for aerobic respiration, and nitrogen for nitrogen fixation).
- A subterranean portion (soil) from which most water and ions are obtained, and an atmospheric portion from which gases are obtained and where the physical energy of light is transformed into the organic energy of carbon-carbon bonds through the process of photosynthesis.

Wetland Vegetation Ecosystem

Wetland Vegetation Ecosystems are considered semi aquatic and are differentiated into swamp, marsh, bog and fen by the quality, quantity and timing of water and the associated vegetation that develops as a result of the input of water. Section 2.4.1 describes how these features were identified and delineated.

Aquatic Vegetation Ecosystem

Freshwater aquatic Vegetation Ecosystems are characterized as lotic (having flowing water) or lentic (still water). Lotic water systems include streams, springs, rivulets, creeks, brooks and rivers etc., and can be narrow, shallow and relatively rapid to increasingly broad, deep and slow moving. Lotic systems can be cold or warm water and the major source of food is the organic matter brought in from the surrounding terrestrial Vegetation Ecosystems. Therefore, nutrient levels tend to the higher downstream because there is continual addition of nutrients. Lentic systems include pools, ponds, some swamps, bogs and lakes. They vary considerably in physical, chemical and biological characteristics. For this study, aquatic Vegetation Ecosystems include natural or constructed permanent water bodies or major watercourses.

Table 4. Relationship between *Vegetation Communities*, Groups and Ecosystems

	Vegetation Ecosystem		
Vegetation Group ↓	**Aquatic**	**Wetland**	**Terrestrial**
Vegetation Community			
Deciduous Woodland			Yes
Coniferous Woodland			Yes
Mixed Woodland			Yes
Mature Plantation			Yes
Deciduous Swamp		Yes	
Mixed Swamp		Yes	
Coniferous Swamp		Yes	
Plantation Swamp		Yes	
Upland Thicket			Yes
Wetland Thicket		Yes	
Young Plantation			Yes
Young Plantation Wetland		Yes	
Upland Meadow			Yes
Meadow Marsh		Yes	
Water Bodies	Yes		
Major Watercourse	Yes		
Connected Vegetation Feature			Yes
Watercourse Bluff + Depositional Area			Yes
Vegetation Group			
Woodland		Yes	Yes
Thicket		Yes	Yes
Meadow		Yes	Yes
Wetland		Yes	
Water body feature	Yes		
Connected Vegetation Feature			Yes
Watercourse Bluff + Depositional Area			Yes

2.7 Results of Mapping the Vegetation Layers

Table 5 summarizes the number and area of the three vegetation layers: communities, groups and patches. The 15,045 *Vegetation Communities* are merged into over 6,813 *Vegetation Groups*, and then are compiled into 3,502 *Vegetation Patches*. The total area of natural vegetation cover is around 66,887 ha, or 20.1% of the study area (geographic Middlesex). The area of each layer varies slightly due to the way the communities are merged (see Chapter 2).

Table 5. Number and Area of the Vegetation Layers

Vegetation Layers	**Number**	**Area** (ha)	**% Area of Geographic Middlesex** (333,330ha)
Communities	15,045	66,955	
Groups (including wetlands)	8,732	66,574	
Patches	3,502	66,887	20.1%

Table 6 shows the number and area of each *Vegetation Community* in the study area. Table 7 shows the same information, sorted from largest to smallest area. The three *Vegetation Communities* making up the largest area are: deciduous woodland, deciduous swamp and upland meadow. Deciduous woodland is the largest community by far at 38,413 ha or 57.3% of the total vegetation cover and 11.5% of the study area. In second place is deciduous swamp at 7,843 ha or 11.7% of the total vegetation cover and 2.4% of the study area. A close third, upland meadow, covers 7,727 ha or 11.5% of the vegetation cover and 2.3% of the study area.

Table 8 summarizes the information by *Vegetation Group*. Overall, woodland covers 15.8% of geographic Middlesex, thicket covers 1.0%, meadow 2.5% and water features 0.7%. Connected vegetation features cover less than 0.1% and watercourse bluff and depositional area are not yet mapped but also will be very small.

There is 3.5% wetland cover in the county, composed swamps, wetland thickets and meadow marshes. The 3.5% wetland cover is part of the 20.1% vegetation cover.

Table 6. Number and Area of the 18 *Vegetation Community* Types in the Study Area (Geographic Middlesex)

Vegetation Community	Number of *Vegetation Communities*	Area of *Vegetation Communities* (ha)	% Area of all *Vegetation Communities* (66,955 ha)	% Area of Middlesex Land Base (333,330 ha)
Deciduous Woodland	4928	38413	57.3	11.5
Mixed Woodland	622	3252	4.9	1.0
Coniferous Woodland	364	632	0.9	0.2
Mature Plantation	492	1326	2.0	0.4
Deciduous Swamp	1961	7843	11.7	2.4
Mixed Swamp	189	1299	1.9	0.4
Coniferous Swamp	17	47	0.1	0.0
Plantation Swamp	17	6	0.0	0.0
Upland Thicket	1182	2369	3.5	0.7
Wetland Thicket	175	333	0.5	0.1
Young Plantation	299	532	0.8	0.2
Young Plantation Swamp	3	1	0.0	0.0
Upland Meadow	3507	7727	11.5	2.3
Marsh Meadow (Meadow Marsh)	510	759	1.1	0.2
Water Body	535	1169	1.8	0.4
Major Watercourse	119	1150	1.8	0.3
Connected Vegetation Feature	125	97	0.1	0.0
Watercourse Bluff and Depositional Areas *	Not mapped	--	--	--
TOTAL	**15,045**	**66,955**	**100.0**	**20.1**

*Not yet mapped as these features are usually too small to detect on air photos.

Table 7. *Vegetation Community* Types sorted by Area

Order Number	*Vegetation Community*	Area (ha)
1	**Deciduous Woodland**	38,413
2	**Deciduous Swamp**	7,843
3	**Upland Meadow**	7,727
4	**Mixed Woodland**	3,252
5	**Upland Thicket**	2,369
6	**Mature Plantation**	1,326
7	**Mixed Swamp**	1,299
8	**Water Body**	1,169
9	**Major Watercourse**	1,150
10	**Marsh Meadow**	759
11	**Coniferous Woodland**	632
12	**Young Plantation**	532
13	**Wetland Thicket**	333
14	**Connected Vegetation Feature**	97
15	**Coniferous Swamp**	47
16	**Plantation Swamp**	6
17	**Young Plantation Swamp**	1
18	**Watercourse Bluff + Depositional Areas (Bars/Beaches)**	Not mapped
	TOTAL	**66,955**

Table 8. Number and Area of *Vegetation Groups* as a Percentage of the Study Area

Vegetation Group	**# of Groups**	**Area (ha)**	**% Area of Middlesex Land Base** (333,330 ha)
Woodland	4,123	52,748	15.8%
Thicket	1,365	3,205	1.0%
Meadow	3,040	8,319	2.5%
Water Feature	284	2,205	0.7%
Connected Veg. Feature	124	97	<0.1%
Watercourse Bluff + Depositional Area	0	0	Not mapped
Total	**8,936**	**66,574**	**20.1%**
Wetland Group (part of the total above)	1,916	11,729	3.5%

North Thames River valley in Thames Centre. *Photo by Cathy Quinlan*

3.0 Criteria for Significance

3.1 Background − Evaluation of Significance

In settled landscapes, both habitat loss and fragmentation of the original natural cover increases the significance of, and need to protect, any remaining natural heritage features and functions (Levenson 1981, Lovett et al. 2005, Manning et al. 2004). However, haphazard protection of individual natural heritage features is unlikely to ensure the survival of species or ecosystems, since it does not take into account how well the remaining natural features function or how effective they are in providing environmental benefits (Humke et al. 1975).

Carter (2000), Bowles (1997) and Bowles et al. (2000) argue that no single characteristic can sufficiently measure the value of a natural feature. On the one hand, there is a danger of cumulative loss if habitat patches are assessed solely on site specific characteristics since their importance within the broader landscape is unknown. On the other hand, the external characteristics or location of a feature using landscape metrics such as size, connectedness, regional representation, and hydrological function may not always reflect its internal quality. Instead, it is important to use multiple criteria to assess the characteristics of a natural feature.

Since site level analysis (i.e., biological inventory) is not feasible at a county level, local municipalities are encouraged to conduct more in-depth studies and evaluate their natural heritage features at the site level. For example, the City of London has used landscape, community and species parameters to assess significance (City of London 2006). In general, regional (i.e., county) natural heritage studies evaluate natural areas based on landscape metrics while local (i.e., lower tier) natural heritage studies tend to use both landscape metrics and site specific content metrics (i.e., what the natural feature contains).

The location, size and shape of a *Vegetation Patch* have been identified as critical factors in the maintenance of species diversity and abundance in fragmented landscapes (Burgess and Sharpe 1981, Forman 1995a, b and c, Forman and Godron 1986, Harris 1984, Turner and Gardner 1991, Schiefele and Mulamoottil 1987, Robbins et al. 1989, Hounsell 1989, Weyrauch and Grubb 2004). These metrics act as surrogate measurements of more detailed studies and can be easily measured using remote sensing.

However, these indicators provide only a partial picture of the complexity of ecosystem functioning. Land managers must realize that conservation of biological diversity might not be achieved by manipulating the size and configuration of remnant *Vegetation Patches*, but instead depend on how the extensive areas surrounding the *Vegetation Patches* are managed. Recognizing that this area of human-modified land, the habitat matrix, overwhelmingly dominates all of the world's terrestrial ecosystems (Foley et al. 2005, Lindenmayer and Franklin 2002), conservation biologists and resource managers need to also focus attention on improving the quality of the habitat matrix and the environmental impacts associated with a change of land use in the habitat matrix if programs to conserve biological diversity are to succeed.

3.2 Significance Criteria

According to the Natural Heritage Reference Manual (OMNR 2010), the responsibility for the identification and evaluation of significant wetlands and Areas of Natural and Scientific Interest (ANSIs) lies with the Ontario Ministry of Natural Resources (OMNR). The OMNR also approves what is to be considered as significant habitat of endangered species and threatened species. In all other cases, the responsibility for the identification, evaluation and designation of significant features and areas lies with the planning authority.

The purpose of this 2014 Middlesex Natural Heritage Systems Study is to identify significant natural heritage features existing and identifiable on 2010 colour air photos of Middlesex County. According to the Provincial Policy Statement (PPS), significant natural heritage features and areas include:

- significant wetlands,
- significant woodlands,
- significant valley lands,
- Areas of Natural and Scientific Interest (ANSIs),
- fish habitat,
- habitat of endangered and threatened species, and
- significant wildlife habitat.

This study does not include fish habitat as it is identified by DFO (Department of Fisheries and Oceans). Also, the study does not include habitat of endangered and threatened species as Species at Risk have their own legislation and are not uniformly mapped across the landscape. Significant wildlife habitat is not mapped currently and can only be found at the site level. It is dealt with in Chapter 5 (recommendations). The identification of all other significant natural heritage features is incorporated into the MNHSS criteria.

Fifteen significance criteria were developed in this study to identify significant *Vegetation Patches*, using the discrete *Vegetation Communities*, *Vegetation Groups* and *Vegetation Patches* defined in Chapter 2. Table 9 provides a summary of the criteria. A more detailed summary table that includes rationale and a list of other studies using the criterion is included in Appendix D.

Of the 15 criteria, nine are used to identify significant *Vegetation Groups*. Three of the nine criteria are applied to all *Vegetation Groups*, while the remaining six criteria are based on specific size cutoffs that depend on the type of *Vegetation Group*. Three criteria are applied to the *Vegetation Patches* and three criteria are applied to the *Vegetation Patch* but the information is not currently mapped. These significance criteria are the test of PPS. While there are 15 criteria, only 12 were run in the model as three are not currently mapped.

Two additional criteria were modeled but did not capture any patches that were not already captured by other criteria, so they were not used. However, the results are provided as additional information.

Many other criteria were examined but were not used for a variety of reasons and these are described in Appendix E.

The criteria are based on ecological literature and local knowledge as of 2014 (the time of the publication of this study). Therefore, in the future, it is important to go back to the original source when confirming significance.

Table 9. Summary of the 15 Significance Criteria

Criterion #	Key Words	Description
Applied to *Vegetation Groups*		
1	**Significant Valley System**	Any *Vegetation Group* within or touching a significant valley system
2	**ANSI**	Any *Vegetation Group* located within or touching a Life Science ANSI (Area of Natural and Scientific Interest)
3	**Open Watercourse**	Any *Vegetation Group* located within 30 m of an open watercourse
4	**Wetlands**	All evaluated wetlands and any unevaluated Wetland *Vegetation Groups* >0.5 ha
5	**Woodland Size**	Any Woodland *Vegetation Group* ≥ 4 ha
6	**Woodland Proximity**	Any Woodland *Vegetation Group* within 100 m of a 4 ha Woodland *Vegetation Group*
7	**Thicket Size**	Any Thicket *Vegetation Group* ≥2ha
8	**Meadow Size**	Any Meadow *Vegetation Group* ≥ 10 ha
9	**Meadow Proximity**	Any Meadow *Vegetation Group* within 100 m of a large size Woodland or Thicket *Vegetation Group*
Applied to *Vegetation Patches*		
10	**Patches with a *Vegetation Group* that meet a Group Criteria**	Any *Vegetation Patch* that contains a *Vegetation Group* that meets a group criteria (i.e., meets Criteria 1 – 9 above)
11	**Diversity**	Any *Vegetation Patch* that contains a diversity of *Vegetation Communities*, Groups or Ecosystems
12	**Proximity**	Any *Vegetation Patch* within 100 m of a significant *Vegetation Patch* (Meeting Criteria 10 or 11)
Applied to *Vegetation Groups* but Not Mapped Currently		
13	**Significant Wildlife Habitat**	Any *Vegetation Group* that contains Significant Wildlife Habitat
14	**Groundwater Dependent Wetland**	Any *Vegetation Group* that contains a Groundwater Dependent Wetland
15	**Bluff or Depositional Area**	All Watercourse Bluff or Depositional Areas

3.3 Significance Criteria applied to all *Vegetation Groups* and Ecosystems

Note: When delineating *Vegetation Group* boundaries, some *Vegetation Groups* may end up being less than 0.5 ha in size. For example, Figure 2 shows a *Vegetation Patch* comprised of a wetland *Vegetation Group* made up of a 1 ha swamp *Vegetation Community* and a 0.4 ha meadow marsh *Vegetation Community*. Wetland *Vegetation Group* significance criteria would be applied to the swamp but not to the marsh as it is < 0.5ha. However, both the marsh and the swamp *Vegetation Communities* would be included in the *Vegetation Patch* and evaluated using the *Vegetation Patch* criteria.

3.3.1 Criterion 1 – *Vegetation Group* within or touching a Significant Valley System

Rationale

River valleys perform numerous ecological functions. The Natural Heritage Reference Manual (OMNR 2010) recognizes that valleys can be important linkages and corridors for wildlife movement, providing habitat for a variety of wildlife and connecting natural areas over large distances. Some river valleys have unusual features associated with them, such as calcareous seeps, cliffs, bedrock pavements, etc. These features are characterized by micro-environments that may provide conditions for unusual and diverse *Vegetation Communities* and / or species.

Permanent vegetation on valley lands improves water holding capacity and reduces river erosion. Actively eroding valleys have unstable slopes with little or no vegetation cover. As they erode, valleys deepen, widen and land area is lost. Valley land erosion is exacerbated by human activity. Excess weight near the top of the slope from buildings, roads or farm machinery can increase internal stresses. Structural attempts to stabilize valleys (e.g., retaining walls or hardening the toe of the slope) can be expensive and are usually unsuccessful in the long term.

Valleys are linear depressions that stretch across the landscape from their origins in headwater areas to their outlets into aquatic systems such as wetlands and lakes. They contain water that flows for at least some periods of the year. The Natural Heritage Reference Manual (OMNR 2010) recognizes that an understanding of hydrological and geomorphic structure is important to identifying valley lands. Valley lands are formed by a combination of the down cutting action of swiftly flowing water, the slumping action of river banks, and the removal of slumped material from the river bed (Etmanski and Schroth 1980, Bowles 1993).

Application / Mapping Rules

Figure 6 illustrates the delineation of the Significant Valley System boundary using flood limit, steep slope and 100 m from watercourse edge.

For well-defined valleys, the following components of the Conservation Authority riverine erosion and flooding hazards boundaries were used to identify the stable top of bank (top of slope):

i) The valley must be ≥ 100 m wide and ≥ 2 km long.
ii) The valley banks must be ≥ 3 m in height (extrapolated from the 5 m contours at 1:10,000 or better information where available).
iii) Where valley slope is 3:1 on one side with no slope on the opposite side of the watercourse, the opposite valley limit was delineated using either 100 m from centreline of the water course or the limit of the floodplain to create a continuous valley feature.
iv) Where 3:1 valley slopes occur on both sides of the river, but they are not continuous, the flood plain limit (or contour information and professional judgment) was used to delineate a continuous valley feature.
v) Within the City of London, the boundaries used in the Thames Valley Corridor Plan (Dillon Consulting Ltd., and D.R. Poulton and Associates 2011) were used to define the valley land.

For less defined valleys, riparian vegetation, flooding hazard limit (based on regional events), meander belt, or highest seasonal (annual) inundation were used to determine the valley boundary.

All *Vegetation Groups* found within or touching the valley land meet this criterion (Figure 7).

Figure 6. Criterion 2, illustration of Significant Valley System boundary delineation using flood limit, steep slope and 100 m from watercourse edge

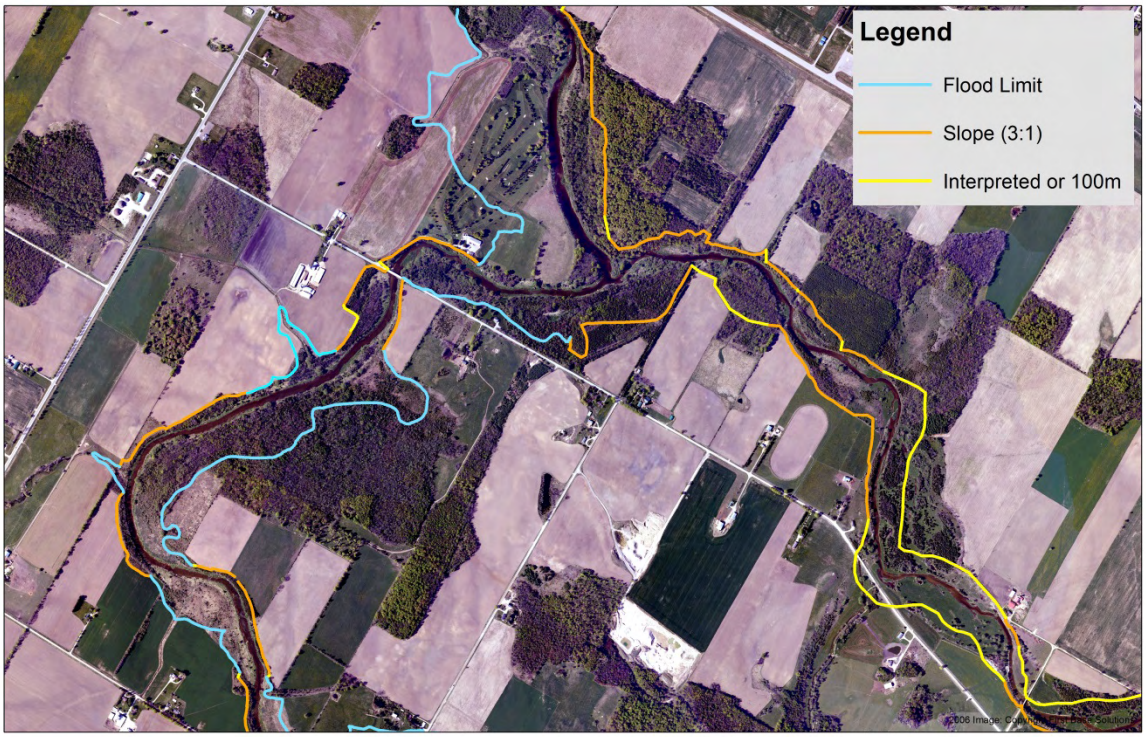
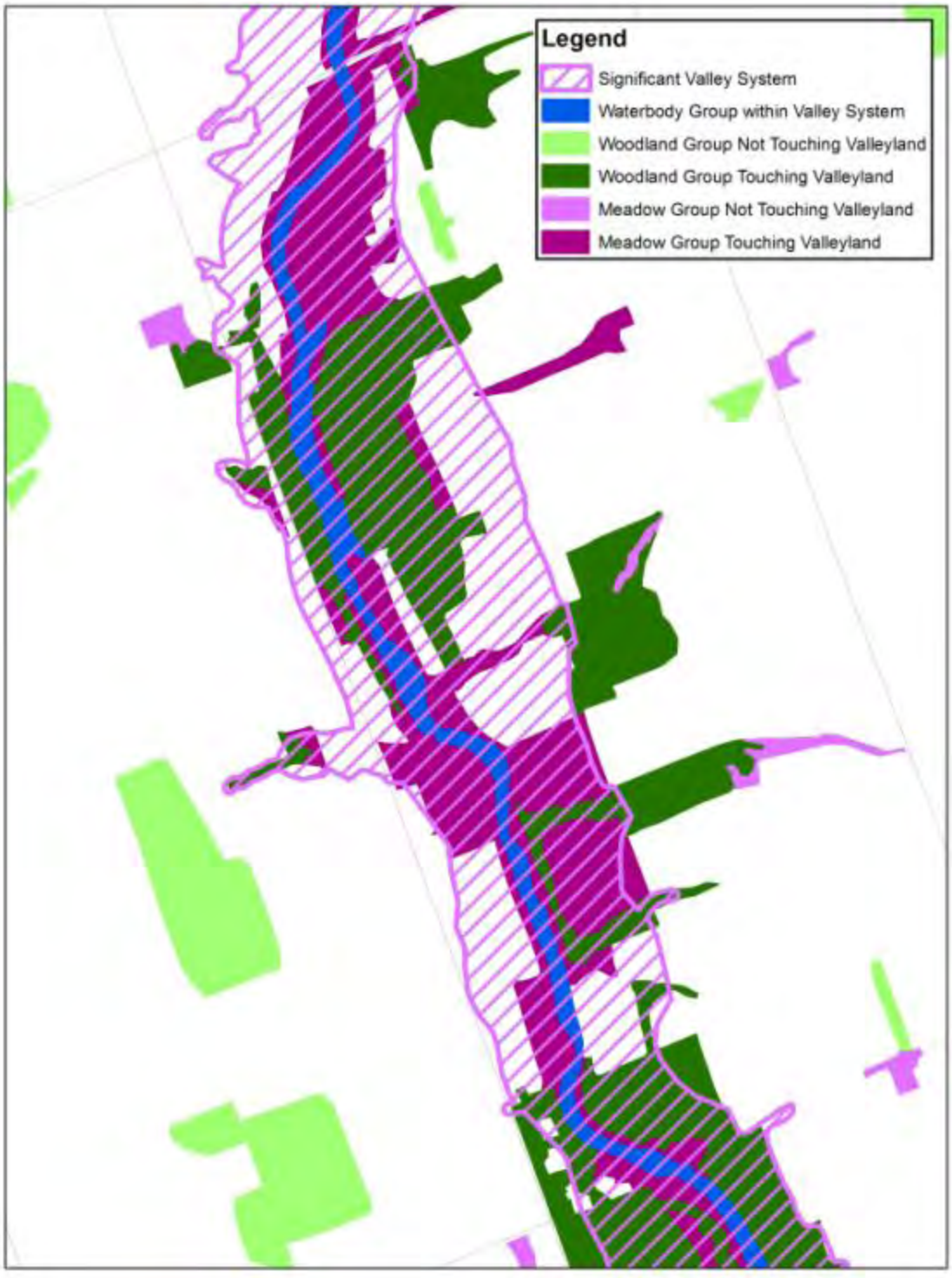


Figure 7. Criterion 1, illustration showing *Vegetation Groups* on or touching the Significant Valley System



Results

Table 10 below shows the results of the application of Criterion 1 in Middlesex. Over a quarter (26.1%) of the *Vegetation Groups* meet Criteria 1, accounting for 41.8% of the total vegetation cover (total of all *Vegetation Groups*). Of the *Vegetation Groups* that meet this criterion, only a small number (114 of 2,332) meet only Criteria 1 and no other. See map in Appendix I-1.

Table 10. Criterion 1 Results -- *Vegetation Groups* located on or touching Significant Valley Systems

	Number of Groups				**Area of Groups**			
Vegetation Group	**# that meet Criterion 1**	**Total #**	**% that meet Criterion 1**	**# that meet only Criterion 1**	**Area that meets Criterion 1 (ha)**	**Total area (ha)**	**% Area that meet Criterion 1**	**% of Middlesex Land Base** (333,330ha)
Woodland	773	4,123	18.7	18	22,908	52,748	43.4	6.9%
Thicket	432	1,365	31.7	57	189	3,205	5.8	0.1%
Meadow	980	3,040	32.2	9	3,217	8319	37.9	1.0%
Water Feature	88	284	31.0	25	1,593	2,205	68.7	0.5%
Connected Veg. Feature	59	124	47.6	5	55	97	56.7	0.0%
TOTAL	**2,332**	**8,936**	**26.1**	**114**	**27,962**	**66,574**	**41.7**	**8.5%**
Wetland	244	1,919	12.7	0	2,877	11,729	28.0	0.9 %

3.3.2 Criterion 2 – *Vegetation Group* within or touching a Life Science ANSI

Rationale

The Natural Heritage Reference Manual (OMNR 2010) recognizes that significant areas are typically used as a starting point in natural heritage studies as they provide a logical foundation on which to design a planning area's natural heritage system. Life Science Areas of Natural and Scientific Interest (ANSIs) are areas of land and/or water located on both public and private lands that are significant representative segments of Ontario's biodiversity and natural landscapes (OMNR 2000a). These areas contain relatively undisturbed vegetation and landforms including specific types of forests, valleys, prairies, and wetlands as well as their associated plant and animal species and communities. ANSIs are a critical complement to provincial parks and conservation reserves as they represent important natural features that are not found in publically protected areas. Earth Science ANSIs were not included in this criterion (see Appendix E).

The Ontario Ministry of Natural Resources (OMNR) evaluates and subdivides candidate ANSIs into three categories of significance (provincial, regional, or local) based on the consideration of five evaluation selection criteria (OMNR 2000a):

i. Representation – landform/vegetation features of an ecodistrict,
ii. Condition – degree of human-induced disturbances,
iii. Diversity – the number of high quality, representative features that exist within a site,
iv. Other ecological considerations – ecological and hydrological functions, connectivity, size, shape, proximity to other important areas, etc., and
v. Special features – such as populations of species at risk, special habitats, unusual life science features and educational or scientific value.

Application / Mapping Rules

The Life Science ANSI boundary is based on OMNR data. Both provincially and regionally designated Life Science ANSIs are considered significant in Middlesex County as they contain the best examples of landform/vegetation features and contribute to the representation of the natural features and landscapes of Ontario. All *Vegetation Groups* included within a Life Science ANSI boundary are mapped meet the criteria significant as well as those touching the ANSI (Figure 9).

There are six Life Science ANSIs in Middlesex (see map in Appendix I-2):

- Ausable River Valley,
- Komoka Park Reserve,
- Dorchester Swamp,
- Thames River Floodplain,
- Mud Lakes and
- Skunk's Misery.

Results

Table 11 below summarizes the mapping results for Criterion 2. Not surprisingly, only a small number of *Vegetation Groups* (142) meet Criteria 2 since there are only six ANSIs in the study area. However, they do amount to over 6,000 ha or 9.4% of the vegetation cover, indicating that the ANSIs include some of the largest natural areas on the landscape. Only five *Vegetation Groups* meet this criterion and no other.

Table 11. Criterion 2 Results – *Vegetation Groups* located on a Life Science ANSI

Vegetation Group	Number of *Vegetation Groups*				Area of *Vegetation Groups*			% of Middlesex Land Base (333,330 ha)
	# that meet Criterion 2	Total #	% that meet Criterion 2	# that meet only Criterion 2 and no other criteria	Area that meet criterion 2 (ha)	Total area	% Area of All Veg Groups	
Woodland	33	4,123	0.8%	1	5,019	52,748	9.5	1.5%
Thicket	24	1,365	1.8%	3	57	3,205	1.8	0.0%
Meadow	71	3,040	2.3%	0	9	8,319	0.1	0.0%
Water Feature	10	284	3.5%	1	1,243	2,205	53.6	0.4%
Connected Veg. Feature	4	124	3.2%	0	3	97	3.1	0.0%
Total	**142**	**8,936**	**1.6%**	**5**	**6,331**	**66,574**	**9.4**	**1.9%**
Wetland	56	1,919	2.9%	0	1,451	11,729	14.1	0.4%

Figure 8. Criterion 2, illustration showing *Vegetation Groups* within or touching a Life Science ANSI (Dorchester Swamp)

3.3.3 Criterion 3 – *Vegetation Group* within 30 m of an Open Watercourse

Rationale

Natural areas adjacent to watercourses (i.e., areas of riparian vegetation) are significant because they affect, and are affected by, the watercourse. Open watercourses contain flowing water for at least part of the year and can be natural or channelized but not buried or tiled.

The Natural Heritage Reference Manual (OMNR 2010) recognizes that the relationship between water features and vegetation is interactive. Vegetation along watercourses can influence aquatic communities since aquatic species tend to have very specific habitat requirements that are easily affected by a change in habitat resulting from changes in water temperature, pollution, spawning grounds, or food source. The physical processes operating in and adjacent to the stream channel create and maintain fish habitat in by providing shade for water temperature regulation, food (through organic inputs such as leaves), habitat from input of large woody debris, and cover in the form of accumulated vegetation. As a result, fish community composition and productivity in streams is partly related to the condition and health of vegetation beside the stream.

Vegetation along watercourses can also protect hydrological features such as quality and quantity of water. Permanently vegetation near waterways protects water quality by dampening peaks in water flow, filtering out sediments and excess nutrients, trapping toxins, and reducing soil erosion by retaining water run-off (Bosch and Hewlett 1982, Mooney 1993, Filyk 1993).

Riparian habitats are important terrestrial habitat in their own right and are supported by healthy watercourses. Vegetated riparian strips along streams are regional hot spots for a disproportionately high number of wildlife species, providing a wide array of ecological functions and values (Naiman et al. 1993, Fischer and Fischenich 2000). Watercourses and associated riparian areas can provide important linkage functions and act as continuous corridors for the movement of wildlife because the land-water interface usually supports a high level of biodiversity that meets multiple species needs (Wegner and Merriam 1979). Many plants and animals benefit from riparian habitat where the water and the high level of nutrients derived from overland flow create primary centres of bird activity and critical locations for amphibians and reptiles (Harris and Gallagher 1989).

Definition / Riparian Buffer Width

Many Conservation Authorities are promoting the establishment of riparian buffers to protect water quality and to serve as corridors for wildlife movement. A number of studies have identified various widths of stream-side vegetation buffers, depending on adjacent land use and slope (reviewed in Castelle et al. 1994). Some have shown that vegetation strips 15-30 meters wide (on each side) along streams should be adequate to protect the stream from sedimentation, erosion and increased water temperature (Budd et al. 1987, Environment Canada 2013). Other sources have found that if 25% of the land within 100 m of streams was natural, the water quality would be unimpaired regardless of the surrounding landscape (Griffiths 2001, Steedman 1987). Based on a review of literature, Fischer and Fischenich (2000) found a vegetated strip of 30 m will protect most water quality parameters on moderate slopes, while 30 m is the minimum width for ecological functions such as wildlife movement. Environment Canada (2013) sets a guideline target of 30 m wide naturally vegetated riparian areas on both sides of streams, as a minimum, to protect aquatic habitat, and wider riparian buffers to provide highly functional wildlife habitat.

Since 30 m is a commonly held buffer width, 30 m from a watercourse was used as the distance for this criterion.

Application / Mapping Rules

Open watercourses are linear features that contain flowing water for at least part of the year and can be natural or channelized. They include open intermittent or headwater drainage features, streams, rivers, creeks and open drains. Tiled or buried drains with no surface connection are considered "closed" watercourses and were excluded from the analysis.

Although digital data for watercourses exists for southern Ontario, this data is not current. Recognizing time and budget constraints, a method was developed that eliminates the need to update the entire watercourse layer. Using spring 2010 aerial photography (SWOOP), an on-screen interpretation of the edge (i.e., the bankful width) of open watercourses was completed in tandem with the interpretation of *Vegetation Community* boundaries. Onscreen measurements were made from the edge to community and were identified as being with in 30m from the edge.

Vegetation Communities within 30 m of the bankful width of an open watercourse are identified as a riparian area (Figure 10). As these riparian *Vegetation Communities* were attributed to their broader *Vegetation Groups*, the *Vegetation Groups* containing these riparian *Vegetation Communities* were identified as significant (i.e., met this criterion). This criterion identifies significant *Vegetation Groups*, not significant watercourses. Since major watercourses are identified as a *Vegetation Group* (Section 2.2.2.5), it follows that all major watercourses are significant according to this criterion. Minor watercourses are protected by other legislation such as the Fisheries Act and the Municipal Drainage Act.

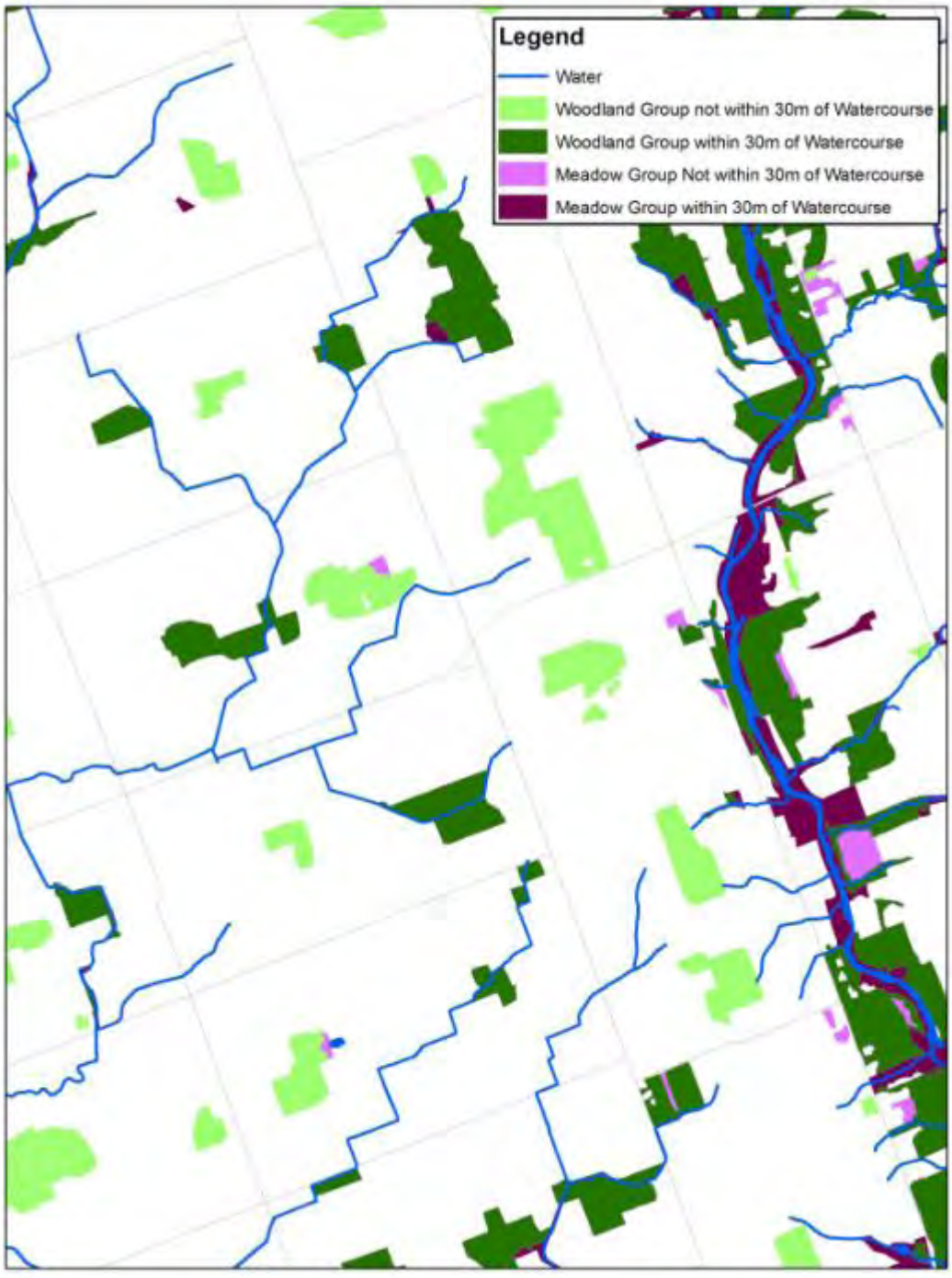
Results

Table 12 below summarizes the results for Criterion 3 and the map in Appendix I-3 shows the results. About half of the *Vegetation Groups* meet this criterion. This fact indicates that a lot of the natural areas on the landscape are near a watercourse because the land is harder to farm or develop and also that there is a high density of watercourses in the county. Of the 4,855 *Vegetation Groups* that met this criterion, about 23% (1,102) met only this criterion and no other criterion.

Table 12. Criterion 3 Results – *Vegetation Groups* containing or within 30 m of an Open Watercourse

Vegetation Group	Number of *Vegetation Groups*				Area of *Vegetation Groups*			% of Middlesex Land Base (333,330 ha)
	# that meet Criterion 3	Total #	% that meet Criterion 3	# that meet Criterion 3 and no other	Area that meet Criterion 3 (ha)	Total area	% Area of All Veg Groups	
Woodland	1,957	4,123	47.5%	379	43,174	52,748	81.8%	13.0%
Thicket	808	1,365	59.2%	296	2,232	3,205	69.6%	0.7%
Meadow	1,871	3,040	61.5%	327	6,069	8,319	72.9%	1.8%
Water Feature	130	284	45.8%	65	1,671	2,205	75.8%	0.5%
Connected Veg. Feature	89	124	71.7%	35	76	97	78.3%	0.0%
Total	**4,855**	**8,936**	**54.3%**	**1,102**	**62,892**	**66,574**	**94.5%**	**19.0%**
Wetland	1,236	1,919	64.4%	0	9,670	11,729	82.4%	3.0%

Figure 9. Criteria 3, illustration showing *Vegetation Groups* within 30 m of Open Watercourses



3.4 Size Significance Criteria Applied to Specific *Vegetation Groups*

A note about clustering Vegetation Groups around roads and railroads

Vegetation Groups separated by a road or railroad less than 20 m in width were clustered into one *Vegetation Group* (Section 2.4.8). All significance criteria for *Vegetation Groups*, except area, were applied to the clustered *Vegetation Group*. When calculating the area of a *Vegetation Group* cluster, the area of the road or railway was not included in the calculation. Instead, area was calculated as the area of the entire *Vegetation Group* cluster less the area of the road or railroad. Area of the woodland *Vegetation Group* and interior area were calculated on the non-clustered woodland *Vegetation Groups*.

3.4.1 Criterion 4 – All Wetland *Vegetation Groups* ≥ 0.5 ha

Rationale

Since European settlement, approximately 85% of wetlands greater than 10 ha have been lost in Southern Ontario (Ducks Unlimited Canada 2010). The Natural Heritage Reference Manual (OMNR 2010) recommends protection of wetland areas for their important contribution to groundwater flows through groundwater release. In catchment basins containing wetland storage areas in the headwaters, the wetlands maintain the hydrological regime of the surrounding area by dampening water peaks and reducing the potential for erosion in river gullies. In Wisconsin, Hey and Wickencamp (1996) found that increasing the amount of wetland in a watershed to 10% resulted in reduced flooding, higher base flows, and reduced occurrence of high flows. Environment Canada (2013) sets a guideline target of at least 10% wetland cover for major watersheds and 6% wetland cover for subwatersheds.

Also, it has been well documented that wetlands improve water quality and base flow by filtering out contaminants, encouraging infiltration, and storing water on the landscape. Wetlands provide important breeding and overwintering habitat for reptiles and amphibians.

It is important to protect as many wetlands on the landscape as possible. Johnson et al. (1990) found that watersheds containing less than 10 percent wetland cover were more susceptible to incremental losses of wetlands than those with more wetlands. The amount of natural habitat that is located adjacent to wetlands can be important to the maintenance of wetland functions and attributes. The value of a wetland is enhanced where the wetland is located close to other wetlands and natural areas so that wildlife can move between them to take advantage of favorable habitat and food (Findlay and Houlahan 1997, Houlahan and Findlay 2003). For example, wetlands situated within 100 m of other wetlands are more likely to have movement of fish among them (Golet 1976).

Wetlands occur where the water table is close to or at the surface and are characterized as seasonally or permanently covered by shallow water less than 2 m deep. The presence of this abundant water causes the formation of hydric soils. The fluctuation of water levels and the presence of herbaceous and woody water tolerant plants distinguish wetlands from aquatic Vegetation Ecosystems (Lee et al. 1998).

Application / Mapping Rules

The wetland layer was derived from the OMNR evaluated wetland mapping layer, as well as the unevaluated wetland layers developed by each of the Conservation Authorities in Middlesex County (refer to Mapping Criteria Section 2.2).

All provincially and locally significant evaluated wetlands approved by the OMNR regardless of size, as well as unevaluated wetlands ≥ 0.5 ha identified by Conservation Authorities, meet Criterion 4. ***Note:*** The term "significant wetland" is reserved for wetlands that have been evaluated and deemed significant using the Ontario Wetland Evaluation System (i.e., Provincially Significant Wetland, Locally Significant Wetland). The identification and delineation of significant wetlands must be approved by MNR.

Results

Table 13 shows the results of all wetland *Vegetation Groups* containing Wetland Communities (see map in Appendix I-4). The total area of these *Vegetation Groups* is 11,729 ha or 3.5% of the study area (geographic Middlesex). The 3.5% value is below the recommendation of Environment Canada (2013) for 6-10% wetland cover.

Table 13. Criterion 4 Results -- *Vegetation Groups* that contain Wetland Communities

Vegetation Croup	**# that meet Criterion 5 and no other**	**# that meet Criterion 5**	**# of Wetland Groups**	**% that meet Criterion 5**	**Area (ha)**	**% of Middlesex Land Base** (333,330 ha)
Wetland *Vegetation Group*	670	1,916	1,916	100%	11,729	3.5%

3.4.2 Criterion 5 – Woodland *Vegetation Group* ≥ 4 ha

Rationale

Habitat size is one of the most important measures for sustaining stable, diverse and viable populations of wildlife species. Larger woodland *Vegetation Communities* tend to have a greater diversity of habitat niches and are more effectively buffered from external negative influences such as environmental disturbances, nest predation, and parasitism (Askins and Philbrick 1987, Villard et al. 1999, Schwartz 1999, Soulé and Terborgh 1999, Burke and Nol 2000, Burke et al. 2011, Forman 1995c, Kohm and Franklin 1997, Bennett 2003, Marini et al. 1995). In a highly fragmented landscape, the definition of a large size woodland can be relatively small. Studies indicate that smaller woodlands (less than 10 ha) can be considered significant and worthwhile protecting as they provide certain ecosystem benefits.

Small mammals, such as mice and voles, use woodlands as small as 0.1 ha. In agricultural landscapes, these small woodlands become especially important during harvest, when these rodents are displaced from the field (Fitzgibbon 1997). Although small woodland *Vegetation Groups* are often regarded as poor habitat for breeding birds, Friesen et al. (1999) have demonstrated that small woodlands in agricultural landscapes can experience high pairing success for birds. Small forest fragments of 1 to 4 ha are also important stopover sites for migratory birds (Packett and Dunning 2009, Swanson et al. 2005). Insects, especially bees and butterflies, also rely on small woodlands in a fragmented landscape. Small woodlands may be just as important as larger ones for pollinator diversity and abundance (Banaszak 1996, Cane 2001, Donaldson et al. 2002).

Application / Mapping Rules

Riley and Mohr (1994) and the Natural Heritage Reference Manual (OMNR 2010) recommend that the minimum standard for determining the size of wooded *Vegetation Groups* considered to be significant within the planning area is a function of the percentage of forest cover within that area. The Natural Heritage Reference Manual (OMNR, 2010) recommends that woodlots of 4 ha or more should be considered significant in landscapes with about 5% -15% woodland cover. However, the NHRM recommends a 20 ha size cutoff for landscapes with about 15-30% woodland cover, a huge increase in size cutoff.

Table 6 shows that there is 15.8% woodland cover in the study area (geographic Middlesex). The 2003 MNHS recorded 12.3% woodland cover but it did not include the City of London or the First Nation Reserves. The Technical Committee, using local knowledge and experience, chose the 4 ha woodland size threshold for significance and this was accepted by the peer reviewer. The NHRM also recommends that the size threshold can be reduced to address the potential loss of biodiversity in the planning area. This local study takes guidance from the NHRM, but makes local decisions, as recommended. The 15.8% woodland cover is much closer to the lower range of 5-15% cover in the NHRM than the upper range of 15- 30%. The Huron Natural Heritage Study also used a 4 ha threshold (County of Huron 2013). Since woodland size is a very important criterion, it should capture a large number of woodlands in a fragmented landscape such as Middlesex. A 20 ha threshold would have captured far fewer woodlands.

Therefore, all woodland *Vegetation Groups* ≥ 4 ha in size meet Criterion 5 (see Appendix I-5).

Results

Table 14 shows the results for Criterion 5 and a map of the results is provided in Appendix I-5. Just less than half the woodland *Vegetation Groups* (1,924 of 4,123) meet this criterion but account for almost 93% of the woodland area. Thus, the remaining woodland groups that don't meet the criterion are very small and don't add up to a lot of area. Of the 1,924 *Vegetation Groups* that meet this size criterion, about 25% (475) meet only criterion 5 and no other criterion.

Table 14. Criterion 5 Results -- Woodland *Vegetation Group* >4 ha

	Number of *Vegetation Groups*				**Area of *Vegetation Groups***			
Vegetation Group	**# meet Criterion 5 only**	**# meeting Criterion 5**	**Total #**	**% that meet Criterion 5**	**Area that meet Criterion 5** (ha)	**Total Area**	**% total woodland area**	**% of Middlesex County Area** (333,330 ha)
Woodland *Vegetation Group* ≥ 4ha in size	475	1,924	4,123	46.7 %	48,992	52,895	92.6	14.7 %

3.4.3 Criterion 6 − Woodland *Vegetation Groups* within 100 m of a woodland *Vegetation Group* ≥ 4 ha

Rationale

The Natural Heritage Reference Manual (OMNR 2010) recognizes that the distance between individual woodlands is an important factor in maintaining woodland integrity. Woodlands that happen to be situated near each other or to other natural features have more opportunities for restoring connectivity since linkages are important for both animal and plant dispersal. Small woodlands located close to big woodlands are more important in feature and function than those that are isolated. One reason is that smaller woodlands that are closely spaced can serve as stepping stones for species movement. For example, Bowles (1997) found that species richness was higher for small *Vegetation Patches* closely linked to larger *Vegetation Patches* than similarly sized *Vegetation Patches* not linked to larger *Vegetation Patches.*

Linkages are important for both animal and plant dispersal. However, the identification of landscape connectivity is an evolving science. Sutherland et al. (2000) compared dispersal data for 77 bird and 68 mammal species. In the case of birds, maximum dispersal distances ranged from 130 m for the European Magpie to 1,305 km for the Great Horned Owl. For mammals, maximum dispersal distances ranged from 140m for the Prairie Vole to 930.1 km for the Lynx. As for plants, the limited distances that most seeds travel are well documented for all growth forms (Cain et al. 2000, Harper 1977, Howe and Smallwood 1982, Willson 1993, Cain et al. 1998). Recognizing that plants have limited mobility compared to animals, the average wind dispersal distance of 100 m (Nathan et al. 2002) was used as the distance that would functionally connect two woodlands.

Application and Mapping Rules

In Middlesex County, woodland *Vegetation Groups* < 4 ha that are within 100 m of a woodland *Vegetation Group* ≥4 ha, regardless of what is surrounding them, meet Criterion 6 and are considered significant.

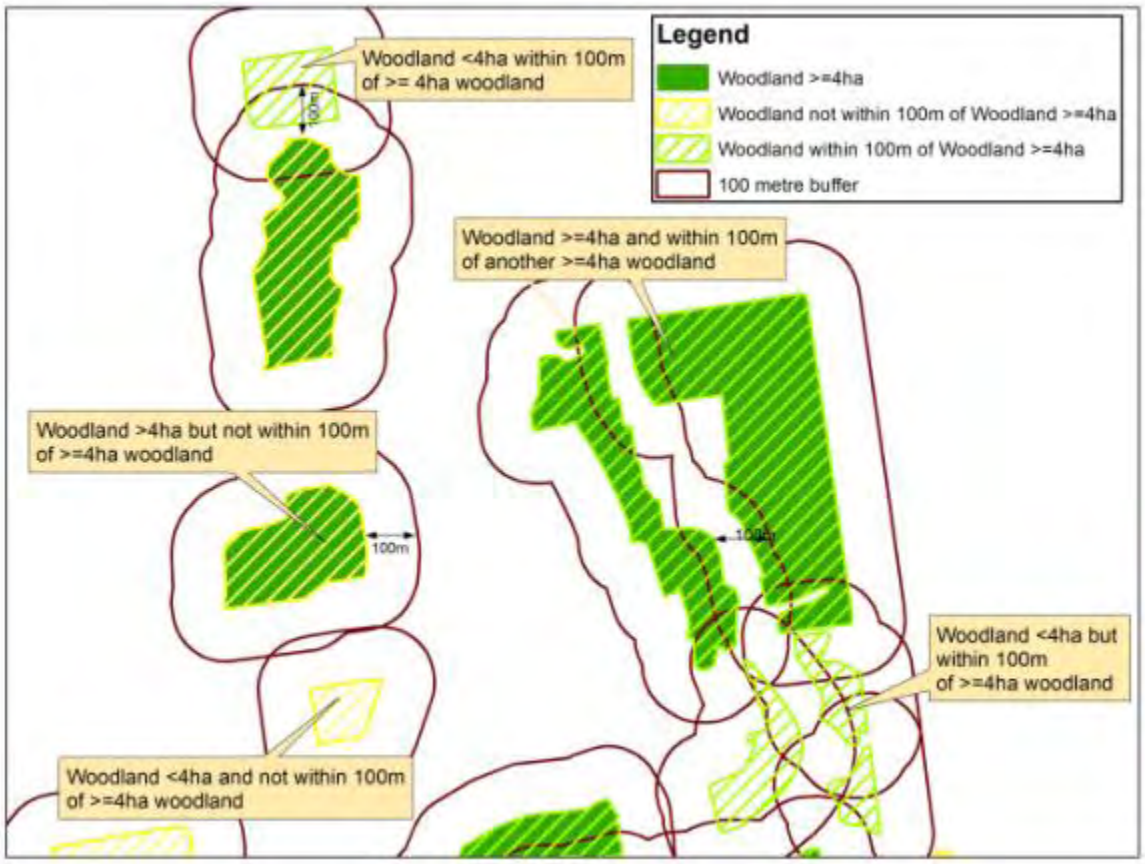
Results

The findings are shown in Table 15 and in Appendix I-6. Over a third (37.6%) of all the woodland groups are within 100 m of a woodland group ≥ 4 ha, amounting to 60% of all woodland area. Of the 1550 woodland groups that met this criterion, 339 or about 22% met this criterion and no other. These figures indicate that there is a substantial amount of woodland that is in close enough proximity to larger woodlands to help maintain ecological integrity.

Table 15. Criteria 6 Results ─ Woodland *Vegetation Groups* within 100 m of a Woodland *Vegetation Group* ≥4 ha

	Number	**% of all Woodland Groups** (4,123)	**Area meeting Criterion 6** (ha)	**% of Total Woodland Group Area** (52,748 ha)	**% of Middlesex County Area** (333,330 ha)
Woodland Group within 100 m of a Woodland Group ≥ 4ha	1,550	37.6 %	31,528	60.0%	9.5 %
Woodland Groups meeting Criterion 6 and no other	339	8.2 %	566	1.1%	0.2 %

Figure 10. Criterion 6, Illustration of 100 m proximity between Woodland Groups ≥4 ha



3.4.4 Criterion 7 – Thicket *Vegetation Group* ≥ 2 ha

Rationale

Thicket habitats dominated by shrubs or young trees are most likely to support and sustain a diversity of species if they are large (Rodewald & Vitz 2005, OMNR 2012). Often these habitats are temporary and eventually transition into woodlands. When a farm field is left fallow for just a few years, shrubs, young trees, grasses and sun-loving herbaceous plants will start to grow as part of the natural succession process. As the trees grow, they shade out shrubs, grasses and wildflowers and within 25 to 30 years, the area will become a young woodland. Climate and human land use activities, such as active reforestation, can also alter the composition and structure of thicket habitats (Curtis 1959, Niemi and Probst 1990, Askins 2000). However, thickets maintained by wet, poor or shallow soils or disturbance processes such river flooding and ice scour may remain as thickets for a long period of time since tree growth is inhibited.

The literature on bird species that use thickets suggests that thicket habitat is on the decline and large thickets are becoming increasingly uncommon. Thickets may be declining due to changes in rural landuses (e.g., more cropland and less rough land pasture and hedgerow). As a result, many of the bird species that typically use thickets and early succession stages of woodland development are also declining rapidly (Sauer et al. 2001). Some thicket birds are area sensitive and select large areas of contiguous habitat for breeding. Birds such as the Chestnut-sided Warbler will use smaller areas (less than 0.5 ha), but the more uncommon species such as Golden-winged Warblers, Yellow-breasted Chats or Woodcock require areas of 10 ha or more (Chandler et al. 2009, Rodewald and Vitz 2005, Oehler et al. 2006, Schlossberg and King 2008, King et al. 2001, King and Byers 2002, King et al. 2009). In general, large blocks of any habitat (grassland, thicket, mature forest, wetland, etc.) are more valuable to wildlife because they tend to support both the common species and the uncommon species.

Application / Mapping Rules

If managing thickets to enhance the long-term survival of a variety of wildlife, larger is better. Thickets of at least 10 ha in size are required for area sensitive thicket birds, yet this class size is very rare in Middlesex.

To determine the cut-off size for thicket *Vegetation Groups* in the study area, the top 25th percentile of data was calculated (a method of descriptive statistical analysis to determine rarity). The 25th percentile was 2.4 ha and it was then rounded down to the nearest whole number, 2 ha. Thus, all thicket *Vegetation Groups* ≥2 ha meet Criterion 7.

Results

The results of the mapping are shown in Table 16 and in Appendix I-7. Almost one third of all thicket *Vegetation Groups* (437 of 1365) meet the criteria. Appendix I-6 shows the results in map form. About 25% (109 of 437 thicket *Vegetation Groups*) met only this criterion.

Table 16. Criterion 7 Results -- Thicket *Vegetation Group* ≥2 ha

	Number	% of all thicket groups	Area (ha)	% area of all thicket groups (3,250 ha)	% of Middlesex Land Base (333,330 ha)
Thicket *Vegetation Group* >2 ha	437	32.0%	2224	68.6%	0.7%
Thickets meeting Criterion 7 and no other	109	8.0%	470	14.5%	0.1%

3.4.5 Criterion 8 – Meadow *Vegetation Group* ≥10 ha

Rationale

Meadows and grasslands of all sizes are used by many different wildlife species throughout the year. The amount of native grassland and meadow habitat has declined drastically throughout North America. Grassland birds are of special concern since they have suffered more serious population declines than any other group of birds (Igl and Johnson 1997, Peterjohn and Sauer 1999, Sauer et al. 2001). Johnson (2001) demonstrated a preference for large grassland *Vegetation Groups* by a number of grassland bird species, including the Savannah, Grasshopper, and Henslow's Sparrows which have territory sizes typically 1 ha or less. Corace et al. (2009), Davis (2004), Winter et al. (2006) and Ribic and Sample (2001) also found that the density of open land bird species is regulated by the interaction of field size, shape and edge type, and that larger open areas tend to support a more diverse bird community.

To benefit the greatest number of wildlife species, land conservation should be focused on grasslands ≥10 ha in size. The Significant Wildlife Habitat Technical Guide (OMNR 2000b) identifies 10 ha blocks of undisturbed grassland as excellent raptor hunting areas, and meadows >30 ha as significant open country bird breeding habitat. Grassland species such as Bobolinks, Savannah Sparrows, Eastern Meadowlarks and Grasshopper Sparrows are more abundant as breeding birds in continuous grassland habitats of 4 - 6 ha (McCracken et al. 2013, Ochterski 2006a, 2006b, Mitchell et al. 2000).

Application

The Technical Committee and Peer Reviewer accepted a 10 ha threshold as a reasonable number for Middlesex. The Huron County Natural Heritage Study used ≥10 as the cutoff as well. Thus, in the study area, all meadow habitats ≥ 10 ha meet Criterion 8.

Results

The results for Criterion 8 are shown in Table 17 below. Only 4.4% of the meadow *Vegetation Groups* meet this criterion, meaning that most of the meadow *Vegetation Groups* are smaller than 10 ha. Of the 135 meadow *Vegetation Groups* that meet the criterion, only two meet this criterion alone. Thus, the vast majority of thicket groups meet other criteria as well. The map in Appendix I-8 shows the meadows that meet this criterion.

Table 17. Results for Criterion 8 -- Meadow *Vegetation Groups* ≥10 ha

	Number	**% of Total Number** (3,040)	**Meadow Area** (ha)	**% of total Meadow Area** (8,319 ha)	**% of Middlesex County Area** (333,330 ha)
Meadow *Vegetation Groups* ≥ 10 ha	135	4.4 %	2,333	28.0%	0.7 %
Meadows that meet Criterion 8 and no other	2	0.1 %	27	0.3%	0 %

3.4.6 Criterion 9 – Meadow *Vegetation Group* within 100 m of a large Woodland or large Thicket *Vegetation Group*

Rationale

According to the USDA and the Wildlife Habitat Council (2000), land use and development practices have resulted in significant losses of native butterfly habitat. Among the invertebrates, butterflies are an iconic species for recognition and conservation for many reasons. Butterflies are important pollinators, are not usually considered pest species, are of interest to the public, have a relatively short lifespan as an adult, are relatively low in biodiversity, and are a food source for other species.

Minimum habitat size is not usually a limiting factor for most generalist species and no reasonable estimate of minimum habitat size exists for butterflies as a group (USDA and the Wildlife Habitat Council 2000). Instead, it is important to consider meadow butterfly habitat in context with the surrounding range of habitats. To be effective, butterfly habitat must support as many of the life stages of the butterfly species as possible. These life stages have very different food and cover needs. For example, the host plants that feed caterpillars are different from the host plants that provide the nectar sources required by adults. As well, adult butterflies have a strong preference for open, sun-lit habitats with nectar sources, while the larvae require host trees found in shaded thicket and woodland habitats (USDA and Wildlife Habitat Council 2000).

Lederhouse (1982) found that male Black Swallowtail butterflies (*Papilio polyzenes*) defend areas of approximately 75 m^2. Davis (1978) found that male Speckled Wood Butterflies (*Pararge aegenia*) defend territories of 50 m^2, yet females fly distances of up to 600 m.

Application / Mapping Rules

Given the benefits associated with large habitats, including persistence, and using 100 m as the cutoff distance (a conservative estimate based on the scientific literature above and 100 m wind seed dispersal distance) all meadow *Vegetation Groups* found within 100 m of a large thicket *Vegetation Group* or woodland *Vegetation Group* meet criterion 9.

Results

The results for Criterion 9 are shown in Table 18 and in Appendix I-9. Over three-quarters (78.2%) of all Meadow *Vegetation Groups* meet this criterion. Of the 2,378 groups that met this criteria, a large number, 678 (22.3%), met only this criterion and no others. These results suggest the three habitat types of meadow, thicket and woodland are closely tied in the landscape.

Table 18. Results for Criterion 9 -- Meadow *Vegetation Groups* within 100 m of a larger Woodland or large Thicket *Vegetation Group*

	Number	**% of all Meadow Groups** (3,040)	**Area**(ha)	**% of all Meadow Area**(8,319 ha)	**% of Middlesex Area** (333,330 ha)
Meadow *Vegetation Group* within 100 m of a large woodland or thicket *Vegetation Group*	2,378	78.2 %	6,932	83.3%	2.1 %
Meadow *Vegetation Group* meeting Criterion 9 and no other	678	22.3 %	1,172	14.1%	0.4 %

3.5 Significance Criteria Applied to All *Vegetation Patches*

3.5.1 Criterion 10 – *Vegetation Patches* containing a *Vegetation Group* that meets a Group Criteria

Note: Criterion 10 is used to identify the natural heritage system since it recognizes that vegetation groups identified using criteria 1 - 9 and 13 -15 do not exist in isolation. Criterion 10 is a mapping rule that translates group criteria 1-9 and 13-15 into a single patch criterion.

Rationale

Vegetation Patches are comprised of one- to- many *Vegetation Groups*. The spatial arrangement between the *Vegetation Communities* within the *Vegetation Patch* determines the resistance to flow or movement of species, energy, materials, and water (Forman 1995b). Recognizing this interdependency between landscape structure and function, it is important to consider the entire *Vegetation Patch* as a single entity when determining significance. To maintain biological diversity, natural functions, and viable populations of native species and ecosystems, significant natural features and functions cannot exist in isolation.

Application

Mapping rules of adjacency and proximity were used to define a *Vegetation Patch*. If a *Vegetation Patch* contained a *Vegetation Group* that met a group criteria (i.e. criteria 1, 2, 3, 4, 5, 6, 7, 8 or 9), the entire *Vegetation Patch* meets this criterion.

Results

The results for Criterion 10 are shown in Table 19 and in Appendix I-10. Some 2,738 patches meet this criterion or 78.2% of all patches. Since Criterion 10 is really a summary of Criteria 1 through 9, it should account for a great number of patches on the landscape. Criterion 10 captures 97.5% of all *Vegetation Patch* area.

Table 19. Results for Criterion 10 – *Vegetation Patches* containing a *Vegetation Group* that meets a Group Criteria

	Number	**% of all *Vegetation Patches*** (3,502)	**Patch Area** (ha)	**% Area of all *Vegetation Patches*** (66,887)	**% of Middlesex County Area** (333,330 ha)
***Vegetation Patches* that contain a *Vegetation Group* that meets a Group Criteria**	2,738	78.2 %	65,227	97.5%	19.6 %
***Vegetation Patches* meeting Criterion 10 and no other**	1,439	41.1 %	8,257	12.3%	2.5 %

3.5.2 Criterion 11 – *Vegetation Patch* contains a Diversity of Vegetation Ecosystems, Groups or Communities

Rationale

Representation approaches have become key concepts in developing methods to select the most significant remaining natural areas (Canadian Council on Ecological Areas 1991, Peterson and Peterson 1991, Horn and Koford 2004). The Natural Heritage Reference Manual (OMNR 2010) recognizes that a fundamental step in natural heritage system planning is to consider the protection of the full range of natural features that occur in an area (representation), including both rare and common features, in order to preserve biodiversity at the species and community levels.

Natural areas (or clusters of areas) that span a range of topographic, soil and moisture conditions tend to contain a wider variety of plant and animal species, and may support a greater diversity of ecological processes. The diversity of species is dependent upon the diversity of habitats on the landscape since dissimilar habitats provide food, shelter, and reproductive requirements for different species. Since many species use more than one habitat type to meet their life cycle requirements, it is important for *Vegetation Patches* to be comprised of different habitat types. This criterion encompasses structural diversity (i.e., the full range of canopy heights and types), as well as diversity in the context of slope, aspect, wetness, physiography, etc.

Definition

The number of different Vegetation Ecosystems, *Vegetation Groups*, and *Vegetation Communities* in a *Vegetation Patch* can be used as proxy measures of diversity.

The three types of Vegetation Ecosystems are linked by a multitude of processes. For example, aquatic Vegetation Ecosystems in forests are coupled to adjacent terrestrial Vegetation Ecosystems by transitional riparian zones and wetland areas. Processes within wetlands and riparian zones can regulate the retention and release of nutrients and carbon into the aquatic Vegetation Ecosystem (Tufford et al. 1998, Junk et al. 1989). At a broader scale, the inflow of water, nutrients, and sediments from surrounding watersheds are heavily influenced by conditions within the floodplain. Conversely, floodplain plant and animal habitat value and sediment supply and fertility are often determined by river hydrology. The surrounding landscape can also influence the capacity of wetlands to perform functions such as sequestering pollutants, modifying nutrient loads, and providing habitat (Wetzel 2001). The interdependencies between the three natural Vegetation Ecosystems provide strong support for significance criteria based on linkages and spatial patterns.

Application

Three different measures were used to determine if a *Vegetation Patch* was diverse. If any one of the following three measures was met, the *Vegetation Patch* was identified as significant (see Figure 11). To determine the number thresholds, many scenarios were run on the data set to find the right combination that reduced redundancy within the three layers.

i) *Vegetation Patch* contains > 1 Vegetation Ecosystem and/or
ii) *Vegetation Patch* contains > 2 *Vegetation Groups* and/or
iii) *Vegetation Patch* contains > 3 *Vegetation Communities*.

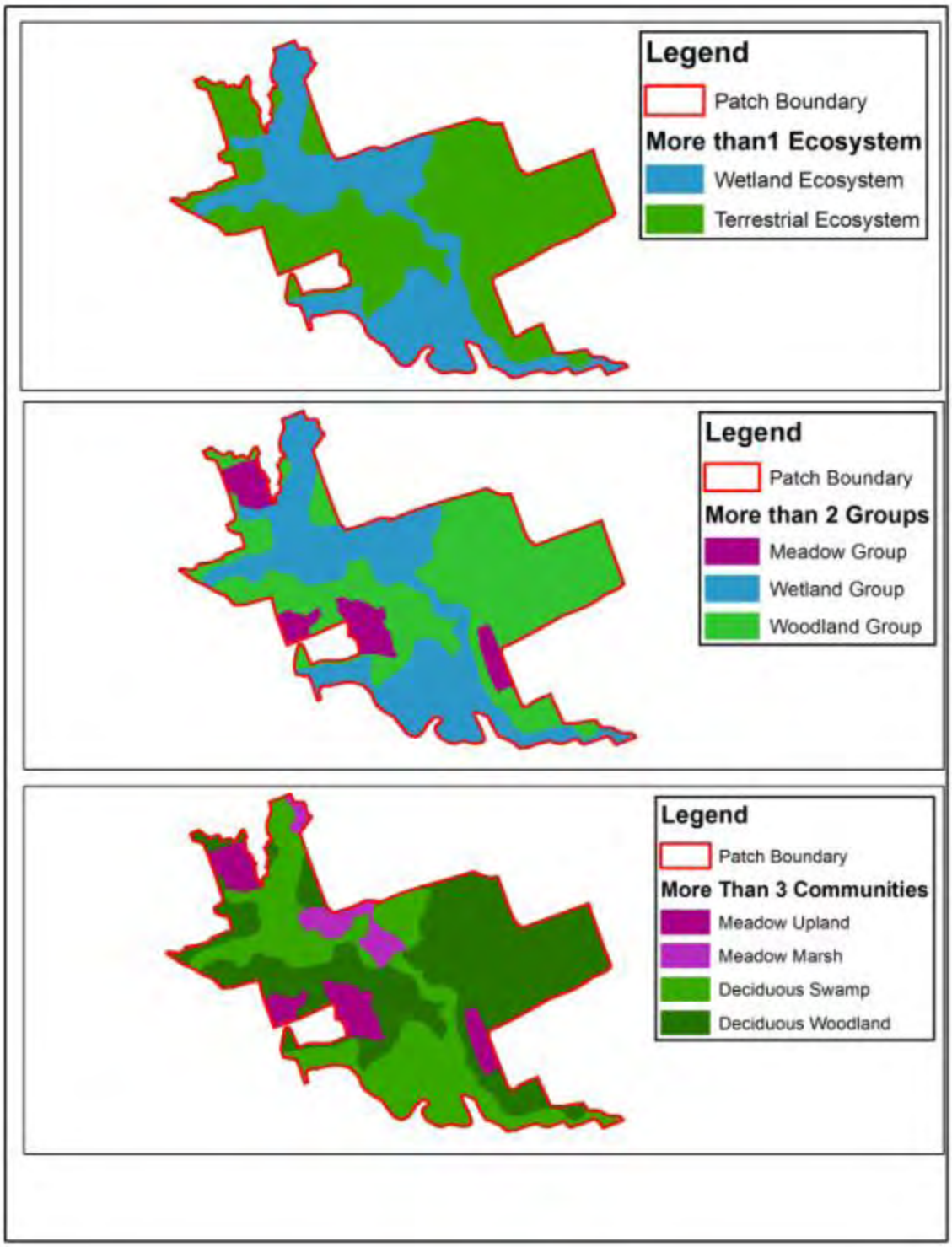
Results

Table 20 below shows the results for Criterion 11 and the results map is included in Appendix I-11. A third of all patches (1,156 of 3,503) met this criterion, representing over 85% of patch area. Because of the large area it captures, this diversity criterion picks up mostly larger patches. It is not surprising that large patches contain more habitat types than small patches. Only a small number of patches (32) met this criterion alone.

Table 20. Results for Criterion 11 -- *Vegetation Patch* contains a diversity of vegetation ecosystems, groups and communities

	Number	**% of *Vegetation Patches*** (3,502)	**Area** (ha)	**% Total Patch Area** (66,887 ha)	**% of Middlesex County Area** (333,330)
***Vegetation Patches* that contain:** **> 1 Veg Ecosystem and/or** **> 2 Veg Groups and/or** **> 3 Veg Communities**	1,156	33.0%	57,107	85.2%	17.1%
***Vegetation Patches* meeting Criterion 11 and no other**	32	0.9%	83	0.1%	0.0%

Figure 11. Criterion 11, illustration of patches containing many different Vegetation Ecosystems, Groups and Communities



3.5.3 Criterion 12 − *Vegetation Patches* within 100 m of a *Vegetation Patch* that meets other Patch Criteria

Rationale

The presence of large natural habitat patches is not sufficient to counteract the effects of fragmentation, especially if there are relatively few such patches, they are widely dispersed, or there are few natural corridors linking them (Riley and Mohr 1994, Prugh et al. 2008). Natural areas close to protected areas are increasingly seen as important to the ecological integrity of the protected sites. Research shows local landscapes that include large natural areas, linked to the regional landscape mosaic by a network of smaller interacting natural areas and corridors, offer the highest probability of maintaining overall ecological integrity (Larson et al. 1999, Villard et al. 1999).

Smaller *Vegetation Patches* of natural cover that are closely spaced can serve as stepping stones for species movement. For example, Baguette and Van Dyck (2007) showed that the ability and willingness of wildlife species to move between and successfully settle in different *Vegetation Patches* was affected by the distance between the *Vegetation Patches*. Environment Canada (2013) found that two or more *Vegetation Patches* are more likely to support more species collectively than they would if they were isolated from each other. In areas where large core areas do not exist, clusters of smaller natural areas that span a range of habitats and are arranged close together support a greater diversity of ecological processes and are able to reduce the effects of fragmentation.

Application / Mapping rules

Recognizing that plants have limited mobility compared to animals, the average wind dispersal distance of 100 m was used as the distance that would functionally connect two *Vegetation Patches* (Cain et al. 2000, Harper 1977, Howe and Smallwood 1982, Nathan et al. 2002, Willson 1993, Cain et al. 1998).

In Middlesex County, all *Vegetation Patches* that don't meet a criteria but are within 100 m of a *Vegetation Patch* that does meet a criteria meet this criterion. Figure 12 illustrates this criterion.

Results

Table 21 below shows the mapping results for Criterion 12. The map showing the results is included in Appendix I-12 (note, the patches are very tiny and difficult to see). Though this criterion is not met by a lot of patches (162 of 3,503), the vast majority that do meet it, only meet this criterion and no other (154 of 162). Thus this criterion picks up a moderate number of patches that would not have been picked up with any other criteria.

Table 21. Results for Criterion 12 -- *Vegetation Patches* within 100 m of a *Vegetation Patch* that meets other patch criteria

	Number	**% of all *Vegetation Patches*** (3,502)	**Patch Area** (ha)	**% of Total Patch Area** (66,887 ha)	**% of Middlesex Land Base** (333,330 ha)
***Vegetation Patches* within 100m of a *Vegetation Patch* that meets other patch criteria**	162	4.6%	4,639	6.9%	1.4%
***Vegetation Patches* meeting Criterion 12 and no other**	154	4.4%	237	0.4%	0.1%

Figure 12. Criterion 12, illustration of a small patch that doesn't meet any significance criteria but is within 100 m of a patch that does meet significance criteria

3.6 Significance Criteria Applied to *Vegetation Groups* Not Currently Mapped

For significance criteria where mapping is not yet available or consistent across the study area, a procedure will need to be developed to report findings of these features and incorporate them in the MNHSS (see Chapter 5).

3.6.1 Criterion 13 − Significant Wildlife Habitat (SWH)

Rationale

Wildlife habitat is considered significant when it is ecologically important in terms of features, functions, representation (amount), and quality of an identifiable geographic area or Natural Heritage System. The Significant Wildlife Habitat Technical Guide (OMNR 2010) describes four categories of significant wildlife habitat:

- Seasonal concentrations of animals
- Rare *Vegetation Communities* or specialized habitat for wildlife (includes IUCN S1-S3)
- Habitat of species of conservation concern
- Animal movement corridors

Criteria for Significant Wildlife Habitat (SWH) are provided by OMNR in the Significant Wildlife Habitat Technical Guide (OMNR 2000b) and the Natural Heritage Reference Manual (OMNR 2010). More detailed guidelines for evaluating habitat within Ecoregions 6E and 7E, including thresholds of number of species that designate an area as a Significant Wildlife Habitat, have been provided in draft form as the Significant Wildlife Habitat Ecoregional Criteria Schedules (OMNR 2012). The OMNR also recommends that the IUCN (International Union for Conservation of Nature) class S1-S3 species be considered under Significant Wildlife Habitat.

Application / Mapping Rules

Currently, Significant Wildlife Habitat (SWH) as defined by OMNR is not comprehensively mapped at a county-level scale in Ontario. Identification of this habitat can occur through field studies conducted through DARs or other field studies/inventories, then reported to the OMNR.

Green Frog. *Photo by Cathy Quinlan*

3.6.2 Criterion 14 − Groundwater Dependent Wetlands (GDW)

Rationale

Groundwater is not only an important water source to meet human consumptive needs, it also plays a critical role in supporting many ecosystems. Yet the policies and regulations that protect groundwater for human consumption may not necessarily protect Groundwater-Dependent Wetlands (GDWs), a vital yet poorly understood sub-set of the natural environment (Howard and Merrifield 2010).

GDWs are ecosystems that require access to groundwater to maintain their communities of plants and animals, ecological processes and ecosystem services. Typical examples of these systems are spring, seeps, fens and perched groundwater wetlands.

In all of these systems, terrestrial vegetation interacts with the groundwater. Recognizing that the chemical composition of groundwater is closely related to the type of bedrock and surficial deposits through which it has moved, the groundwater contributes water and nutrients to maintain a rich and unique biodiversity adjusted to these special conditions (Howard and Merrifield 2010). For example, the constant supply of 47ºF (8ºC) water at the upper edges of seeps typically results in lush and dense herbaceous cover.

There has not been a great deal of study or conservation planning around groundwater-dependent ecosystems. Consequently, there is much that needs to be learned about these ecosystems. The increasing demand for groundwater resources due to the combined pressures of development, a variable climate, and a growing population threatens these ecosystems (Brussard et al. 1999, MacKay 2006). The availability of surface water to meet consumptive needs has declined and the pressure on groundwater resources is growing. GDW's are threatened by the alteration of the quality or quantity of groundwater discharge resulting from development in groundwater recharge areas and by heavy machinery either in the GDW itself or in its immediate vicinity. Heavy machinery can create deep ruts that destroy the vegetation, alter the hydrology, and disturb resident amphibian species that spend their adult lives in or near water.

It is important to protect natural features on significant groundwater recharge areas since the vegetation found within them help to purify and protect groundwater sources. The bacteria filters located on the roots of living vegetation fix the heavy metals in the groundwater. Through natural decomposition, organic carbon filters the water and degrades contaminants before they reach the groundwater. Natural features also cool the water through shading. Filtering and shading improves groundwater quality and quantity, which in turn improves ecosystem features and functions.

Definition

According to the NHRM (OMNR 2010), woodlands should be considered significant if they are located within, or a specific distance from, a sensitive groundwater discharge area (e.g., springs, seepage slopes). Groundwater discharge is evident at the seep margin and provides a constant supply of water to the seep community, with flows at many seeps persisting even through the driest summer months. As a result of the continuous soil saturation, thin surface organic layers are generally present over saturated mineral soils.

Currently, areas of groundwater release tend to be small occurrences (i.e., not picked up by satellite imagery). Groundwater ecosystems can be classified by their geomorphic setting (aquatic or terrestrial) and associated groundwater flow mechanism (deep or shallow). On this basis, Howard and Merrifield (2010) identified three groundwater dependent ecosystem types:

- **Springs and seeps** − small wetlands formed by groundwater discharge from relatively deep flow systems that rise to form distinctive springs with associated and often unique aquatic ecosystems. Downward movement of groundwater is often impeded, resulting in horizontal flow and discharge of water at the surface. Seeps are typically long and narrow with a total area less than 0.5 acre and tend to occur on or near the base of slopes or watercourses or on benches in upland forests. Seeps can vary seasonally and depend on the depth and size of the groundwater resource supporting them.

- **Wetland ecosystems** − discharge of shallow and sometimes perched groundwater flow. Fens are an example of a groundwater dependent wetland.

The third type identified by Howard and Merrifield (2010) is groundwater dependent streams, but these are not considered in the MNHSS.

Application

Groundwater Dependent Wetlands of any size can be found and mapped through site inventories, studies and DARs. A possible procedure for a landscape scale study is found in Appendix C.

Watercress often grows in groundwater discharge areas. *Photo by Cathy Quinlan*

3.6.3 Criterion 15 – Watercourse Bluff and Deposition Areas

Rationale

Steep slopes, cliffs, valley bluffs, gravel bars and beaches are similar to upturned sections of earth and can create unique natural features for specialized assemblages of plants and animals.

Bluffs found along rivers can be devoid of life due to the arid conditions or full of rare and fragile plant life that grow sporadically along different soil layers. Bluffs of steep river banks are formed by river erosion on the outside of a meander. Erosion can also be the result of ground water movement and surface runoff. Bluffs can provide prime nesting quarters for all sorts of birds, including an assortment of swallows, Belted Kingfishers and Turkey Vultures. The Bank Swallow that nests along naturally eroding slopes of streams, rivers, and lakes, has undergone significant population declines throughout Canada. In Ontario, Bank Swallows have declined at a rate of 4.7% annually over the last 40 years based on Breeding Bird Survey (BBS) data. Although the precise mechanisms driving the declines are unknown, the size and longevity of Bank Swallow colonies is dependent on bank erosion, which determines suitable nesting habitat. Declines are generally thought to be a consequence of habitat loss, changes in food source (i.e., aerial insects), and threats during migration or on the wintering grounds.

Depositional areas include gravel bars and beaches that form in watercourses where water flow is slower (e.g., inside river meander), allowing soil, sand and gravel to settle out of the water column. These features, while often small in scale, are prime nesting sites for turtles, especially Snapping Turtles and Spiny Softshells. Bars and beaches can be unvegetated or support early successional plants, depending on how recent there has been flooding and re-shaping of the feature.

Application

To identify potential bluffs on the landscape, one could use digital contour data and GIS analysis of very steep slopes. However, it is very difficult to accurately identify a vertical face. Therefore, as this habitat is detected and / or verified through site studies as part of the Ecological Site Assessment Process and recorded in the Development Assessment Report (DAR), it should be mapped. All Watercourse Bluff and Depositional Area *Vegetation Groups* meet criterion 15.

A short bluff along the Thames River near Delaware. *Photo by Cathy Quinlan*

3.7 Additional Information – Criteria that did not pick up any patches not already picked up by other criteria

Two parameters, Woodland Interior and *Vegetation Patches* ≥ 100 ha, were originally part of the significance criteria. However, when the model was run they did not pick up any patches that were not already picked up by other criteria. However, these criteria and their results are provided here as an added information items.

3.7.1 *Vegetation Patches* ≥ 100 ha

Rationale

Size is a key landscape-level factor affecting the presence, abundance, and diversity of species (Environment Canada 2013, Mazerolle and Villard 1999, Lovett-Doust and Kuntz 2001, Lovett-Doust et al. 2003, Bender et al. 1998). The Natural Heritage Reference Manual (OMNR 2010) recognizes that large patches of natural area are more valuable than smaller patches, provided that size is not the only consideration.

The size of a *Vegetation Patch* considered to be large depends on the landscape of the planning area. In a planning area with a low percentage of natural feature cover that is highly fragmented, the size of areas considered to be large would be smaller than in a region where natural feature cover is extensive. As well, natural areas should be large enough to be resilient to typical natural disturbances. Current science suggests that 100 hectare woodland *Vegetation Groups* will support approximately 60% of area sensitive species while 200 hectare woodland *Vegetation Groups* will support approximately 80% (Environment Canada 2013). Burke and Nol (2000) determined that reproductive success of forest birds in southern Ontario was consistently higher for woodland *Vegetation Groups* greater than 94 ha.

Application / Mapping Rules

Since natural cover is relatively low in geographic Middlesex, all *Vegetation Patches* 100 ha in size or greater were identified as meeting the large *Vegetation Patch* parameter (Figure 19).

Results

Table 22 shows that there are only 79 patches (2.3% of all patches) that are 100 ha or larger. However, these patches account for over half of the area of all the patches combined. Appendix J-1 shows the results in map form. Most of the 100 ha patches are long patches along major watercourses. There are several within the First Nation Reserves as well.

Table 22. *Vegetation Patches* ≥100 ha

	Number	**% of *Vegetation Patches*** (3,502)	**Area** (ha)	**% of all Veg Patch Areas** (66,887 ha)	**% of Middlesex County Area** (333,330)
***Vegetation Patches* ≥ 100 ha in size**	79	2.3 %	37,527	56.0%	11.3 %
***Vegetation Patches* meeting this parameter and no other**	0	0	0	0	0

3.7.2 Woodland Interior Habitat

Interior habitat is useful as a measure of ecosystem health (Weathers et al. 2001, LRC and OMNR 2000, Sandilands and Hounsell 1994, Sisk et al. 1997), but not as useful in selecting significant woodlands. Environment Canada (2013) recommends that a minimum of 10% of watersheds should be in woodland interior habitat. The NHRM (OMNR 2010) defines edge habitat as habitat that exists within 100 m from the outermost trees. Meffe and Carroll (1997), Matlack (1993), Chen et al. (1995), and Hamill (2001) consider edge habitat as a zone of influence that varies in depending on where and what is being measured.

Application / Mapping Rules

To define interior habitat, a swath of 100 m around the inside perimeter of the woodland *Vegetation Group* before clustering around roads was delineated as "edge" habitat. Any habitat within the woodland *Vegetation Community*, but not within the 100 m wide edge, was identified as woodland interior. Figure 13 provides an illustration of the mapping of interior.

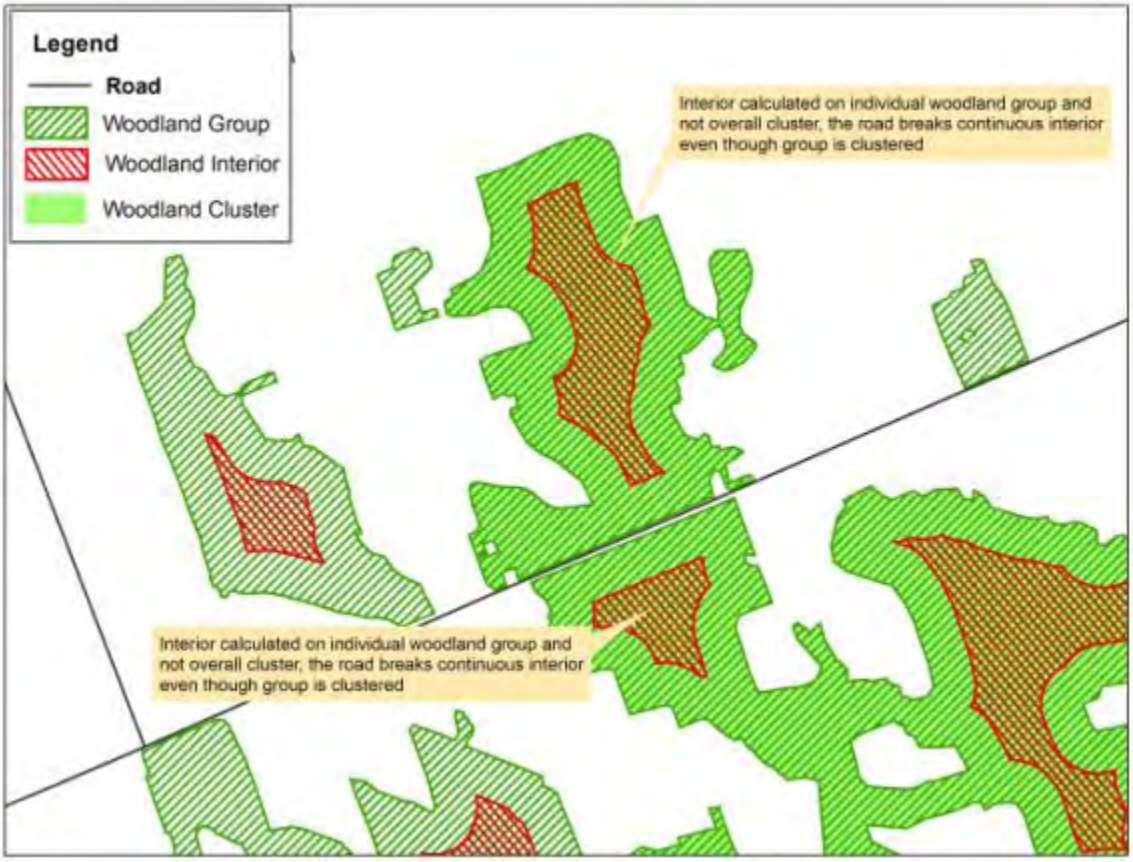
Results

Table 23 provides a summary of interior woodland habitat found in Middlesex County. Less than 20% of all woodland groups contain interior habitat, indicating most woodlands are small and/or narrow. However, the woodlands with interior habitat, amount to 72.2% of all woodland group area. See map in Appendix J-2.

Table 23. Results of Woodland Interior Habitat

	Number	**% of all Woodland Groups** (4,123)	**Area (ha)**	**% of Woodland Group Area** (52,748 ha)
Woodland *Vegetation Groups* that contain ≥ 0.5 ha of interior woodland habitat	761	18.5 %	38,060	72.2%
Number of woodland Veg Groups that met this criteria alone	0	0		

Figure 13. Illustration of how Interior Woodland Area is calculated



3.8 Criteria Reviewed but Not Included

Several additional criteria were reviewed by the Technical Committee and consultants as part of this study. Some were used in the past, some were used in other natural heritage studies, and some were suggested by committee members. Each was evaluated and determined to not fit this study for various reasons or were redundant with other criteria already used. A full description of these criteria and the rationale for not including them is shown in Appendix E. Below is a list of the 19 criteria that were not used:

- Best representative *Vegetation Patch* on landform physiography and soil type
- Located on a distinctive, unusual or high quality landform. All areas (both vegetated and non-vegetated) on: gullies, valley lands, within 30 m of limestone outcroppings
- All *Vegetation Patches* found alongside a coldwater watercourse or watercourse containing Brook Trout
- Shape of *Vegetation Patch*
- Adjacent to an OMNR evaluated wetland or life science ANSI
- Contains an area identified in the local official plans e.g. Local Significant Natural Areas (Hilts and Cook 1982).
- Unique Intrinsic Characteristics (i.e., site level)
- Distance from development (e.g., permanent infrastructure and buildings) or matrix
- Persistence or Threatened
- Porous or erodible soils
- *Vegetation Patch* contains a large sized wetland defined as:
    - Wooded wetlands >4ha based on Environment Canada (2013)
    - Wetland meadows and marshes > 10ha based on Environment Canada (2013)
    - Small wetland meadows and marshes adjacent to other *Vegetation Communities* may be vital to butterflies
    - Wetland thicket size determined by top 75th percentile distribution cutoff of all county wetland thicket sizes
- *Vegetation Patch* contains a wetland that is within 1,000 m of another wetland
- *Vegetation Patch* contains a recently observed (post 1980) Regionally Rare Plant
- *Vegetation Patch* contains thicket with interior
- *Vegetation Patch* contains an Earth Science ANSI that contributes to the presence of an uncommon *Vegetation Community*
- Carolinian Canada Big Picture Corridors
- Interior woodland habitat that is $\geq$ 0.5 ha in size of continuous habitat
- Species at Risk

4.0 Results of Running the Significance Criteria

Each significance criteria measures a unique aspect of the ecological services that a natural feature provides. Thus, any patch that meets at least one criterion is considered "significant" in the study area (geographic Middlesex including the City of London and the First Nation Reserves). This one-criterion approach was agreed upon by the Technical Committee and the Peer Reviewer and has been utilized in many other studies including the 2003 Middlesex Natural Heritage Study, the 2006 Oxford Natural Heritage Study and the 2014 Huron Natural Heritage Study.

Table 24 summarizes the modeling results for each of the 12 Significance Criteria (three other criteria cannot be modeled at this time, see Section 3.6). Appendix H provides additional results tabulated at the *Vegetation Group* level. Figure 14 shows all of the patches that met at least one significance criteria in the study area. Table 25 shows the number of *Vegetation Patches* versus the number of criteria met.

The key findings are:

- 20.1 % of the study area is in natural cover (66,999 ha of 333,592 ha land base)
- 98.9% of the natural cover by area meets one or more criteria and is significant on the landscape (65,666 of 66,999 ha)
- 78.5% of the *Vegetation Patches* (2749 of 3502) meet one criterion or more and 22% of the patches meet no criteria
- 3 *Vegetation Patches* meet 10 criteria (the maximum number that can be met).
- 19.7% of the study area is significant natural heritage cover (65,666 of 333,592 ha)

Table 24. Results of Modeling 12 Significance Criteria for all Patches in the Study Area (Geographic Middlesex)

Number of Patches			Area of Patches				
# Patches in study area	# Patches that are significant	% of Patches that are significant	Study Area (ha)	Area of all patches (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of study area land base that is significant
3,502	2,749	78.5%	333,330	66,887	65,666	98.2%	19.7%

Table 25. The Number of *Vegetation Patches* versus the Number of Criteria Met in the Study Area (Geographic Middlesex)

# of Criteria Met	# *Vegetation Patches*	% of Patches (3,502)
0	760	21.7
1	1034	29.5
2	557	15.9
3	406	11.6
4	302	8.6
5	206	5.9
6	122	3.5
7	73	2.1
8	26	0.7
9	12	0.3
10	3	0.1
TOTAL	**3,502**	**100%**

Notes:
The number of criteria met refers to the total number of criteria, not any specific criterion.
The maximum number of criteria any patch can meet is 10 since Criterion 10 is simply a mapping rule to bring Criteria 1-9 from a *Vegetation Group* to a *Vegetation Patch*, and Criterion 12 can only apply to patches that don't meet any criteria.

Tables 26-33 and Figures 15-22 show the patches that meet at least one significance criteria for each local municipality in Middlesex County and for the City of London. Areas were calculated based on municipal corporate boundaries. The patches were clipped at the municipal boundaries and no buffer was added. The area of each municipality was obtained from Land Information Ontario, 2013 and may not coincide exactly with the area known to the municipality.

Table 26. Results of Modeling 12 Significance Criteria for all Patches in Middlesex Centre

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
653	546	83.6	59,301	9,385	9,221	98.3	15.5

Table 27. Results of Modeling 12 Significance Criteria for all Patches in Thames Centre

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
524	402	76.7	43,746	7,334	7,146	97.4	16.3

Table 28. Results of modeling 12 significance criteria for all patches in Strathroy-Caradoc

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
392	303	77.3	27,529	5,462	5,330	97.6	19.4

Table 29. Results of modeling 12 significance criteria for all patches in North Middlesex

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
327	263	80.4	60,074	11,767	11,633	98.9	19.4

Table 30. Results of modeling 12 significance criteria for all patches in Lucan Biddulph

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
161	109	67.7	16,914	1,296	1,188	91.6	7.0

Table 31. Results of modeling 12 significance criteria for all patches in the City of London

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
589	454	77.1	42,320	6,935	6,718	96.9	15.9

Table 32. Results of modeling 12 significance criteria for all patches in Southwest Middlesex

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
368	293	79.6	42,949	8,524	8,399	98.5	19.6

Table 33. Results of modeling 12 significance criteria for all patches in Newbury

Number of Patches			Area of Patches				
# Patches	# patches that are significant	% of patches that are significant	Municipal Area (ha)	Area of all patches in (ha)	Area of patches that are significant (ha)	% of patch area that is significant	% of Municipality that is significant
2	2	100	186	21	21	100	11.3

Figure 14. Patches that meet one or more criteria in geographic Middlesex

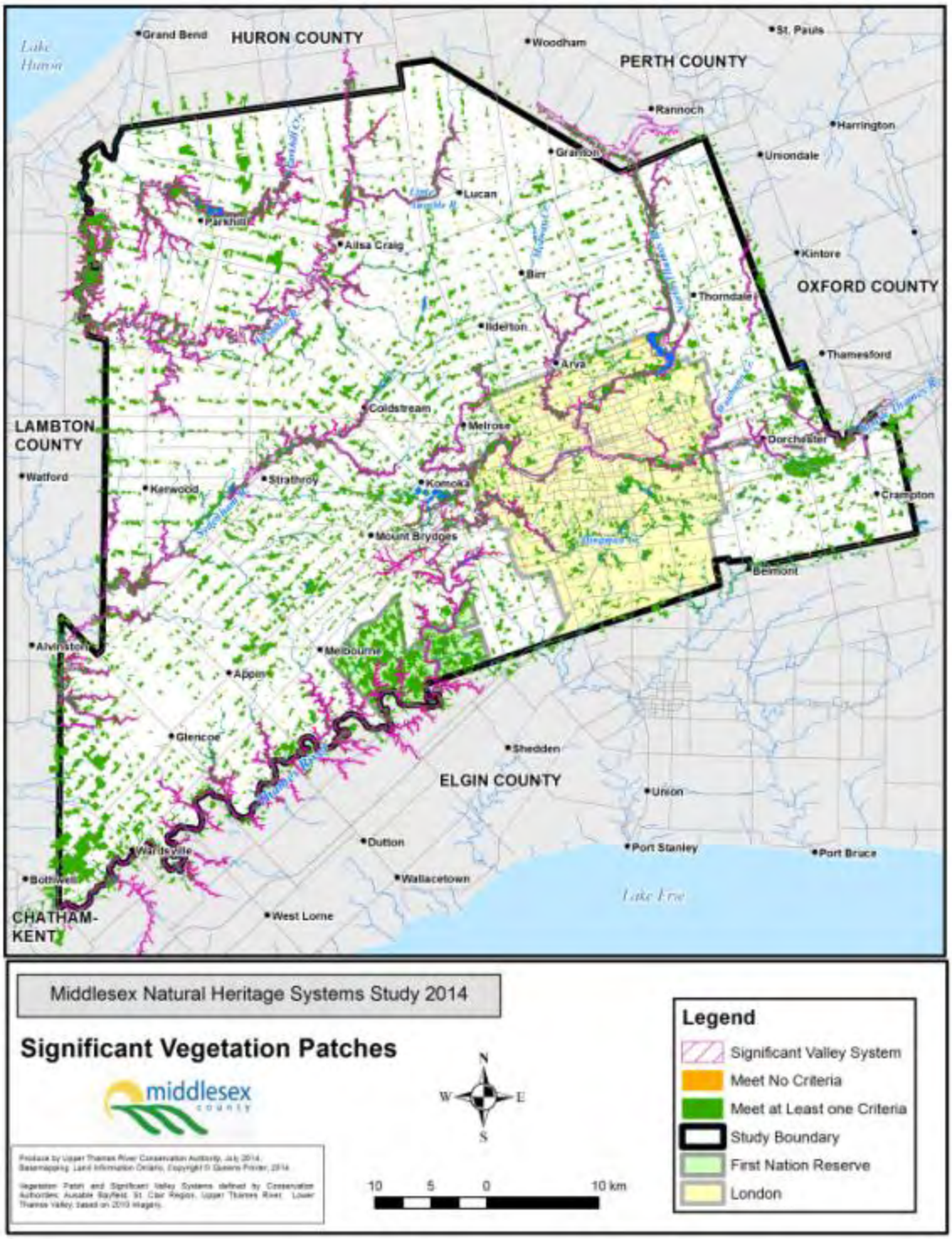


Figure 15. Patches that meet one or more criteria in Middlesex Centre

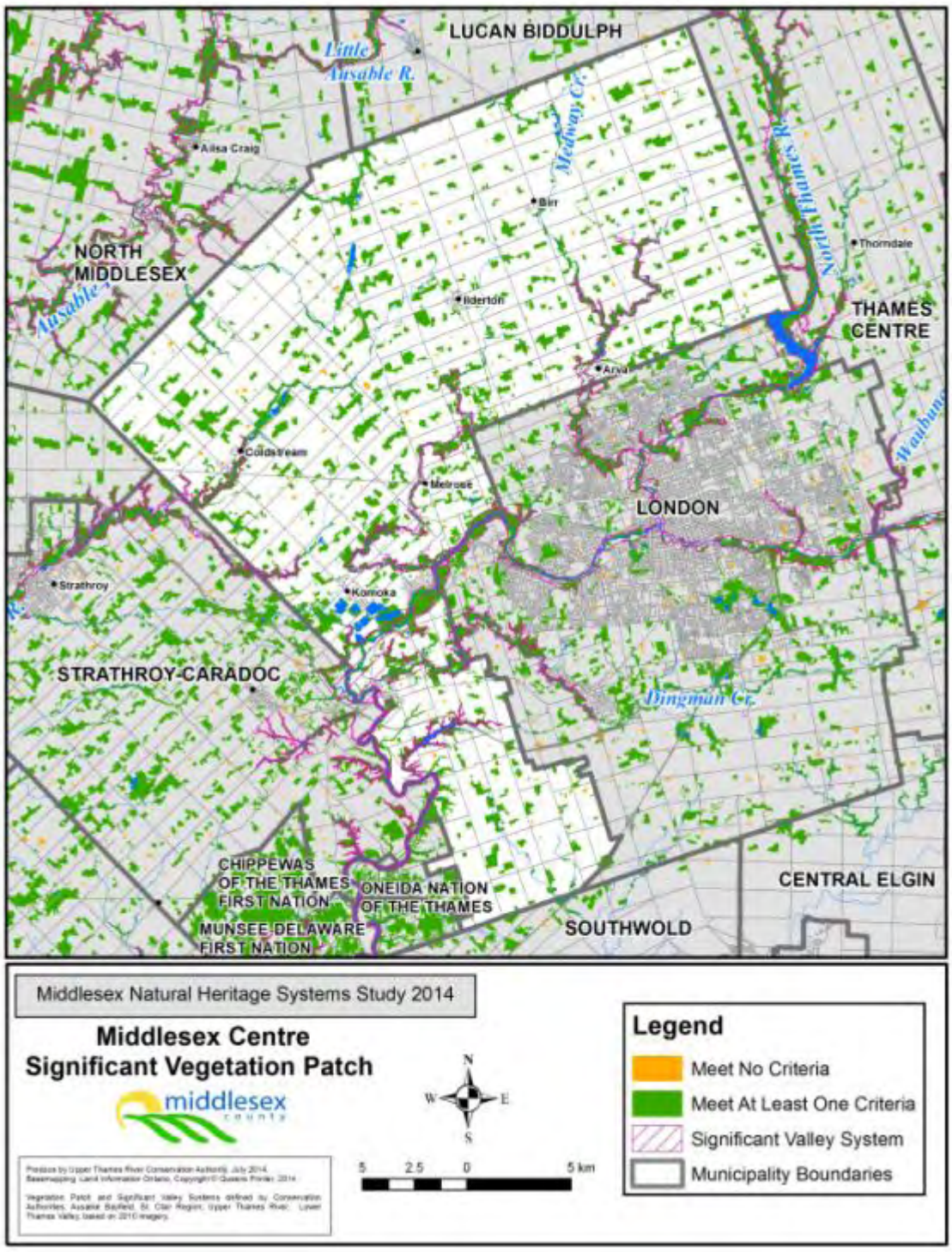


Figure 16. Patches that meet one or more criteria in Thames Centre

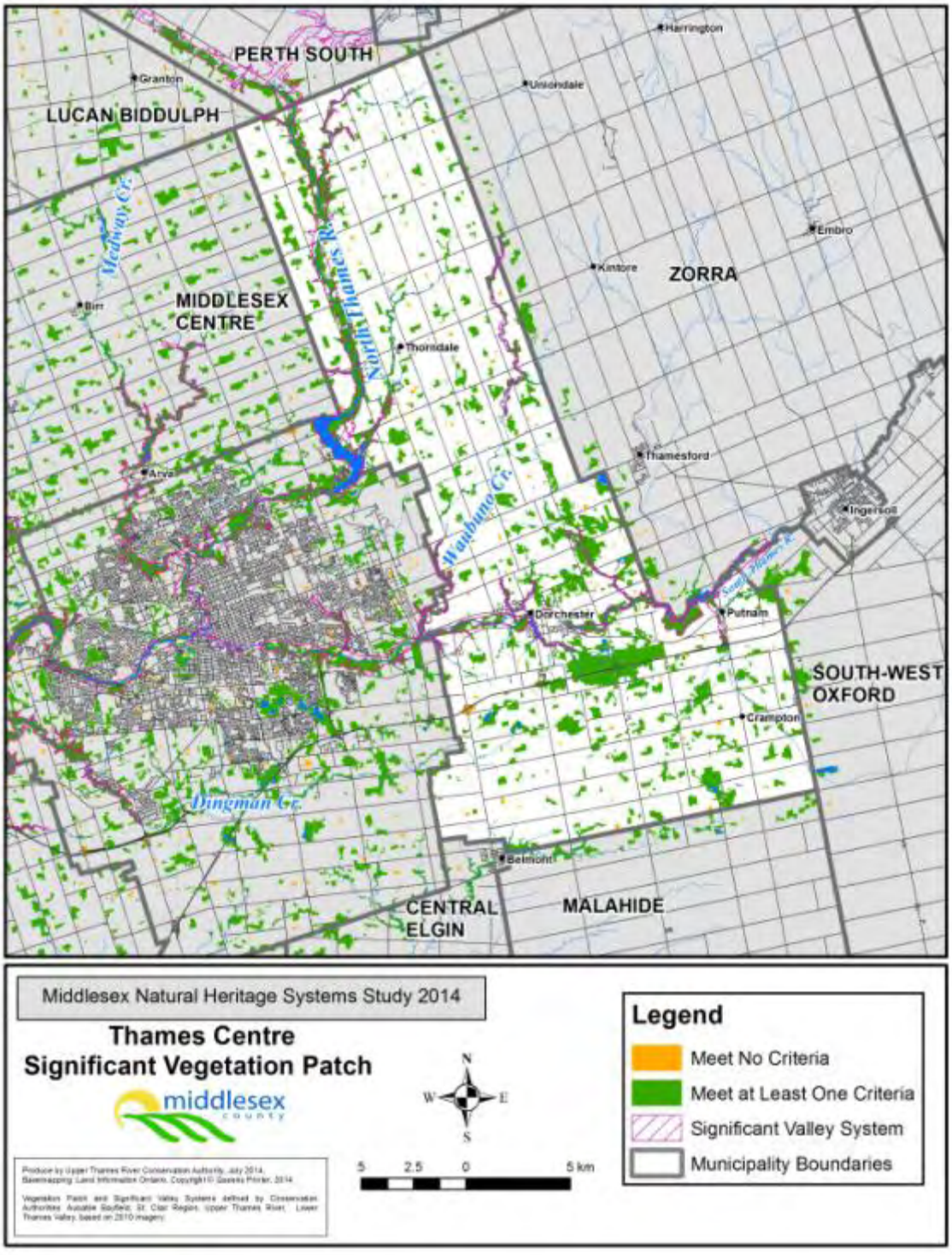


Figure 17. Patches that meet one or more criteria in Strathroy-Caradoc

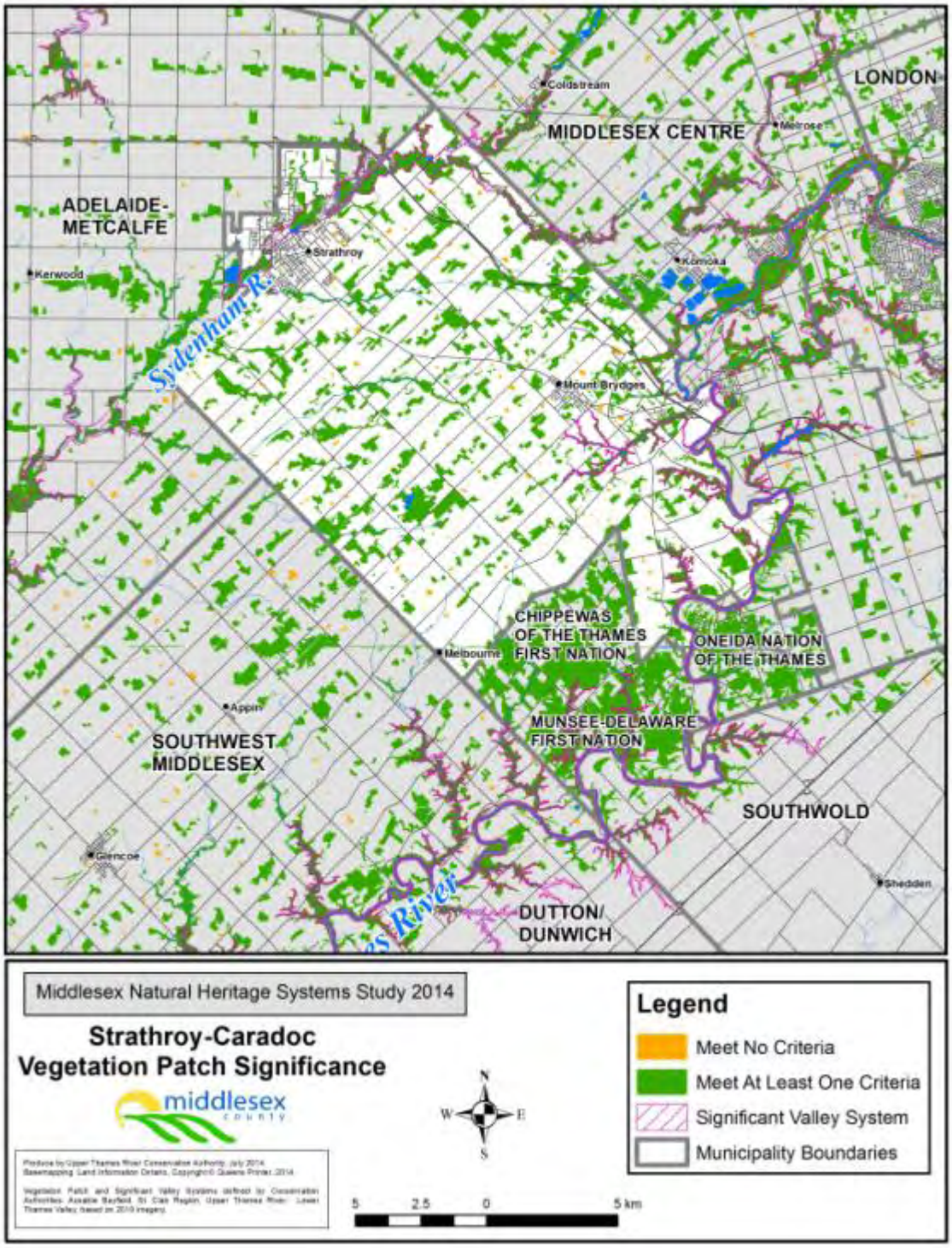


Figure 18. Patches that meet one or more criteria in North Middlesex

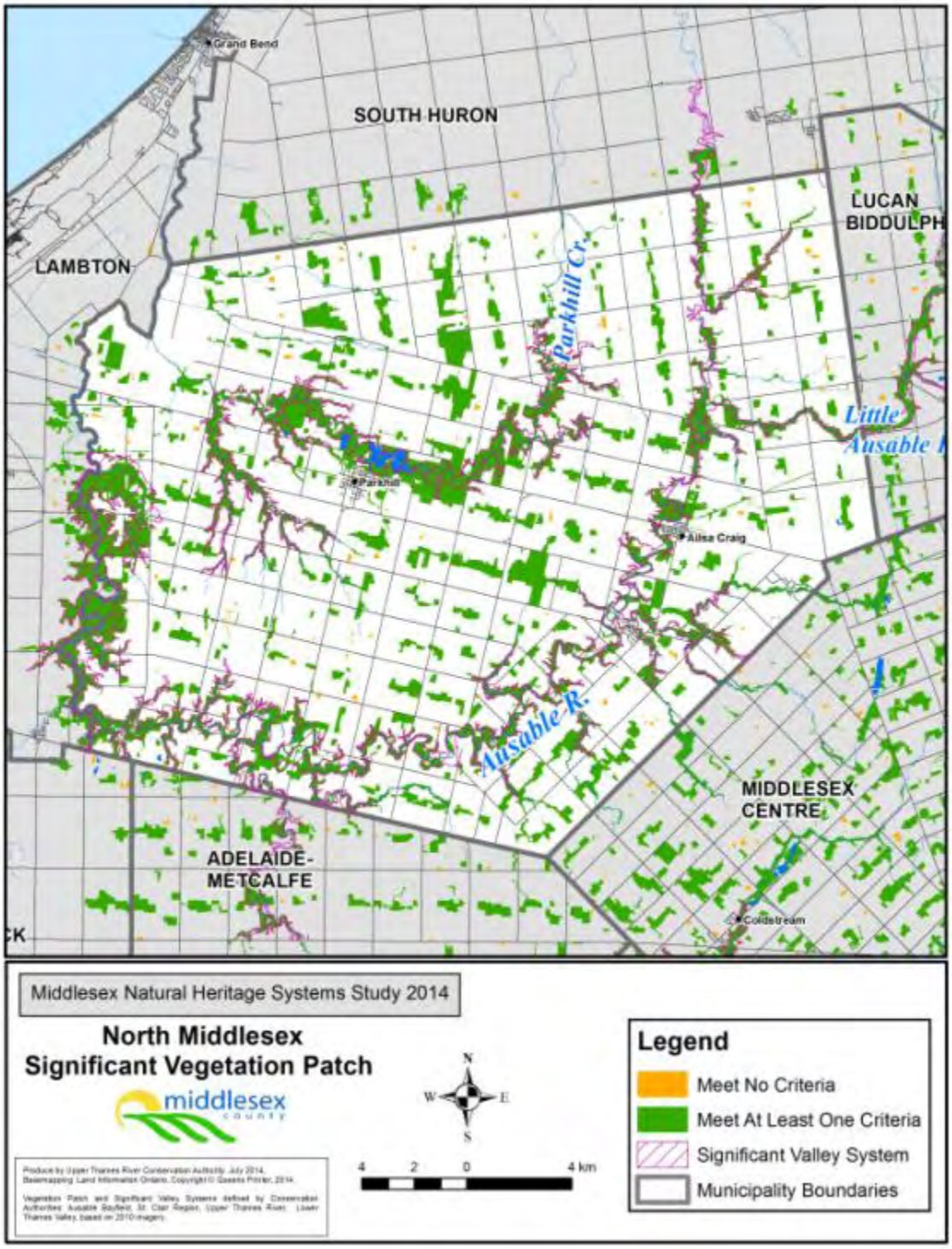


Figure 19. Patches that meet one or more criteria in Lucan Biddulph

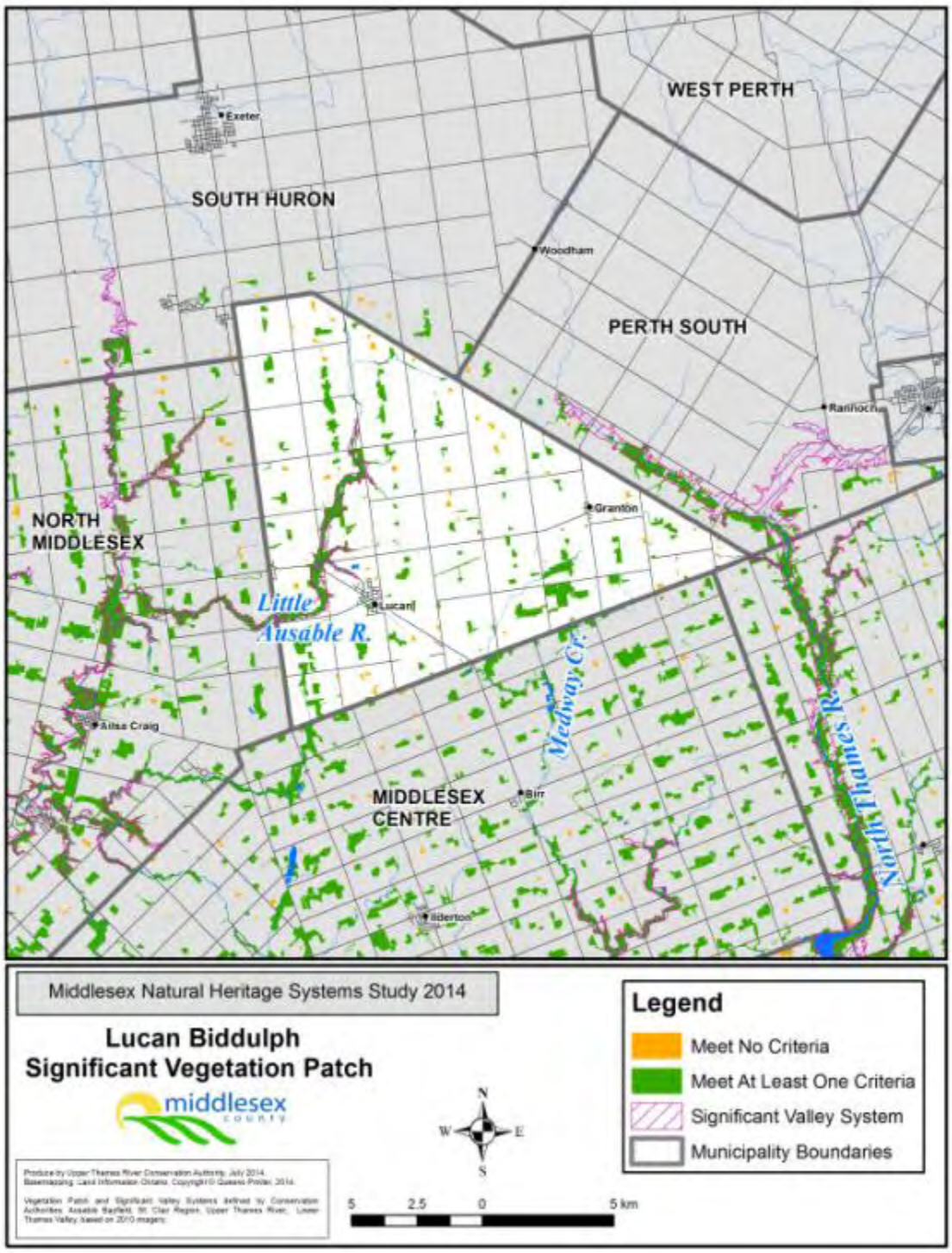


Figure 20. Patches that meet one or more criteria in the City of London

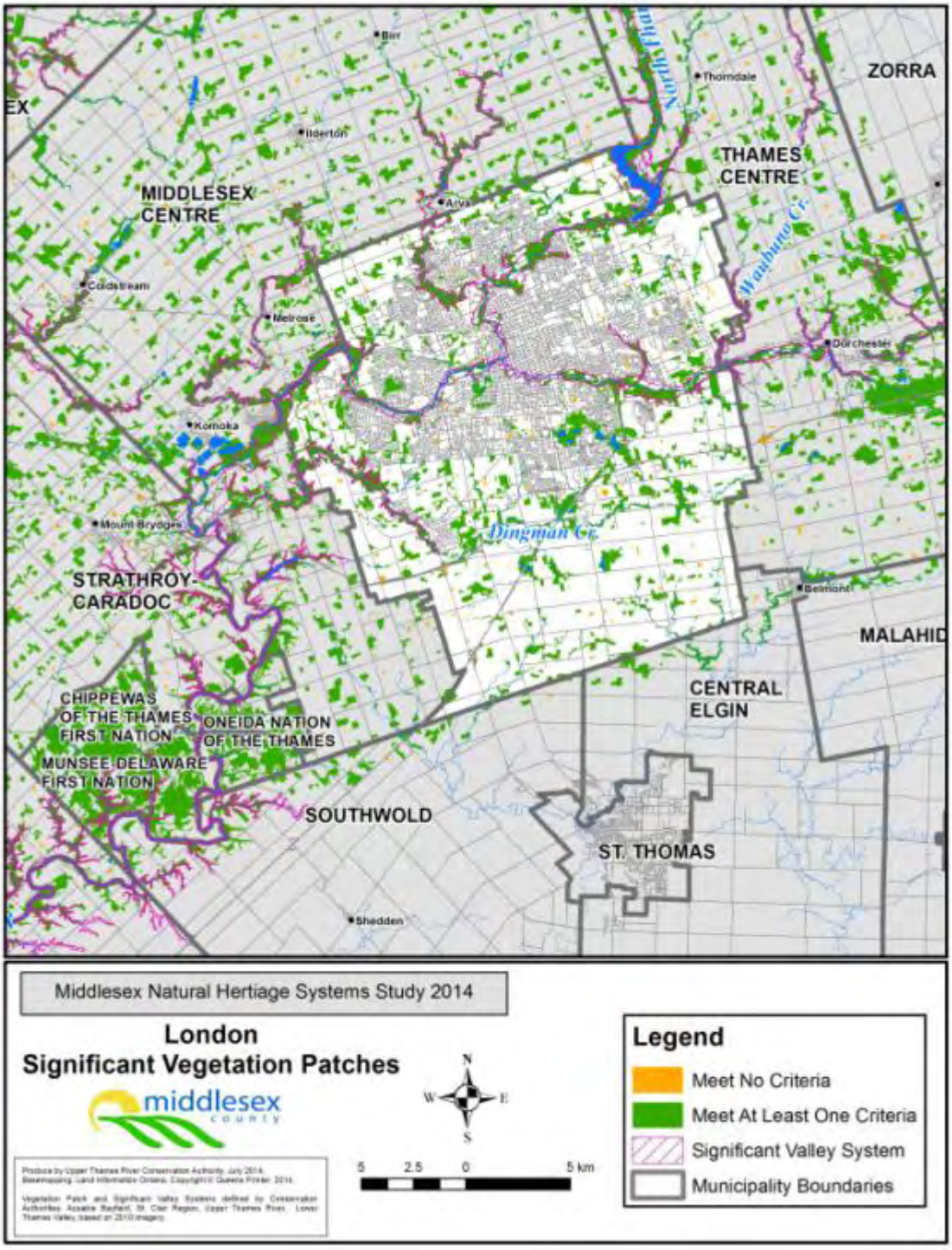


Figure 21. Patches that meet one or more criteria in Southwest Middlesex

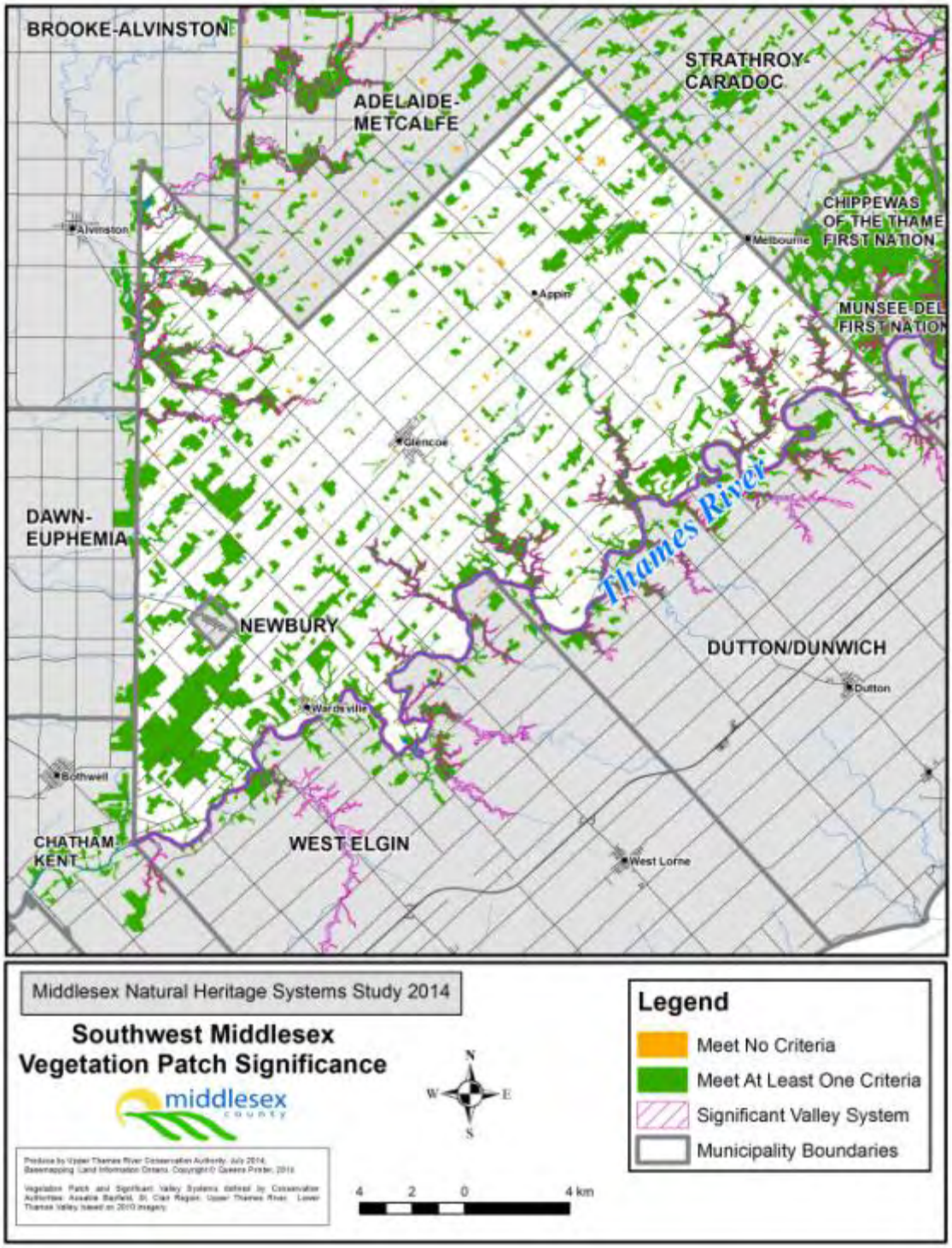
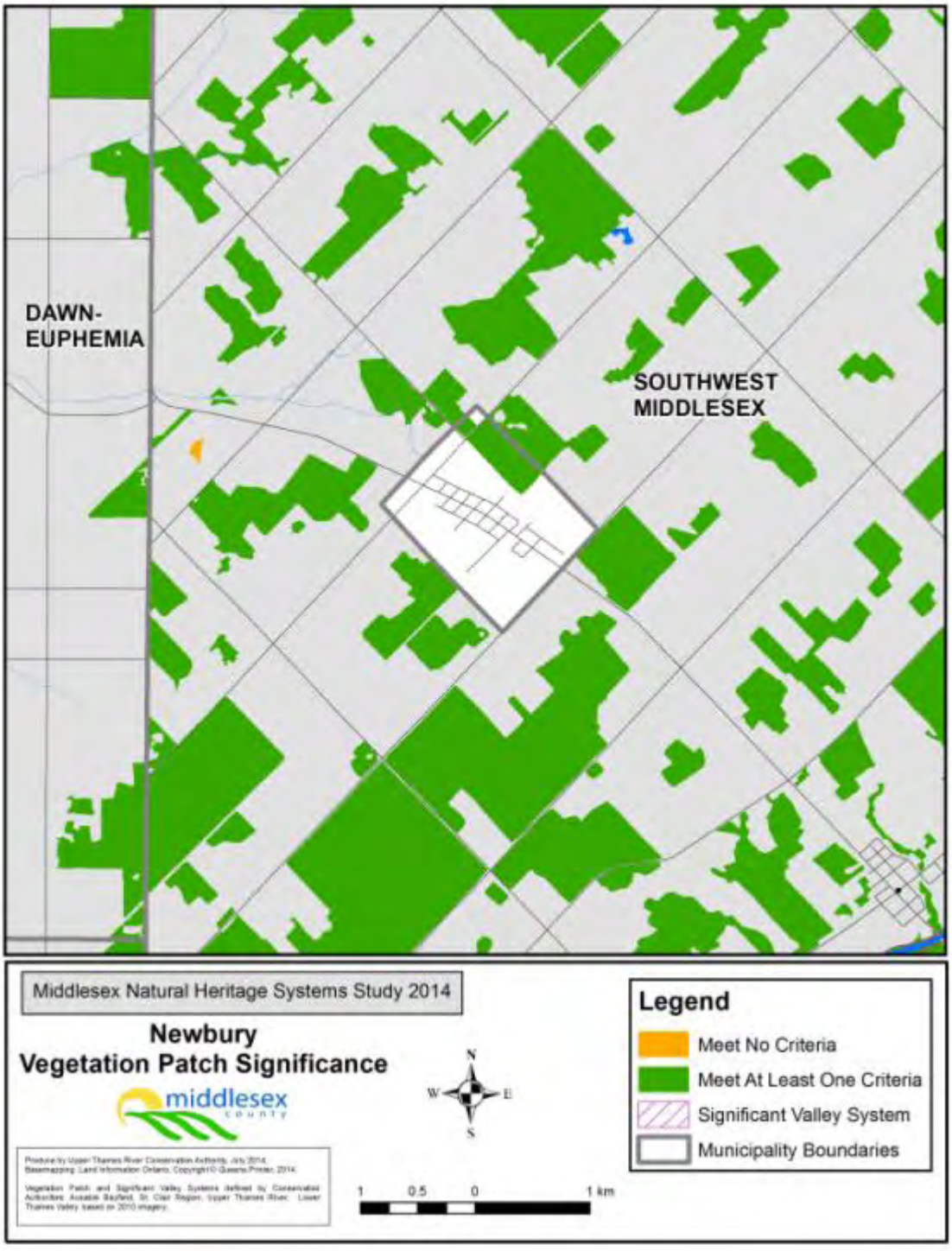


Figure 22. Patches that meet one or more criteria in Newbury



4.1 Man-made Ponds

Man-made ponds including sewage lagoons, stormwater management ponds, irrigation ponds, and ponds in licensed aggregate pits can be picked up in the Water *Vegetation Group* if they are connected to meadows, woodlands or other *Vegetation Groups*. Some of these *Vegetation Groups* may be significant by meeting one or more criteria.

The results of this study do not presume to change the intended purpose of these man-made structures. These structures can continue to function as designed. However, since they attract plants and wildlife by their very design (i.e., on the earth, holding water, using biological processes to break down pollutants, etc.), undertaking cleanouts and other maintenance activities should be done prior to wildlife hibernation or after fledging. It would be desirable to provide a pond/wildlife factsheet to assist managers of these structures.

4.2 Patches that don't meet any criteria

Patches that don't meet any criteria can be viewed as not significant or candidate significant. If a landuse change is planned, a DAR will need to be carried out to confirm this (see Chapter 5).

4.3 Comparison with the 2003 MNHS Findings

Table 34 summarizes the key elements of the 2003 MNHS and the 2014 MNHSS.

The 2003 MNHS study, determined there was 12.3% forest/woodland cover. It did not include other *Vegetation Communities* such as thicket and meadow as the GIS mapping capabilities were more limited then. The study was based on 2000 black and white air photography. The 2003 study did not include the City of London and the First Nation Reserves in the final modeling. Based on six criteria, shown in the text box below, 74% of woodland patches met at least one criterion and 26% did not meet any.

Any woodland patch:

1. Where 50% of the area is within 750 m of a recognized natural heritage feature (e.g. ANSI, ESA)
2. ≥ 10 ha or <10 ha but contains forest interior
3. 100 m from a woodland patch ≥10 ha
4. In a recognized corridor (Big Picture, Ausable River, Thames River Valley)
5. Containing a watercourse or within 50 m of a watercourse but not containing a watercourse
6. On porous soils that may have sensitive groundwater recharge / discharge resources

The current study determined there is 15.8% woodland cover plus 4.2% other cover such as thicket, meadow and water features, for a total of 20.1% natural cover. The 2014 MNHSS uses 12 significance criteria using 2010 colour aerial photography. It includes the City of London and First Nations reserves in the modeling results. The model was re-run using the Corporate Middlesex boundaries (see third column in Table 34).

Table 34. Comparison of findings between the 2003 MNHS and the 2014 MNHSS

	2003 MNHS	2014 MNHSS
Study Area Jurisdiction	Corporate Middlesex	Geographic Middlesex
Aerial Photography Used	2000 Black and White	2010 Colour ortho-imagery
Study Area (ha)	284,464	333,330
# Woodland Patches (2003) vs # Woodland *Vegetation Communities* (2014)	8,684	8,590
# Woodland *Vegetation Groups*	5,961	4,123
# *Vegetation Patches*	--	3,502
Woodland Area (ha)	53,838	52,748
Thicket, meadow, water feature, connected vegetation feature area (ha)	--	13,826
# Significance Criteria	6	12
% patches that meet 1 or more criteria	74%	98%
Area of patches that meet 1 or more criteria (ha)	not available	65,666

Deciduous woodland near a small ravine in North Middlesex. Photo by Cathy Quinlan

5.0 Recommendations and Implementation

The MNHSS is a science based study that identifies natural heritage system components following a landscape ecology methodology. This study forms the base science and the information it provides can be implemented in various ways. This section provides various recommendations for implementation of the study.

It is important to note that the MNHSS focused primarily on the natural heritage system of the Middlesex landscape and that implementation will require the more comprehensive consideration of cultural, economic and public health and safety factors. This broader consideration of factors is inherent in implementation processes such as the Planning Act and the Environmental Assessment Act which have the realization of the public interest as their ultimate goal. These processes will be guided by public input which assists with determining the various interests that make up the public interest. The MNHSS project did not include a process to engage stakeholders on implementation options but rather, it focused on characterizing the natural heritage system so that this information could inform the future consideration of implementation options. Recommendations for implementation are offered in this report recognizing that stakeholder consultation or public approval processes will follow.

5.1 Land Use Planning

The results of the study should be incorporated into municipal official plans and should be considered in all land use planning activities. The appropriate means to implement the results will be determined at the time that Planning Act applications are considered and will be guided by the Provincial Policy Statement and input obtained through the process. Specific recommendations to be considered are listed below.

a. It is recommended that the County Official Plan and local official plans refer to the MNHSS 2014 as the study that is relied on to identify significant features and areas and the significant natural heritage system in the County of Middlesex Planning area. The choice to apply designations or constraint overlays or some combination of these approaches will need to be assessed through the official plan update process. The official plan should include policies governing the protection of natural heritage systems through land use change and the policies should require assessment that is appropriate to the scale of the proposed land use change. For example, small scale applications should consider the potential impact on the natural heritage system through the preparation of a Development Assessment Report (DAR) or edge management planning process. Larger scale developments and urban expansions should be assessed at a subwatershed scale of study and include the integration of natural heritage, natural hazard and servicing planning.

b. An updated Development Assessment Report (DAR) guideline document should be developed to allow for implementation of the MNHSS through the land use planning and development process.

c. A patch validation guideline should be developed to support the DAR guideline document. The patch validation guideline can assist with confirming patch attributes and boundaries.

d. Natural heritage features not identified in this study (i.e., *Vegetation Patches* not meeting one criterion) should be considered candidates for significance until proven otherwise. A Scoped DAR should be required for these features.

e. Policies should be included in the official plan to encourage natural heritage planning in Middlesex to move beyond identifying significant remnant natural heritage features to protecting and restoring the natural heritage system. The MNHSS identifies significant remnant areas, but does not determine if we have enough natural heritage features in the right places or of the right type. Also, this study does not determine how to improve the Natural Heritage System so that it is sustainable in the long term.

f. It is recommended that the City of London utilize the MNHSS as a background document to support their land use planning activities.

5.2 Other Implementation Measures

Additional non-land use recommendations are as follows:

a. The MNHSS should be used to support the review of applications made under the County of Middlesex Woodlands Conservation By-Law.

b. The MNHSS should be considered in the development of stewardship and incentive programs, education programs and the management of publically owned forests and natural areas in the study area.

c. Local municipalities should consider completing more detailed studies of remnant natural *Vegetation Patches* that are located within urban growth areas and may be subject to future development pressure.

d. Management plans should be developed for all publically owned natural *Vegetation Patches* including County Forests.

e. For early successional lands, it is recommended that the municipalities work with conservation authorities and the Ministry of Natural Resources to develop a framework for meadow management planning for publicly and privately owned lands.

f. It is recommended that the municipalities continue to support the Southwestern Ontario Ortho-Imagery Project (SWOOP) as a means to obtain updates of photography on a regular basis. It is also recommended that the County support the updating of the vegetation layers as the new Ortho-Imagery comes available for the purpose of assessing landscape change and that the updated vegetation mapping be used to update the MNHSS modeling.

g. The watercourse layer should be updated to ensure that smaller watercourses are accurately delineated from other features such as swales.

h. As updated vegetation information comes available (every five years), the natural heritage system model should be updated. It is recommended that the MNHSS criteria be re-visited after 10 years.

References

Askins, R.A. 2000. Restoring North America's Birds: Lessons from Landscape Ecology. Yale University Press, new haven, CT. 320 pp.

Askins, R.A., and M.J. Philbrick. 1987. Effects of changes in regional forest abundance on the decline and recovery of a forest bird community. Wilson Bulletin 99: 7-21.

Baguette, M., and H. Van Dyck. 2007. Landscape connectivity and animal behaviour: functional grain as a key determinant for dispersal. Landscape Ecology 22: 1117 – 1129.

Banaszak, J. 1996. Ecological bases of conservation of wild bees. Pages 55–62 in A. Matheson, S. Buchamann, C. O'Toole, P. Westrich, and I. Williams, editors. The conservation of bees. Academic Press, London, UK.

Bender, D.J., T.A. Contreras and L. Fahrig. 1998. Habitat loss and population decline: a meta-analysis of the patch size effect. Ecology 79(2): 517-533.

Bennett, A.F. 2003. Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation. IUCN, Gland, Switzerland and Cambridge, UK. xiv + 254 pp.

Bosch, J. and M. Hewlett. 1982. A review of catchment experiments to determine the effect of vegetation changes on water yield and evapotranspiration. Journal of Hydrology 55: 3-23.

Bowles, J.M. 1993. Ecological model of the Lake Middlesex shoreline terrestrial ecosystems. Maitland Valley Conservation Authority. 74pp.

Bowles, J. 1997. Oxford County Terrestrial Ecosystems Study: Life Sciences Report. Upper Thames River Conservation Authority, London, Ontario.

Bowles, J.M., T.D. Schwan, D. Kenny, N. Gaetz, and R. Steele. 2000. Maitland Valley Conservation Authority Forest Resource Assessment. 70pp. + maps

Brussard, P.F., D.A. Charlet and D. Dobkin. 1999. The Great basin – Mojave desert region. In: Mac, M.J., P.A. Opler, C.E. Puckett-haecker and P.D. Doran (eds.). The status and trends of the nation's biological resources. Reston, VA: U.S. Department of the Interior, U.S. Geological Survey: pp. 505-542.

Budd, W.W., P.L. Cohen, P.R. Saunders, and F.R. Steiner. 1987. Stream corridor management in the Pacific Northwest: determination of stream corridor widths. Environmental Management 11(5): 587-597.

Burgess, R.L., and D.M. Sharpe. (eds.). 1981. Forest Island Dynamics in Man-Dominated Landscapes. Springer-Verlag, New York, New York.

Burke, D.M. and E. Nol. 2000. Landscape and Fragment Size Effects on Reproductive Success of Forest-breeding Birds in Ontario. Ecological Applications 10:1749-1761.

Burke, D.M., K. Elliot, K. Falk and T. Piraino. 2011. A Land Managers Guide to Conserving Habitat for Forest Birds in Southern Ontario. OMNR Science and Information Resources Division. Queen's Printer for Ontario. MNR # 52508. ISBN: 978-1-4435-0097-5.

Canadian Council on Ecological Areas (CCEA). 1991. Framework for Developing a nation-wide System of Ecological Areas. CCEA Systems Plan task Force report. 12pp.

Cain, M.L., B.G. Milligan and A.E. Strand. 2000. Long-distance seed dispersal in plant populations. American Journal of Botany 87(9): 1217- 1227.

Cain, M. L., H. Damman, and A. Muir. 1998. Seed dispersal and the Holocene migration of woodland herbs. Ecological Monographs 68: 325–347.

Cane, J. H. 2001. Habitat fragmentation and native bees: a premature verdict? Conservation Ecology 5: 3.

Carter, N. 2000. Predicting internal conservation value of woodlots in south western Ontario using landscape features. 4th year honours thesis. Department of Plant Sciences. University of Western Ontario. 41pp. + Appendices.

Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirements – a review. Journal of Environmental Quality 23: 878 – 882.

Chandler, R.B., D.I. King, and C.C. Chandler. 2009. Effects of management regime on the abundance and nest survival of shrub land birds in wildlife openings in northern New England, USA. Forest Ecology and Management 258:1669-1676.

Chen, J., J.F. Franklin and T.A. Spies. 1995. Growing Season Microclimate Gradients from Clear cut Edges into Old-growth Douglas-Fir Forests. Ecological Applications 5:74-86.

City of London. 2006. Guideline Document for the Evaluation of Ecologically Significant Woodlands. Approved by Council June 26, 2006.

Corace, R.G. III, P.C. Goebel, and T.C. Wyse. 2009. A multi-scale assessment and evaluation of historic open lands at Sleeping Bear Dunes National Lakeshore. Vol. Natural Resource Technical Report NPS/GLKN/NRTR?2009/150 Fort Collins, CO: National Park Service.

County of Huron. 2013 (Draft). Huron County Natural Heritage Study.

County of Lambton, City of Sarnia, St. Clair Region Conservation Authority, Carolinian Canada Coalition, and North-South Environmental Inc. 2012 (Draft). Lambton County Natural Heritage Study.

County of Oxford. 2006. Oxford Natural Heritage Study. www.county.oxford.on.ca

County of Perth Official Plan. 2008. http://www.perthcounty.ca/County_of_Perth_Official_Plan

Cunningham, R.B., D.B. Lindenmayer, M. Crane, D. Michael, C. MacGregor, R. Montague-Drake and J. Fischer. 2008. The combined effects of remnant vegetation and tree planting on farmland birds. Conserv Biol 22:742–752.

Curtis, J.T. 1959. The Vegetation of Wisconsin. University of Wisconsin Press, Madison, Wisconsin.

Davis, N.B. 1978. Territorial defense in the speckled wood butterfly (Pararge aegenia): the resident always wins. Anim. Behav. 26: 138-147

Davis, S.K. 2004. Area sensitivity in grassland passerines: effects of patch size, patch shape, and vegetation structure on bird abundance and occurrence in southern Saskatchewan. Auk 121: 1130 – 1145.

Dillon Consulting Ltd. and D.R. Poulton and Associates. 2011. The City of London Thames Valley Corridor Plan.

Donaldson, J., I. Nanni, C. Zachariades, J. Kemper and J. D. Thompson. 2002. Effects of habitat fragmentation on pollinator diversity and plant reproductive success in renosterveld shrublands of South Africa. Conservation Biology 16:1267–1276.

Ducks Unlimited Canada. 2010. Southern Ontario Wetland Conversion Analysis – Final Report. 23pp. + Appendices

Environment Canada. 2013. How Much Habitat is Enough? Third Edition. Environment Canada, Toronto, Ontario.

Etmanski, A., and R. Schroth. 1980. An inventory of gully erosion problems along the Lake Middlesex shoreline. Maitland Valley Conservation Authority. 77pp.

Experimental Farm Service. 1952. Soil map of Middlesex County, Ontario. Soil Survey Report No. 13. Compiled, drawn, and published by the Experimental Farm Service from base maps supplied by the Department of Mines and Technical Surveys, Ottawa.

Filyk, G. 1993. Agricultural Stewardship. In: Marczyk, J.S., and D.B. Johnson (eds.). 1993. Sustainable Landscapes. Proceedings of the Third symposium of the Canadian Society for Landscape Ecology and Management. Polyscience Publications, Morin Heights, Canada. Pp. 37 - 43.

Findlay, S. and J. Houlahan, 1997. Anthropogenic Correlates of Species Richness in South eastern Ontario Wetlands. Conservation Biology 11(4):1000-1009.

First Base Solutions. 2007. Selected Vector Compilation - Ausable Bayfield Conservation Authority (ABCA). Markham, Ontario.

Fischer, R. A. and J. C. Fischenich. 2000. Design recommendations for riparian corridors and vegetated buffer strips. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24). U.S. Army Engineer Research and Development Center, Vicksburg, MS. http://el.erdc.usace.army.mil/elpubs/pdf/sr24.pdf

Fitzgibbon, C.D. 1997. Small mammals in farm woodlands: the effects of habitat, isolation and surrounding land-use. Journal of Applied Ecology 34: 530-539.

Foley, J.A., R. DeFries, G.P. Asner, C. Barford, G. Bonan, S.R. Carpenter, F.S. Chapin, M.T. Coe, G.C. Daily, H.K. Gibbs, J.H. Helkowski, T. Halloway, E.A. Howard, C.J. Kucharik, C. Manfreda, J.A. Patz, I.C. Prentice, N. Ramankutty, and P.K. Snyder. 2005. Global consequences of land use. Science 309:570–574.

Forman, R.T.T. 1995a. Land Mosaics: The Ecology of Landscapes and Regions (Cambridge Univ Press, New York).

Forman, R. T. T. 1995b. Some general principles of landscape and regional ecology. Landscape Ecology 10(3):133-142.

Forman, R.T.T. 1995c. Some General Principles of Landscape and Regional Ecology. Landscape Ecology 10(3):2-9.

Forman, R.T.T., and M. Godron. 1986. Landscape Ecology. John Wiley & Sons, New York.

Friesen, L.E., Wyatt, V.E. and M.D. Cadman. 1999. Pairing success of wood thrushes in a fragmented agricultural landscape. Wilson-Bulletin 11(2): 279-281.

Golet, F.C. 1976. Wildlife Wetland Evaluation Model. In: Models for the Evaluation of Freshwater Wetlands. J.S. Larson (ed.). Water Resources Research Centre, University of Massachusetts. Pp. 13 – 34.

Griffiths, R.W. 2001. Mapping the water quality of watercourses in the Region of Halton. Planning and Public Works, Regional Municipality of Halton.

Hamill, S. 2001. Biodiversity Indicators for Woodland Owners. Prepared for Canadian Biodiversity Institute and eastern Ontario Model Forest. 23pp.

Harper, J. L. 1977. Population biology of plants. Academic Press, London, UK.

Harris, L.D. 1984. The Fragmented Forest: Island Biogeography Theory and the Preservation of Biotic Diversity. University of Chicago Press, Chicago, Illinois.

Harris, L.D., and P.B. Gallagher. 1989. New initiatives for wildlife conservation: the need for movement corridors. In: Defense of Wildlife. Preserving Communities and Corridors. Washington, D.C. Defenders of Wildlife.

Hey, D.L., and J.A. Wickencamp. 1996. Effects of wetlands on modulating hydrologic regimes in nine Wisconsin Watersheds. The wetlands Initiative. Chicago, Illinois.

Hilts, S.G., and F.S. Cook. 1982. Significant Natural Areas of Middlesex County.

Horn, D.J. and R.R. Koford. 2004. Could the area-sensitivity of some grassland birds be affected by landscape composition? Proceedings of the 19th North American Prairie Conferences. pp. 109 – 116.

Houlahan, J.E. and S.C. Findlay. 2003. The Effects of Adjacent Land Use on Wetland Amphibian Species Richness and Community Composition. Canadian Journal of Fisheries and Aquatic Sciences 60(9):1078-1094.

Hounsell, S.W. 1989. Methods for assessing the sensitivity of forest birds and their habitats to transmission line disturbances. Land Use and Environmental Planning Department. Ontario Hydro, Toronto, Ontario.

Howard, J. and M. Merrifield. 2010. Mapping Groundwater Dependent Ecosystems in California. PLOS One: 5(6): e11249.

Howe, H. F., and J. Smallwood. 1982. Ecology of seed dispersal. Annual Review of Ecology and Systematics 13: 201–228.

Humke, J.W., B.S. Tindall, R.E. Jenkins, H.L. Wietung, and M.S. Lukowski. 1975. The Preservation of Natural Diversity: A Survey and Recommendations. The (US) Nature Conservancy.

Igl, L.D., and D.H. Johnson. 1997. Changes in breeding bird populations in North Dakota: 1967 to 1992-93. Auk 114: 74-92.

Johnson, D.H. 2001. Habitat Fragmentation Effects On Birds In Grasslands and Wetlands: A Critique of our Knowledge. Great Plains Research 11: 211- 231. Published by the Center for Great Plains Studies.

Johnson, C.A., N.E. Detenbeck, and G.J. Nieme. 1990. The cumulative effects of wetlands on stream quality and quantity, a landscape approach. Biogeochemistry, Vol. 10 (3): 105 – 141.

Junk, W.J., P.B. Bayley and R.E. Sparks. 1989. The flood pulse concept in river floodplain systems. Pp. 110-127. In: D.P. Dodge (ed.). Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci.106.

King, D.I., Degraaf, R.M., and C.R. Griffin. 2001. Productivity of early-successional shrub land birds in clear cuts and group cuts in an eastern deciduous forest. Journal of Wildlife Management 65: 345 – 350.

King, D.I. and B.E. Byers. 2002. An evaluation of power line rights-of-way as habitat for early-successional shrub land birds. Wildlife Society Bulletin 30: 868-874.

King, D.I., R.B. Chandler, J.M. Collins, W.R. Petersen, and T.E. Lautzenheiser. 2009. Habitat use and nest success of scrubland birds in wildlife and silvicultural openings in western Massachusetts, U.S.A. Forest Ecology and Management 257:421 – 426.

Kohm, K.A., and J.F. Franklin (eds.). 1997. Creating a Forestry for the 21st Century: The Science of Ecosystem Management (Island Press, Washington, DC).

Larson, B.M., J.L. Riley, E.A. Snell and H.G. Godschalk. 1999. The Woodland Heritage of Southern Ontario. A Study of Ecological Change, Distribution and Significance. Federation of Ontario Naturalists. 262pp.

Lederhouse, Robert C. 1982. Territorial defense and lek behavior of the black swallowtail butterfly, Papilio polyxenes Behavioral Ecology and Sociobiology 10 (2): 109-118

Lee, H., W. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. Ecological Land Classification for Southern Ontario. First Approximation and its Application. Ontario Ministry of Natural Resources, South-Central Science section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

Lesica, P. and F.W. Allendorf. 1995. When Are Peripheral Populations Valuable for Conservation? Conservation Biology 9(4):753-760.

Levenson, J.B. 1981. Woodlots as biogeographical islands in south eastern Wisconsin. Pp. 13 – 14 in R.L. Burgess and D.M. Sharpe (eds.). Forest island dynamics in man-dominated landscapes. Springer-Verlag. 310 pp.

Lindenmayer, D.B, J.F. Franklin. 2002. Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach (Island Press, Washington, DC).

Lomolino, M.V. and R. Channell. 1995. Splendid Isolation: Patterns of Geographic Range Collapse in Endangered Mammals. Journal of Mammalogy 76:335-347.

Lovett, G.M., C.G. Jones, M.G. Turner, K.C. Weathers, J.F. Franklin. 2005. (In): Ecosystem Function in Heterogeneous Landscapes, (eds) Lovett, G.M., C.G. Jones, M.G. Turner, K.C. Weathers, (Springer, New York), pp 427–441.

Lovett-Doust, J., M. Biernacki, R. Page, M. Chan, R. Natgunarajah and G. Timis. 2003. Effects of Land Ownership and Landscape-level Factors on Rare-species Richness in Natural Areas of Southern Ontario, Canada. Landscape Ecology 18:621-633.

Lovett-Doust, J. and K. Kuntz. 2001. Land Ownership and other Landscape-level Effects on Biodiversity in Southern Ontario's Niagara Escarpment Biosphere Reserve, Canada. Landscape Ecology 16:743-755.

MacKay, H. 2006. Protection and management of groundwater-dependent ecosystems: emerging challenges and potential approaches for policy and management. Australian Journal of Botany. 54: 231-237.

Manning, A.D., D.B. Lindenmayer, H.A. Nix. 2004. Continua and Umwelt: Novel perspectives on viewing landscapes. Oikos 104:621–628.

Marini, M.A., S.K. Robinson, and E.J. Heske. 1995. Edge effects on nest predation in the Shawnee National Forest, Southern Illinois. Biological Conservation 74:203-213.

Matlack G.R. 1993. Microenvironment Variation Within and Among Forest Edge Sites in the Eastern United States. Biological Conservation 66:185-194.

Mazerolle, M.H. and M.A. Villard. 1999. Patch Characteristics and Landscape Context as Predicators of Species Presence and Abundance: A Review. Ecoscience 6:117-124.

McCracken, J.D., R.A. Reid, R.B. Renfrew, B. Frei, J.V. Jalava, A. Cowie, and A.R. Couturier. 2013. DRAFT Recovery Strategy for the Bobolink (Dolichonyx oryzivorus) and Eastern

Meadowlark (Sturnella magna) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. viii + 86 pp.

Meffe, G.K., and C.R. Carroll. 1997. Principles of Conservation Biology, 2nd ed. Sinauer Associates Inc. Sunderland, Massachusetts.

Mitchell, L.R., C.R. Smith, and R.A. Malecki. 2000. Ecology of grassland breeding birds in the Northeastern United States: A literature review with recommendations for management. USGS, Biological Resources Division, New York Cooperative Fish and Wildlife Research Unit, Cornell University, Ithaca, NY.

Mooney, P.F. 1993. Structure and connectivity as measures of sustainability in agro ecosystems. In: Marczyk, J.S., and D.B. Johnson (eds.). 1993. Sustainable Landscapes. Proceedings of the Third symposium of the Canadian Society for Landscape Ecology and Management. Polyscience Publications, Morin Heights, Canada. pp. 13 – 25.

Naiman, R.J., H. Dé camps, and M.Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212.

Nathan, R., G.G. Katul, H.S. Horn, S.M. Thomas, R. Oren, R. Avissars, S.W. Pacala, and S. Levin. 2002. Mechanisms of long-distance dispersal of seeds by wind. Nature 418: 409 – 413.

Niemi, G.J., and J.R. Probst. 1990. Wildlife and fire in the upper Midwest. Pages 31-46 IN: J.M. Sweeney (ed.). Management of Dynamic Ecosystems. The Wildlife Society. Lafayette, IN.

Oehler, J.D., D.F. Covell, S. Capel, and B. Long (eds.). 2006. Managing Grasslands, Shrublands and Young Forest Habitats for Wildlife: a Guide for the Northeast. The Northeast Upland Habitat Technical Committee and the Massachusetts Division of Fisheries and Wildlife.

Ontario Ministry of Natural Resources (OMNR). 2000a. Identification and Confirmation Procedure for Areas of Natural and Scientific Interest. Parks and Protected Areas Policy. Procedure PAM 2.08

Ontario Ministry of Natural Resources (OMNR). 2000b. Significant Wildlife Habitat Technical Guide. 151p.

Ontario Ministry of Natural Resources (OMNR). 2004. Southern Ontario Land Resource Information System (SOLRIS). Image Interpretation Manual.

Ontario Ministry of Natural Resources (OMNR). 2010. Natural Heritage Reference Manual for Policy 2.3 of the Provincial Policy Statement. 2nd edition. 233pp.

Ontario Ministry of Natural Resources (OMNR). 2012. Significant Wildlife Habitat Ecoregional Criteria Schedules. EBR # 011-5740

Ontario Ministry of Natural Resources (OMNR). 2013. Ontario Wetland Evaluation System Southern Manual Covering Hills Site Regions 6 and 7. 4th ed.

Ochterski, J. 2006a. Transforming fields into grassland bird habitat. Cornell Cooperative Extension of Schuyler County, NY. SCNY Agriculture Team Natural Resources.

Ochterski, J. 2006b. Hayfield management and grassland bird conservation. Cornell Cooperative Extension of Shuyler County, NY. 8 p.

Packett, D.L. and J.B. Dunning. 2009. Stopover habitat selection by migrant landbirds in a fragmented forest-agricultural landscape. The Auk 126: 579-589.

Peterjohn, B.G., and J.R. Sauer. 1999. Population status of North American grassland birds from the North American Breeding Bird Survey, 1966 – 1996. Studies in Avian Biology 19: 27-44.

Peterson, E.B. and N.M. Peterson. 1991. A first approximation of principles and criteria to make Canada's protected areas system representative of the nation's ecological diversity. Western Ecological Services Ltd., Victoria, BC. Report for the Canadian Council on Ecological Areas. 47pp. + app.

Prugh, L.R., K.E. Hodges, R.E. Sinclair, J.S. Brashares. 2008. Effect of habitat area and isolation on fragmented animal populations. Proc Natl Acad Sci USA 105:20770–20775.

Ribic, C.A., and D.W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. American Midland Naturalist 146: 105-121.

Riley, J.L. and P. Mohr. 1994. The Natural Heritage of Southern Ontario's Settled Landscapes. A review of Conservation Biology and Restoration Ecology for Land use and Landscape Planning. OMNR, Southern Region, Aurora, Science and Technology Transfer, Technical Report TR-001. 78pp.

Robbins, C.S., D.K. Dawson, and B.A. Dowell. 1989. Habitat area requirements of breeding birds of the middle Atlantic states. Wildlife Monographs, Vol. 103. 34 pp.

Rodewald, A.D. 2003. The importance of land uses within the landscape matrix. Wildlife Society Bulletin 31 (2): 586 – 592.

Rodewald, A.D. & A.C. Vitz. 2005. Edge- and area-Sensitivity of Shrub land Birds. The Journal of Wildlife Management 69(2): 681-688.

Sandilands, A.P., and S.W. Hounsell. 1994. The effects of 5000kV transmission facilities on forest birds in two wetland forest systems in southern Ontario – testing for the edge effect. In: Snodgrass, W.J. (ed.). Wetland Impacts Workshop. Grand River Conservation Authority. Cambridge, Ontario.

Sauer, J.R., J.E. Hines, and J. Fallon. 2001. The North American Breeding Bird Survey, Results and Analysis 1966 – 2000. Version 2001.2. U.S. Geological Survey, Pawtuxet Wildlife Research Center, Laurel, Maryland.

Schiefele, G.W., and G. Mulamoottil. 1987. Predictive models applicable to Ontario's wetland evaluation system. Pp. 267 – 273 in C.D.A. Rubec and R.P. Overend (eds.). Symposium '87 Wetlands / Peatlands. Edmonton, Alberta. Environment Canada. 704pp.

Schlossberg, S.R., and D.I. King. 2008. Are shrub land birds edge specialists? Ecological Applications 18:1325-1330.

Schwartz, M.W. 1999. Choosing an appropriate scale for conservation reserves. Annual Review Ecology and Systematics 30: 83-108.

Sisk, T.,N.M. Haddad, P.R. Ehrlich. 1997. Bird assemblages in patchy woodlands: Modeling the effects of edge and matrix habitats. Ecol Appl 7:1170–1180.

Soulé, M.E. and J. Terborgh. 1999. Conserving nature at regional and continental scales – a scientific program for North America. Bioscience 49: 809-817.

Steedman, R.J. 1987. Comparative analysis of stream degradation and rehabilitation in the Toronto area. PhD thesis. University of Toronto.

Sutherland, G. D., A. S. Harestad, K. Price, and K. P. Lertzman. 2000. Scaling of natal dispersal distances in terrestrial birds and mammals. Conservation Ecology 4(1): 16. [online] URL: http://www.consecol.org/vol4/iss1/art16/

Swanson, D.L., Dean, K.L., Carlisle, H.A. and E.T. Liknes. 2005. Riparian and woodlot landscape patterns and migration of neotropical migrants in riparian forests of eastern South Dakota. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Tufford, D.L., H.N. McKellar, and J.R. Hussey. 1998. In-stream non-point source nutrient prediction with land-use proximity and seasonality. Journal of Environmental Quality 27: 100-111.

Turner, M.G., and R.H. Gardner (eds). 1991. Quantitative Methods in Landscape Ecology: the Analysis and Interpretation of Landscape heterogeneity. Springer-verlag, New York, New York.

Upper Thames River Conservation Authority (UTRCA). 2003. The Middlesex Natural Heritage Study (MNHS). A Natural Heritage Study to Identify Significant Woodland Patches in Middlesex County. 41pps. + Appendices.

USDA and Wildlife Habitat Council. 2000. Butterflies (Order: Lepidoptera). Fish & Wildlife Habitat management leaflet. No. 15. 12 pp.

Villard, M.A., M.K. Trzcinski and G. Merriam. 1999. Fragmentation Effects on Forest Birds: Relative Influence of Woodland Cover and Configuration on Landscape Occupancy. Conservation Biology 13(4):774-783.

Weathers, K.C., Cadenasso, M.L. and S.T.A. Pickett. 2001. Forest edges as nutrient and pollutant concentrators: potential synergisms between fragmentation, forest canopies and the atmosphere. Conservation Biology 15(6): 1506-1514.

Wegner, J.F., and G. Merriam. 1979. Movements by birds and small mammals between a woodland and adjoining farmland habitats. Journal of Applied Ecology 16: 349-357.

Wetzel, R.G. 2001. Fundamental processes within natural and constructed wetland ecosystems: short-term verses long-term objectives. Water Science and Technology Vol 44 (11-12): 1-8.

Weyrauch, S.L. and T.C. Grubb. 2004. Patch and landscape characteristics associated with the distribution of woodland amphibians in an agricultural fragmented landscape: an information-theoretic approach. Biological Conservation 115: 443-450.

Willson, M. F. 1993. Dispersal mode, seed shadows, and colonization patterns. Vegetatio 107/108: 261–280.

Winter, M., D.H. Johnson, J.A. Shaffer, T.M. Donovan, and W.D. Svedarsky. 2006. Patch size and landscape effects on density and nesting success of grassland birds. The Journal of Wildlife Management 70(1): 158 – 172.

List of Acronyms

ABCA	Ausable Bayfield Conservation Authority
ANSI	Area of Natural and Scientific Interest
CA	Conservation Authority
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSSARO	Committee on the Status of Species At Risk in Ontario
DAR	Development Assessment Report
DEM	Digital Elevation Model
DFO	Department of Fisheries and Oceans
ELC	Ecological Land Classification
EO	Element Occurrence
ESA	Environmentally Significant Areas
FEFLOW	Finite Element Subsurface FLOW System (software package for modeling fluid flow)
GDE	Groundwater Dependent Ecosystems
GIS	Geographic Information System
HVA	Highly Vulnerable Aquifer
IRS	Indian Remote Sensing
ISI	Intrinsic Susceptibility Index
IUCN	International Union for Conservation of Nature
KCCA	Kettle Creek Conservation Authority
LTVCA	Lower Thames Valley Conservation Authority
MMU	Minimal Mapping Unit
MNHS	Middlesex Natural Heritage Study (2001 and 2012)
NHIC	Natural Heritage Information Centre
NHRM	Natural Heritage Reference Manual
NHS	Natural Heritage System
NRVIS	Natural Resource Value Information System
OBM	Ontario Base Mapping
OMAF	Ontario Ministry of Agriculture and Food
OMNR	Ontario Ministry of Natural Resources
OWES	Ontario Wetland Evaluation System
PPS	Provincial Policy Statement
SAR	Species At Risk
SCRCA	St. Clair Region Conservation Authority
SOLRIS	Southern Ontario Land Resource Information System
SWH	Significant Wildlife Habitat
SWHTG	Significant Wildlife Habitat Technical Guide
SWOOP	South West Ontario Ortho Photography
SWP	Source water Protection
TIN	Triangulated Irregular Network
USDA	United States Department of Agriculture
UTRCA	Upper Thames River Conservation Authority

Appendices

Appendix A-1. ELC Code Descriptions

FOC – Coniferous Forest
FOD – Deciduous Forest
FOM – Mixed Forest
CUP – Cultural Plantation
TPW – Tallgrass Woodland
CUT – Cultural Thicket
CUW – Cultural Woodland
TPO – Open Tallgrass Prairie
CUM – Cultural Meadow
BBO – Open Beach / Bar
BBS – Shrub Beach / Bar
BBT – Treed Beach / Bar
BLO – Open Bluff
BLS – Shrub Bluff
BLT – Treed Bluff
CLO – Open Cliff
CLS – Shrub Cliff
CLT – Treed Cliff
TAO – Open Talus
TAS – Shrub Talus
TAT – Treed Talus
SWC – Coniferous Swamp
SWD – Deciduous Swamp
SWM – Mixed Swamp
SWT – Thicket Swamp
FET – Treed Fen
FES – Shrub Fen
BOT – Treed Bog
BOS – Shrub Bog
FEO – Open Fen
BOO – Open Bog
MAM – Meadow Marsh
MAS – Shallow Marsh
SAS – Submerged Shallow Aquatic
SAM – Mixed Shallow Aquatic
SAF – Floating-leaved Shallow Aquatic
OAO – Open Aquatic

Source: Lee et al, 1998. *Ecological Land Classification for Southern Ontario: First Approximation and Its Application.* SCSS Field Guide FG-02.

Appendix A-2. The similarities and differences between the ELC *Vegetation Community* Series and the MNHSS 2014 *Vegetation Groups*

ELC *Vegetation Community* Series		**MNHSS 2014 *Vegetation Group***	
Code	**Definition**	***Veg. Group* (Ecosystem)**	**Definition**
SWC, SWD SWM	>25% tree or shrub cover ; >20% standing water;	Woodland (Wetland)	>20% standing water; >25% tree or shrub
CUP	>60% tree cover; >20% standing water; ≥1 linear edge;		
FOC, FOD FOM	>60% Tree cover	Woodland (Terrestrial)	>60% Tree cover <20% standing water
CUP	>60% tree cover < 20% standing water; ≥1 linear edge		
TPW	35-60% tree cover	Thicket (Terrestrial)	25-60% tree/shrub cover; <20% standing water
CUT	<25% Tree cover; >25% shrub cover		
CUW, TPW	35-60% tree cover		
SWT	<25% tree cover; >25% hydrophytic shrub cover	Thicket (Wetland)	10-25% tree cover or <10% tree cover and >25% shrub cover; >20% standing water
FET	20-25% tree cover		
FES	<10% tree cover; >25% shrub cover		
BOT	10-25% tree cover		
BOS	<10% tree cover; >25% shrub cover		
TPO CUM	<25% tree cover; <25% shrub cover	Meadow (Terrestrial)	<10% tree cover and <25% shrub cover
FEO BOO	<10% tree cover; <25% shrub cover	Meadow (Wetland)	<10% tree cover and <25% shrub cover; located in wetland as defined in Section 2.2.2.1 below
MAM MAS	<25% tree cover; <25% shrub cover		
SAS, SAM SAF	No tree cover; >25% macrophytes		
OAO	No vegetation; open water	Water Feature (Aquatic)	No vegetation; open water
BBO, BBS BBT	<60% tree cover; along shorelines	Watercourse Bluff and Depositional Area (Terrestrial)	<60% tree cover; on naturally active sites such as shorelines, steep slopes and base of cliffs
BLO BLS BLT	<10% tree cover; on active or steep near vertical surfaces		
CLO, CLS CLT	<60% tree cover; on steep near vertical surfaces		
TAO, TAS TAT	<60% tree cover; on slopes of rock rubble at base of cliffs		

*Note: Connected *Vegetation Group* can be made up trees and shrubs

Appendix B. Wetland Layer Methodology and Sources

The wetland layer for Middlesex was derived from four sources: (1) OMNR Evaluated Wetlands, (2) UTRCA/LTVCA.KCCA unevaluated wetlands, (3) ABCA unevaluated Wetlands and (4) SCRCA unevaluated wetlands.

(1) Ontario Ministry of Natural Resources (OMNR) Evaluated Wetlands

The Ontario Ministry of Natural Resources evaluates wetlands based on the Ontario Wetland Evaluation System (OWES) Southern Manual (OMNR 2013). Sites are evaluated in the field, mapped, and then scored based on field data, hydrology and use. Since evaluated wetlands have been mapped during site visits, they can be smaller than 0.5 ha and are retained as part of the natural heritage system.

In some cases, CA staff found the perimeter of the evaluated wetland did not match the natural heritage feature boundary on the orthoimagery and so boundary amendments were made. It should be noted that this may have resulted in extending the wetland beyond the true boundary approved under OWES criteria.

If boundary amendments are being made to reflect the outer extent of a natural heritage feature this may be extending the wetland beyond the true boundary approved under OWES criteria. Using OWES criteria the wetland boundary may not always align with the natural heritage feature boundary. For the wetland *Vegetation Community* feature layer, CA staff adjusted the boundaries of the wetland to the ortho-image. However, these amendments are not verified in the field and may extend the wetland boundary beyond the true boundary approved using the criteria in the Southern Ontario Wetland Evaluation manual. Therefore, for policy decisions, the approved wetland boundary should be used.

Recognizing that wetlands are dynamic, it is recommended that a DAR determine the accurate wetland boundary using the criteria in the Southern Ontario Wetland Evaluation Manual. The Ontario Wetland Evaluation System (OWES) uses an open file system where files can be amended as new information becomes available. MNR is the approval authority on Provincially Significant Wetlands (PSW), so any changes to the boundaries of PSWs must be approved by the MNR.

(2) UTRCA, LTVCA and KCCA Unevaluated Wetlands

The Upper Thames River Conservation Authority (UTRCA) began identifying unevaluated wetlands in 2006 in an attempt to consolidate information and map the numerous wetlands that were not part of the evaluated wetland layer of OMNR to better represent natural features in the watersheds. These wetland areas were identified for the generic regulations using the following desk-top procedure:

i. Compile wetland indicators:
   a. Historic Forest Cover. Delineate and digitize historic forest cover information collected in the 1950s and 1960s by teams of foresters who examined every woodlot in the watersheds and characterized cover types. Identify areas associated with wetland species (e.g. silver maple, black ash, cedar, white elm, and tamarack).
   b. Soils. Delineate and digitize organic and clay soils (wetland soils) using OMAF soils maps.
   c. Elevation. Delineate and digitize areas in depressions or lower elevations using a Digital Elevation Model (DEM).
   d. Groundwater. Delineate and digitize recharge and discharge areas from the Six CA Groundwater Model.

e. Proximity. Delineate and digitize areas within 120 m of an OMNR evaluated wetland since 120 m is the distance at which adjacent lands may have an impact on a wetland. This distance ensures there will be enough area to account for changes in the wetland boundary.

ii. Overlay the indicators to determine possible wetland areas. The more indicators that overlap, the more likely there is a wetland in that area.

iii. Compare the areas delineated by overlaying the wetland indicators to an aerial photo interpretation of wetland areas where wetness is indicated by color (dark), texture (granular), and canopy cover (sparse or spotty). Areas that matched were identified as unevaluated wetlands.

The UTRCA staff applied this wetland mapping methodology to the watersheds of the Lower Thames Valley and Kettle Creek within Middlesex County.

(3) ABCA Unevaluated Wetlands

The Ausable Bayfield Conservation Authority (ABCA) developed a methodology for progressively updating their regulated wetland layer in 2006 in order to comply with the CA Generic Regulation (Ontario Regulations 157/06). Regulated unevaluated wetlands include:

- Wetland features > 0.5ha included in the Natural Resource Value Information System (NRVIS) water polygon layer (MNR OBM 1983) were selected and verified with 1999 aerial spring photography. Irrigation ponds, sewage lagoons, and cultivated fields were removed, as were wetlands already identified in another MNR wetland layer.
- ABCA digitized wetland layer based on the existing ABCA Environmentally Significant Areas (ESAs) digital layer (ABCA 1994), and adjusted according to:
  - boundaries drawn on 1978 air photos from field visits,
  - photo interpretation of 1999 aerial photography,
  - soil mapping (Experimental Farm Service 1952), and
  - 1 m contours from a Triangulated Irregular Network (TIN) layer.
- Other wetland mapping including marshes identified in the 1986 OMNR Ontario Base Map series were added

All wetlands have since been viewed and adjusted using the 2010 air photos and 3-D stereo model where required.

(4) St. Clair Region Conservation Authority (SCRCA) Unevaluated Wetlands

In 2012, the SCRCA undertook Wetland Analysis Mapping. The SCRCA developed a desk-top methodology to identify previously unidentified wetlands greater than 0.5 ha. Regulated unevaluated wetlands include those identified in one of two methods:

- Desk top interpretation of 2010 aerial photography. Areas exhibited a high likelihood of wetland potential include areas darker than the surrounding features because of the presence of water, areas that appear granular because of the type of vegetation associated with wetlands, and sparse or spotty canopy cover. OR
- The presence of three indicators of wetland potential overlaid on 2010 aerial photography:
  - Soil mapping (OMAF Soils Ontario Version 1.0) using soil types identified as: Organic, Bottomland and Beach, Silt and Clay and Silt and Clay Loams
  - Groundwater discharge (FEFLOW Groundwater Model, Waterloo Hydrogeologic Inc., 2005)
  - Woodlands (1983 Agricultural Resource Inventory by OMAF)

Appendix C. Groundwater Dependent Wetlands and a possible procedure for landscape scale study

1. An index of ecosystem groundwater dependency can be developed for the watershed by mapping and overlaying the following three ecosystem types to determine areas of ecosystem groundwater dependency:

Springs and seeps. Survey the landscape in late fall (e.g., by plane) when there is fog to identify seeps. Map as point features. All springs are groundwater dependent regardless of location.

Groundwater dependent wetlands. Use the spatial layer of wetland *Vegetation Groups* developed in Section 2.2.2.1 as base layer. Since groundwater dependent wetlands are defined by hydric or partially hydric soils, the wetland *Vegetation Group* layer was intersected with a soils layer to remove all surface water dependent wetlands. Surficial geology can also be used to identify groundwater dependent wetlands as most are located on sand and gravel deposits.

Groundwater dependent streams. Survey the landscape in winter and summer to identify groundwater dependent streams.

2. As groundwater discharge areas are detected through site studies as part of the Ecological Site Assessment Process and recorded in the Development Assessment Report (DAR), it is recommended that the appropriate Conservation Authority is notified and the location of discharge is mapped as significant.

Source: UTRCA Staff

Appendix D. Summary of Significance Criteria and Rationale

#	***Vegetation Group* Criteria**	**Scientific Rationale**	**Other Natural Heritage Study (NHS) Sources**	**Application / MNHSS Rules for Mapping Significant Features**
1	Any *Vegetation Group* within or touching a **valley**	Vegetation on valley lands prevents erosion, improve water holding capacity that ensures regeneration of vegetation, and encourages wildlife movement.	Oxford (ONHS 2006): patches on valley lands Huron (HCNHS 2013): all areas within valley lands or patches < 100 m from valley lands.	Section 3.2.1.1: *Vegetation Group* on valley land defined using 3:1 slope or 100m from centerline of watercourse.
2	Any *Vegetation Group* located within or touching a **Life Science ANSI** (Area of Natural and Scientific Interest)	Recognized significant areas are a logical foundation on which to design a natural heritage system.	Huron (HCNHS 2013): contains a Life Science ANSI	Section 3.2.1.2: Pre-determined by OMNR using five evaluation selection criteria: representation, condition, diversity, other ecological considerations, and special features.
3	Any *Vegetation Group* located within 30 m of an **open watercourse**	Relationship between water course and vegetation is interactive whereby vegetation along watercourses improves water quality for aquatic Vegetation Ecosystems through reduction in soil erosion and input of nutrients; while the watercourse attracts animals and acts as a corridor.	Middlesex (MNHS 2003): <50 m of watercourse Oxford (ONHS 2006): < 50 m of watercourse Huron (HCNHS 2013): < 30 m of watercourse LCNHS 2013: > 0.5 ha woodland < 30 m from watercourse COL 2006: woodland < 50m of watercourse, floodplain, or riparian corridors.	Section 3.2.1.3: All *Vegetation Groups* within 30 m from the edge of an open watercourse (defined as the bank-full width if greater than 20m wide, or a defined channel visible on the aerial photography if less than 20m wide).

Appendix D Continued. Summary of Criteria 4 to 9 -- Size Significance Criteria applied to Specific *Vegetation Groups*

#	***Vegetation Group* Criteria**	**Scientific Rationale**	**Other NH Sources with this criterion**	**Application / MNHSS Rules for Mapping Significant Features**
4	All evaluated wetlands and any unevaluated **wetland** *Vegetation Group* ≥ 0.5 ha	Wetlands have disproportionately been removed from the landscape of southern Ontario. Some of their important functions are to maintain the hydrological regime of the surrounding area by dampening water peaks in the gullies; reduce the potential for erosion; and provide critical breeding and overwintering habitat for reptiles and amphibians.	HCNHS 2013: contains either • OMNR evaluated wetland, • coastal wetland	The wetland layer was derived from the OMNR evaluated wetland mapping layer, as well as the unevaluated wetland layers developed from each of the Conservation Authorities in Middlesex County (refer to Mapping Criteria Section 1.3).
5	Any **woodland *Vegetation Group* ≥ 4 ha**	Habitat size is one of the most important measures for sustaining stable, diverse and viable populations of wildlife species. In a highly fragmented landscape, the definition of a "large sized" woodland can be relatively small.	MNHS 2003: > 10 ha in size and has interior >100 m from edge ONHS 2006: > 10 ha in size and has interior >100 m from edge HCNHS 2013: > 4 ha LCNHS 2013: > 2 ha in size and has interior >100 m from edge Perth 2012: > 1 ha COL 2006: woodland >2 ha and has interior >100 m from edge	Forest cover in Middlesex is 11-12%. Based on NHRM and Env. Canada, any woodland > 4 ha is significant in areas with 5 to 15% forest cover.
6	Any Woodland *Vegetation Group* **within 100 m of a ≥4 ha Woodland** *Vegetation Group*	The < 100 m distance is based on average seed dispersal distances in the literature.	MNHS 2003: <100 m from 10 ha woodland HCNHS 2013: woodland <100 m from 4 ha woodland LCHNS 2013: either – 0.5 ha woodland within 30 m of any veg. community or > 0.5 ha woodland located <120m of a >1 ha *Vegetation Community*.	All woodland less than 4 ha within 100m of a > 4 ha woodland, regardless of what land use surrounds them, are identified.

Appendix D continued

#	***Vegetation Group* Criteria**	**Scientific Rationale**	**Other NH Sources with this criterion**	**Application / MNHSS Rules for Mapping Significant Features**
7	Any **Thicket *Vegetation Group* ≥ 2 ha in size**	Larger thickets are better if managing to enhance the long-term survival of a variety of wildlife. Large thickets greater than 2 ha are relatively rare in Middlesex County, yet thickets of at least 10 ha in size are required for uncommon species (Oehler *et al.* 2006).	HCNHS 2013: > 2.5 ha shrub land	Thickets ≥ 2 ha are relatively rare in Middlesex County
8	Any **Meadow *Vegetation Group* ≥ 10 ha in size**	The amount of native meadow habitat has declined drastically throughout North America. Grassland birds are of special concern since they have suffered more serious population declines than any other group of birds. Johnson (2001) demonstrated a preference for large grassland *Vegetation Groups* by a number of grassland bird species, irrespective of territory size.	HCNHS 2013: ≥ 10 ha shrub land / meadow	All meadows ≥ 10 ha are significant according to the literature.
9	Any **Meadow *Vegetation Group* within 100 m of a large size Woodland or Shrubland** *Vegetation Group*	Meadow butterfly habitat must be considered in context with the surrounding range of habitats. Using the average distance of wind dispersed seeds as a conservative estimate; all meadows found within 100m of a large shrub land or woodland were identified as significant.		All meadows within 100 m of a large woodland (4 ha) or large shrub land (2 ha) are significant.

Appendix D. Summary of Criteria 10 to 12 -- Criteria applied to *Vegetation Patches*

#	***Vegetation Patch* Criteria**	**Scientific Rationale**	**Other NH Sources with this criterion**	**Application / MNHSS Rules for Mapping Significant Features**
10	Any *Vegetation Patch* that contains a *Vegetation Group* identified as significant	The arrangement of spatial elements, especially barriers, conduits, and highly-heterogeneous areas between the *Vegetation Communities* within the *Vegetation Patch* determine the movement of species, energy, material, and disturbance over a landscape.		All *Vegetation Patches* containing a *Vegetation Group* that has been identified as significant.
11	Any *Vegetation Patch* that contains a diversity of *Vegetation Communities*, Ecosystems or Groups	The number of *Vegetation Communities* in a *Vegetation Patch* is a measure of habitat and species diversity.	ONHS 2006: patches with largest *Vegetation Community* type HCNHS 2013: > 15 vegetation polygons COL 2006: > 3 community series	The *Vegetation Patch* was identified as significant if it either contained more than one Vegetation Ecosystem, or more than two *Vegetation Groups*, or more than three *Vegetation Communities*.
12	Any *Vegetation Patch* within 100 m of a significant *Vegetation Patch*	Local landscapes that include large natural areas linked to the regional landscape mosaic by a network of smaller interacting natural areas and corridors, offers the highest probability of maintaining overall ecological integrity. The < 100 m distance is based on average seed dispersal distances in the literature.	MNHS 2003: <100 m from 10 ha woodland HCNHS 2013: woodland <100 m from 4 ha woodland LCHNS 2013: either – • 0.5 ha woodland within 30 m of any *Vegetation Community* or > 0.5 ha woodland located <120m of a >1 ha *Vegetation Community*.	All *Vegetation Patches* within 100m of a significant *Vegetation Patch*, regardless of what land use surrounds them, are identified.

Appendix D. Summary of Criteria 13 to 15 – Criteria that can be used to identify significant *Vegetation Groups* but not currently mapped.

#	***Vegetation Patch*** **Criteria**	**Scientific Rationale**	**Other NH Sources with this criterion**	**Application / MNHSS Rules for Mapping Significant Features**
13	Any *Vegetation Group* that contains **Significant Wildlife Habitat**	According to the PPS, wildlife habitat is considered significant where it is ecologically important in terms of features, functions, representation or amount. Suggested criteria for determining Significant Wildlife Habitat are provided by OMNR in the Significant Wildlife Habitat Technical Guide (OMNR 2000b), the Significant Wildlife Habitat Ecoregional Criteria Schedules (OMNR 2012), and the Natural Heritage Reference Manual (OMNR 2010).	COL 2006: patch with either • > 1 species of amphibian, or • 1 species of amphibian that is occasional, or • 1 critical habitat component, or • Conifer communities> 2.0 ha in size, or • Dissolved oxygen> 5.0 mg/L, or • Moderate in stream woody debris HCNHS 2013: seeps (when identified)	As SWH is identified, the appropriate planning authority must confirm its significance. Significant habitat will be mapped and reported to the OMNR and the appropriate Conservation Authority and submitted to the County as an update to the significant natural heritage mapping layer.
14	Any *Vegetation Group* that contains a **Groundwater Dependent Wetland (GDW)**	GDWs are ecosystems that require access to groundwater to maintain their communities of plants and animals, ecological processes and ecosystem services. Examples: seeps, fens	ONHS 2006: on well head capture zones of GW susceptibility areas. LCNHS 2013: woodland > 0.5 ha on groundwater feature COL 2006: within or contiguous to groundwater recharge area (as defined in Schedule B1 on London the Official Plan)	Section 3.2.1.4: An index of ecosystem groundwater dependency can be developed for the watershed by mapping and overlaying the following three ecosystem types to determine areas of ecosystem groundwater dependency
15	Any *Vegetation Group* that contains a **Watercourse Bluff or Deposition Area**	Steep slopes, areas of erosion and beaches (depositional areas) can create unique natural features for specialized assemblages of plants and animals.	ONHS 2006: patches on valley lands HCNHS 2013: all areas within valley lands or patches < 100 m from valley lands.	Deposition Areas, Steep Slopes, Cliffs and Valley Bluffs identified through the Ecological Site Assessment Process on valley lands.

Natural Heritage Studies Referenced above

COL -- City of London (City of London, 2006)

- evaluation of woodlands, cutoffs based on medium to high rankings

HCNHS -- Huron County Natural Heritage Study (County of Huron, 2013 Draft)

- based on more complete natural heritage system mapping and no field work

LCHNS -- Lambton County Natural Heritage Study (County of Lambton et al., 2012 Draft)

- based only on woodlands and field work

MNHS -- Middlesex Natural Heritage Study (UTRCA, 2003)

- based only on woodlands and field work

ONHS -- Oxford Natural Heritage Study (County of Oxford, 2006)

- based on woodlands, floodplain meadows, watercourses and dated fieldwork

Perth -- Perth County Official Plan Amendment #47 (County of Perth Official Plan. 2008. Section 11.5.5)

- regarding minimal woodland size

Appendix E. Summary of Rationale for 19 Criteria NOT used to identify significance.

Criteria	Rationale for Not Including in MNHSS 2014	Other Natural Heritage Studies*
1. Best representative *Vegetation Patch* on **landform physiography and soil type**	This is redundant as the Life Science ANSI uses this criterion, even though it is done at a different scale (i.e., by site district rather than by county).	ONHS 2006: largest patch on each landform and each soil type LCNHS 2013: largest patch on slope of 10% or greater and largest patch on each landform and each soil type COL 2006: patch contains either: - > 1 ecosite in 1 Community series OR - > 2 vegetation types OR - > 1 topographic feature OR - 1 vegetation type with inclusions/ complexes
2.Located on a **distinctive, unusual or high quality landform**	Definition of a distinctive, unusual or high quality landform is subjective.	COL 2006: patch located on either - Beach Ridge - Sand Plain - Till Plain - Till Moraine
3.All areas (both vegetated and **non-vegetated**) on: - **Gullies** - **Valley lands** - within 30 m of **limestone outcroppings**	The MNHSS will identify *Vegetation Patches* on valley lands as significant and recommend that other land uses on valley lands (e.g., agriculture, golf courses, etc.) be considered as special policy areas with limitations on further development to maintain valley land connectivity. There are no shorelines or limestone outcroppings in Middlesex.	ONHS 2006: patches on valley lands HCNHS 2013: patches on or < 100m from landform features - dunes, - shore bluffs, - gullies, - valley lands, - within 30m of limestone outcroppings
4.All *Vegetation Patches* found alongside a **coldwater watercourse or watercourse containing Brook Trout**	Definition of a watercourse, both cold and warm, includes an additional area immediately adjacent to the water (in proportion to the size of the watercourse feature) and therefore it is not necessary to include additional lands for protection (e.g., *Vegetation Patches* 30 m from edge) Non vegetated setbacks from watercourses can be restricted using other official plan and zoning plan policies. Questions remain: Is this sensitive information? How easy is it to determine coldwater streams? Are they already identified?	
5.Shape of *Vegetation Patch*	When shape metrics are used, often very small and round *Vegetation Patches* are selected over larger *Vegetation Patches*.	COL 2006: has perimeter to area ratio <3.0 m/m^2

Appendix E continued

Criteria	Rationale for Not Including in MNHSS 2014	Other Natural Heritage Studies*
6.Adjacent to an OMNR evaluated wetland or life science ANSI	This is redundant as other adjacency rules have these features incorporated into them.	MNHS 2003: woodland < 750m from recognized feature. ONHS 2006: < 150m of non-wetland feature
7.Contains an area identified in the local official plans e.g. **Local ESAs (**Hilts and Cook 1978).	The MNHSS uses modern landscape parameters. Verification that the old ESAs are being identified as significant will occur.	ONHS 2006: Local OP designated habitats
8.Unique Intrinsic Characteristics (i.e., site level)	No field work or site visits are being conducted for this project, so it is not possible to evaluate the intrinsic or site specific characteristics of *Vegetation Patches* at this fine scale.	LCNHS 2013: > 0.5 ha woodland with either - - unique species composition, - cover type, - age - structure. COL 2006: woodland with either – - mid to old age community, or - tree size > 50 cm DBH, or - > 16 m2/ha for trees >25 cm DBH, or - > 12 m2 / ha for trees > 10 cm DBH, or - All diameter class sizes represented or - community with MCC > 4.1, or - patch MCC > 3.9, or - > 1 community in good condition or - Community with SRANK > S4 or - > 1 northern / specialized habitat / tree / shrub species or - > 2 Carolinian tree / shrub species
9.Distance from development (e.g., permanent infrastructure and buildings) or matrix	Difficult to evaluate. Too complex for this study.	COL 2006: > 7% vegetation cover within 2 km radius from woodland centroid
10.Persistence or Threatened	A natural feature that persists through time is not necessarily more significant. However, it is interesting to compare 2006 to 2010 aerial photography to see what the trends are and why.	LCNHS 2013: > 0.5 ha woodland with high economic or social value
11.Porous or erodible soils	The aim of the MNHSS is to identify biological natural heritage features, not hazards. Natural features found on porous soils should be captured in *Vegetation Patches* found on significant groundwater areas	MNHS 2003: woodland on porous soils COL 2006: patch on either- - 25% slope any soil - Remnant slope - >10% to <25% on clay, silty clay

Criteria	Rationale for Not Including in MNHSS 2014	Other Natural Heritage Studies*
12.*Vegetation Patch* contains **a large sized wetland** defined as: • Wooded wetlands >4ha based on Env. Canada • Wetland meadows and marshes > 10ha based on Env. Canada • Small wetland meadows and marshes adjacent to other *Vegetation Communities* may be vital to butterflies • Wetland shrubland size determined by top 75th percentile distribution cutoff of all county wetland shrubland sizes	The MNHSS 2014 has identified all wetlands ≥0.5 ha (MMU) as significant, regardless of size or type.	HCNHS 2013: either - - 4ha wooded wetland - 10ha wetland meadow or marsh - 2.5ha wetland shrubland COL 2006: woodland contains or contiguous to a wetland
13.*Vegetation Patch* contains a wetland that is **within 1,000m of another wetland;** distance based on S. Ont. Wetland Evaluation Manual where wetlands are scored based on their proximity to another wetland (Section 1.2.4) and receive points if they are within 1 km of another wetland. The 750m is for delineating wetland boundaries, not scoring wetlands.	MNHSS 2014 has identified all wetlands ≥0.5 ha (MMU) as significant.	ONHS 2006: < 750 m from wetland HCNHS 2013: < 1000 m from wetland
14.*Vegetation Patch* contains a recently observed (post 1980) **Regionally Rare Plant**	Uncommon or rare species in Middlesex County may be used as a warning that indicates the continued decline of a species. Regional rarity was once tracked by MNR Aylmer but no longer. Dr. Jane Bowles updated the R status list in 2002, but there is nothing more current. Furthermore, the geo-references for the data are inconsistent or lost. The UTRCA has only one map showing locations of regionally rare plants, mapped by hand onto a topographic map of London-St. Thomas 40-I/14, by Dr. Bowles, circa 1993. Neither MNR Aylmer nor NHIC have retained or digitized the historic data. Presently, no agency is responsible for ensuring the data is being updated and monitored for change in status. There is a need to develop a reporting and evaluation system.	ONHS 2006: contains rare species COL 2006: Contains either: • Rare tree / shrub • Rare herbaceous • Regionally rare plant

Criteria	Rationale for Not Including in MNHSS 2014	Other Natural Heritage Studies*
15.*Vegetation Patch* contains **shrubland/thicket with interior**	Although studies have shown that most shrub land birds avoid edges (Schlossberg and King 2008) and experience lower nesting success near edges (King et al. 2001, King and Byers 2003, King et al. 2009b), there is not a consistent definition of edge habitat. Rather, the size of a shrub land is used as a proxy measure of edge habitat.	
16.*Vegetation Patch* contains an **Earth Science ANSI** that contributes to the presence of an uncommon *Vegetation Community*	Biodiversity planning requires an understanding of uncommon *Vegetation Communities* in terms of their distribution on significant areas. However, the presence of an ES ANSI does not mean there are unique *Vegetation Community* features that are resulting from the characteristics of the Earth Science ANSI.	
17.Carolinian Canada **Big Picture Corridors**	Carolinian Canada's Big Picture has been accepted as a planning tool when no other landscape level studies were complete. Many of the rules used to identify Carolinian Corridors on the larger landscape (SW Ont) have been incorporated in the MNHSS 2014 proposed criteria, but refined for the smaller County scale (e.g., valley land definition layer and proximity criteria). The Big Picture corridors incorporate areas that are <u>not</u> vegetated at present, as part of a restoration plan. The MNHSS captures only vegetated natural heritage patches, not farmland or other lands that could be restored or naturalized. Picking corridors at a larger scale is somewhat arbitrary. It is proposed that more current science and mapping be used to delineate corridors. Recommend as a followup step to the MNHSS or deal with it when there is a landuse change.	<u>MNHS 2003</u>: woodland within recognized corridor <u>COL 2006</u>: woodlands connected by either – - Watercourses - Gaps < 40m - Recognized corridors - Abandoned rail and utility lines - Open space greenways and golf courses - Active agriculture or pasture
18.Interior woodland habitat that is ≥ **0.5 ha in size** of continuous habitat	• Interior is defined as >100 m from the woodland edges. • All woodlands with at least 0.5ha of continuous interior habitat are considered significant. • Habitat found along the edge of a woodland *Vegetation Community* is characterized by a climate (e.g., higher humidity, lower wind) and *Vegetation Community* composition different from that of interior woodland habitat. • Interior habitat is often less prone to disturbances and supports fewer predators.	<u>MNHS 2003</u>: has interior >100 m from edge <u>ONHS 2006</u>: has interior >100 m from edge <u>HCNHS 2013</u>: has interior > 0.5 ha that is > 100 m from edge <u>LCNHS 2013</u>: has interior >100 m from edge <u>COL 2006:</u> : has interior >100 m from edge

Criteria	Rationale for Not Including in MNHSS 2014	Other Natural Heritage Studies*
19.Species at Risk	• Includes plants, *Vegetation Communities*, birds, mammals, herptofaunal (frogs, toads, salamanders, turtles and snakes). Rare or uncommon species can be indicators of unusual and rare habitat and are often used to guide conservation strategies (Lesica and Allendorf 1995, Lomolino and Channell 1995). • Table 3-4 in the Natural Heritage Reference Manual (OMNR, 2010) recognizes species rarity as an ecological function, and habitats that contain rare species are more valuable. MNR recommends that this be restricted to END and THR. • SAR have their own legislation for protection and a DAR needs to consider their presence This is not a criterion for the following reasons: - This is a landscape study rather than an intrinsic characteristics study and there is not a complete inventory - The absence of a species does not mean that suitable habitat or conditions are not present - Areas with END or THR species are already protected in the SAR Act while IUCN S1 – S3 are considered under SWH - Mapping limitations of the past limit accuracy in identifying locations. New species are added to the SAR over time. • These areas are not mapped currently but it is recommended that they be mapped as they are identified through site studies on the landscape and reported to the OMNR and the appropriate Conservation Authority.	

Natural Heritage Studies Referenced above

COL -- City of London (City of London, 2006)
- evaluation of woodlands, cutoffs based on medium to high rankings

HCNHS -- Huron County Natural Heritage Study (County of Huron, 2013 Draft)
- based on more complete natural heritage system mapping and no field work

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- based only on woodlands and field work

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- based only on woodlands and field work

ONHS -- Oxford Natural Heritage Study (County of Oxford, 2006)
- based on woodlands, floodplain meadows, watercourses and dated fieldwork

Perth -- Perth County Official Plan Amendment #47 (County of Perth Official Plan. 2008. Section 11.5.5)
- regarding minimal woodland size

Appendix F. Metadata: Patch and Group Criteria Mapping and Field Description

The following Information describes the feature classes (layers) and fields that are associated with the criteria section of the report. The feature classes are being delivered in a file geodatabase format (name).

Naming Convention

A naming convention is being followed that should make data easy to understand and follow.

Table 1 describes short forms used for Groups:

Group Type	Short Form
Woodland	WDL
Meadow	MDW
Thicket	THK
Wetland	WTL
Connecting Features	CNF
Waterbody	WBY

Table 2 describes short forms used for Patch:

Patch	Short Form
Patch	PTC

Table 3 describes how the level of information are defined.

Level of Detail	Detail
Field provides criteria of the individual group	CR
Fileld provides supporting information that may be important to the group	INF

Populated data and Field Structure

Field names are generally named in the following manner “Short Form”_”Detail”_Description (eg. Woodland_Criteria_Greater Than 4ha is WDL_CR_GT4ha)

Group, Patch and Information filelds are *short integers* fields and are populated with 1 or 0, 1=applicable 0=not applicable – See table below

“Short Form”_”CR”_Total– are short integers fields that indicate the total number of criteria met within the individual group

Table 4 provides field descriptions and field names within each group and patch feature class. It also provides information of what values are populated.

Feature Name and Field Description	Field Name	Value
Group_Woodland_Cluster_02_21_2014		
Within valley land	WDL_CR_Valleyland	0= Not applicable, 1=applicable
With Life Science ANSI	WDL_CR_ANSI	0= Not applicable, 1=applicable
Group within 30m of Watercourse	WDL_CR_Watercourse	0= Not applicable, 1=applicable
Any Woodland or Woodland Cluster >4ha	WDL_CR_GT4ha	0= Not applicable, 1=applicable
Any Woodland within 100m of a Woodland Cluster> 4ha	WDL_CR_100m_GT4ha	0= Not applicable, 1=applicable
Number of Significant Woodland Criteria Met	WDL_CR_Total	0 = Not applicable >0=Applicable
Wetland within Woodland	WDL_INF_Wetland	0= Not applicable, 1=applicable
Individual Woodland or Woodland within Cluster has Interior	WDL_INF_Interior	0= Not applicable, 1=applicable
Group_Meadow_Cluster_01_08_2014		
Within valley land	MDW_CR_Valleyland	0= Not applicable, 1=applicable
With Life Science ANSI	MDW_CR_ANSI	0= Not applicable, 1=applicable
Group within 30m of Watercourse	MDW_CR_Watercourse	0= Not applicable, 1=applicable
Any Meadow or Meadow Cluster >10ha	MDW_CR_GT10ha	0= Not applicable, 1=applicable
Number of Meadow Significant Criteria Met	MDW_CR_Total	0 = Not applicable >0=Applicable
Wetland within Thicket	WDW_INF_Wetland	0= Not applicable, 1=applicable
Group_Thicket_Cluster_01_22_2014		
Within valley land	THK_CR_Valleyland	0= Not applicable, 1=applicable
With Life Science ANSI	THK_CR_ANSI	0= Not applicable, 1=applicable
Group within 30m of Watercourse	THK_CR_Watercourse	0= Not applicable, 1=applicable
Any Thicket or Thicket Group >2ha	THK_CR_GT2ah	0= Not applicable, 1=applicable
Number of Significant Thicket Criteria Met	THK_CR_Total	0 = Not applicable >0=Applicable
Wetland within Thicket	THK_INF_Wetland	0= Not applicable, 1=applicable
Group_Wetland		
Within valley land	WTL_CR_Valleyland	0= Not applicable, 1=applicable

With Life Science ANSI	WTL_CR_ANSI	0= Not applicable, 1=applicable
Group within 30m of Watercourse	WTL_CR_Watercourse	0= Not applicable, 1=applicable
Any wetland >0.5 ha or Provincial Evaluated Wetland	WTL_CR_Wetland	0 = Not applicable >0=Applicable
Number of Significant Wetland Criteria Met	WTL_CR_Total	>0=applicable
Group_Connecting_Feature		
Within valley land	CNF_CR_Valleyland	0= Not applicable, 1=applicable
With Life Science ANSI	CNF_CR_ANSI	0= Not applicable, 1=applicable
Group within 30m of Watercourse	CNF_CR_Watercourse	0= Not applicable, 1=applicable
Number of Connecting FeaturesSignificant Criteria Met	CNF_CR_Total	0 = Not applicable >0=Applicable
Wetland within Connecting Feature	CNF_INF_Wetland	0= Not applicable, 1=applicable
Group_Waterbody_04_04_2014		
Within valley land	WBY_CR_Valleyland	0= Not applicable, 1=applicable
With Life Science ANSI	WBY_CR_ANSI	0= Not applicable, 1=applicable
Group within 30m of Watercourse	WBY_CR_Watercourse	0= Not applicable, 1=applicable
Number of Waterbody Significant Criteria Met	WBY_CR_Total	0 = Not applicable >0=Applicable
Patch_MNH_Cluster_06_18_2014		
Patch contains at least one group significant from field list below (see field descriptions below in Patch Information) MDW_CR_Significant- patch meets a criteria SHB_CR_Significant - patch meets a criteria WDL_CR_Significant- patch meets a criteria WTL_CR_Significant- patch meets a criteria CNF_CR_Significant- patch meets a criteria WBY_ CR_Significant- patch meets a criteria	PTC_CR_Group	0= Not applicable, 1=applicable
Vegetation Communities I) Patch contains more than one vegetation system, or ii) Patch contains more than two *Vegetation Groups*, or iii) Patch contains more than three *Vegetation Communities*	PTC_CR_Diversity	0= Not applicable, 1=applicable
within 100m of a large *Vegetation Group* i) Any Woodland or Woodland Cluster> 4ha ii) Any Thicket >2ha iii) Any Meadow >10ha	PTC_CR_Proximity	0= Not applicable, 1=applicable
Patch Information		
Patch contains a Patch criteria	PTC_CR_Signficiant	0= Not applicable, 1=applicable

Patch contains a Woodland Group criteria	WDL_CR_Signficant	0= Not applicable, 1=applicable
Patch contains a Meadow Group criteria	MDW_CR_Signficant	0= Not applicable, 1=applicable
Patch contains a Thicket Group criteria	THK_CR_Signficant	0= Not applicable, 1=applicable
Patch contains a Wetland Group criteria	WTL_CR_Signficant	0= Not applicable, 1=applicable
Patch contains a Connecting Feature Group criteria	CNF_CR_Signficant	0= Not applicable, 1=applicable
Patch contains a Waterbody Group criteria	WBY_CR_Signficant	0= Not applicable, 1=applicable
Woodland Criteria		
Patch contains a woodland within a Valleyland	WDL_CR_Valleyland	0= Not applicable, 1=applicable
Patch contains a woodland within a ANSI	WDL_CR_ANSI	0= Not applicable, 1=applicable
Patch contains a woodland that is within 30 m of watercourse	WDL_CR_Watercourse	0= Not applicable, 1=applicable
Patch contains a woodland or woodland group >4ha	WDL_CR_GT4ha	0= Not applicable, 1=applicable
Patch contains a woodland that is within a 100m of a woodland >4ha	WDL_CR_100m_GT4ha	0= Not applicable, 1=applicable
Meadow Criteria		
Patch contains a meadow within valley land	MDW_CR_Valleyland	0= Not applicable, 1=applicable
Patch contains a meadow within an Life Science ANSI	MDW_CR_ANSI	0= Not applicable, 1=applicable
Patch contains a Meadow that is within 30m of a watercourse	MDW_CR_Watercourse	0= Not applicable, 1=applicable
Patch contains a Meadow or Meadow Cluster >10ha	MDW_CR_GT10ha	0= Not applicable, 1=applicable
Patch contains a meadow within 100m of large Woodland or Thicket	MDW_CR_Proximity	0= Not applicable, 1=applicable
Thicket Criteria		
Patch contains a Thicket within a valley land	THK_CR_Valleyland	0= Not applicable, 1=applicable
Patch contains a Thicket within a Life Science ANSI	THK_CR_ANSI	0= Not applicable, 1=applicable
Patch contains a Thicket that is within 30m of a watercourse	THK_CR_Watercourse	0= Not applicable, 1=applicable
Patch contains a Thicket or Thicket group >2ha	THK_CR_GT2ah	0= Not applicable, 1=applicable
Wetland Criteria		
Patch contains a Wetland within a valley land	WTL_CR_Valleyland	0= Not applicable, 1=applicable
Patch contains a Wetland within a Life Science ANSI	WTL_CR_ANSI	0= Not applicable, 1=applicable
Patch contains a Wetland that is within 30m of a watercourse	WTL_CR_Watercourse	0= Not applicable, 1=applicable

Patch contains a Wetland >0.5 ha or a Provincial Evaluated Wetland	WTL_CR_Wetland	0= Not applicable, 1=applicable
Connecting Feature Criteria		
Patch contains a *Connecting Feature* within a valley land	CNF_CR_Valleyland	0= Not applicable, 1=applicable
Patch contains a *Connecting Feature* within a Life Science ANSI	CNF_CR_ANSI	0= Not applicable, 1=applicable
Patch contains a *Connecting Feature* that is within 30m of a watercourse	CNF_CR_Watercourse	0= Not applicable, 1=applicable
Waterbody Criteria		
Patch contains a Waterbody within a valley land	WBY_CR_Valleyland	0= Not applicable, 1=applicable
Patch contains a Waterbody within a Life Science ANSI	WBY_CR_ANSI	0= Not applicable, 1=applicable
Patch contains a Waterbody that is within 30m of a watercourse	WBY_CR_Waterbody	0= Not applicable, 1=applicable
Any Patch or Patch Cluster >100 ha	PTC_INF_GT100	0= Not applicable, 1=applicable

Appendix G. Metadata for *Vegetation Community*

Community_MNHS_24_03_2014-06-30
The community feature class consists of all community features that allow them to be dissolved into individual Groups or create the overall Patch Feature Class. Zero in the field indicates that it is not applicable to the community or group/patch type and 1 indicates that it is applicable.

<table>
<tr><th>Feature Class</th><th>Field Name</th><th>Type</th><th>Parameters</th></tr>
<tr><td>Community_MNHS_24_03_2014</td><td>Community</td><td>Text</td><td>Bluff or Deposition, Coniferous, Deciduous, Hedgerow Connected, Meadow Marsh, Meadow Upland, Mixed, Plantation Mature, Plantation Young, Thicket, Water, Watercourse</td></tr>
<tr><td></td><td>Woodland</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>Wetland</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>Meadow</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>Shrub</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>Patch</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>CA</td><td>Text</td><td>AB, KC, LT, SC, UT</td></tr>
<tr><td></td><td>Comments</td><td>Text</td><td></td></tr>
<tr><td></td><td>Riparian</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>Water</td><td>Short</td><td>0, 1</td></tr>
<tr><td></td><td>Connecting_Features</td><td>Short</td><td>0 , 1</td></tr>
<tr><td></td><td>Group_Type</td><td>Text</td><td>Bluff or Deposition Area, Hedgerow,
Meadow, Meadow and Wetland*, Thicket,
Thicket and Wetland*, Water, Water and Wetland*,
Woodland, Woodland and Wetland*
* included in both groups</td></tr>
<tr><td></td><td>Ecosystem</td><td>Text</td><td>Aquatic, Wetland, Terrestrial Upland</td></tr>
<tr><td></td><td>ELC_CODE</td><td>Text</td><td>Bluff or Deposition Area (BBO),
Connecting Feature (NA),
Meadow (CUM),
Meadow and Wetland (MAM),
Thicket (CUT),
Thicket and Wetland (SWT),
Water (OAO),
<table>
<tr><td>Woodland</td><td>Conifer (FOC), Deciduous (FOD),
Mixed (FOM),
Mature Plantation (CUT)</td></tr>
<tr><td>Woodland and Wetland</td><td>Conifer Swamp (SWC),
Deciduous Swamp (SWD),
Mixed Swamp (SWM)
Plantation Swamp (CUT)</td></tr>
</table>
</td></tr>
</table>

Group Woodland_02_21_2014

This feature class was created by exporting woodlands from the Community_MNHS_24_03_2014-06-30 feature class. Using values equal to one in the Woodland field, data was exported to a new feature class and all communities were dissolved using the Woodlands field equal to one to create a seamless polygon woodlands feature class. The woodlands less than 0.5 ha were then deleted using the Shape Area Field to create the Group Woodlands_02-21_2014 feature class. This feature class was then used to establish the Woodland Cluster Feature Class (see below) and perform the interior forest calculation.

Zero in the field indicates that it is not applicable to the Information being provided and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group Woodland_02_21_2014	WDL_Unique	Short	Unique Value
	WDL_Cluster	Short	Woodland Cluster Value
	INF_WDL_Interior	Short	0, 1

Group _Woodland_Cluster_02_21_2014

This feature class was created from the Group_Woodland_02_21_2014 Feature Class. The values in the MDW_Cluster field were merged to create multipart features which act as a single woodland polygon.

This feature class support the criteria information for the woodland group.

Zero in the field indicates that it is not applicable to criteria or information and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Woodland_Cluster_02_21_2014	MDW_Cluster	Short	Unique Value
	MDW_CR_Valleyland	Short	0, 1
	MDW_CR_ANSI	Short	0, 1
	MDW_CR_Watercourse	Short	0, 1
	MDW_CR_GT_4ha	Short	0, 1
	MDW_CR_GT_100m_4ha	Short	0, 1
	MDW_INF_Wetland	Short	0, 1
	MDW_INF_Interior	Short	0, 1
	MDW_CR_Total	Short	0 to 5

Group Meadow_02_21_2014
This feature class was created by exporting meadows from the Community_MNHS_24_03_2014-06-30 Feature Class. Using values equal to one in the Meadow field, data was exported to a new feature class and all communities were dissolved using the Meadow field equal to one to create a seamless polygon meadow feature class. The Meadows less than 0.5 ha were then deleted using the Shape Area Field to create the Group_Meadow_02-21_2014 Feature Class. This feature class was then used to establish the Meadow Cluster Feature Class (see below).

Feature Class	Field Name	Type	Parameters
	MDW_Unique	Short	Unique Value
	MDW_Cluster	Short	Meadow Cluster Value

Group _Meadow_Cluster_02_21_2014
This feature class was created from the Group_Meadow_02_21_2014 feature class. The values in the MDW_Cluster field were merged to create multipart features which act as a single meadow polygon.
This feature class support the criteria information for the meadow group.
Zero in the field indicates that it is not applicable to criteria or information and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Meadow_Cluster_02_21_2014	MDW_Cluster	Short	Unique Value
	MDW_CR_Valleyland	Short	0, 1
	MDW_CR_ANSI	Short	0, 1
	MDW_CR_Watercourse	Short	0, 1
	MDW_CR_GT_10ha	Short	0, 1
	MDW_CR_Proximity	Short	0, 1
	MDW_INF_Wetland	Short	0, 1
	MDW_CR_Total	Short	0 - 5

Group Thicket_02_21_2014
This feature class was created by exporting Thickets from the Community_MNHS_24_03_2014-06-30 feature class. Using values equal to one in the Thicket field, data was exported to a new feature class and all communities were dissolved using the Thicket field equal to one to create a seamless polygon Thicket Feature Class. The Thickets less than 0.5 ha were then deleted using the Shape Area Field to create the Group_Thicket_02-21_2014 Feature Class. This feature class was then used to establish the Thicket Cluster Feature Class (see below).

Feature Class	Field Name	Type	Parameters
	THK_Unique	Short	Unique Value
	THK_Cluster	Short	Thicket Cluster Value

Group _Thicket_Cluster_02_21_2014

This feature class was created from the Group_Thicket_02_21_2014 feature class. The values in the THK_Cluster field were merged to create multipart features which act as a single Thicket polygon. This feature class support the criteria information for the Thicket group.

Zero in the field indicates that it is not applicable to criteria or information and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Woodland_Cluster_02_21_2014	THK_Cluster	Short	Unique Value
	THK_CR_Valleyland	Short	0, 1
	THK_CR_ANSI	Short	0, 1
	THK_CR_Watercourse	Short	0, 1
	THK_CR_GT_2ha	Short	0, 1
	THK_INF_Wetland	Short	0, 1
	THK_CR_Total	Short	0 - 5

Group Wetland_02_21_2014_all

This feature class was created by exporting Wetlands from the Community_MNHS_24_03_2014-06-30 Feature Class. Using values equal to one in the Wetland field, data was exported to a new feature class and all communities were dissolved using the Wetland field equal to one to create a seamless polygon Wetland feature class. All wetlands that were identified are included in this layer. The CR_Wetland field identifies wetlands that are used to be identified as significant (greater than 0.5 ha or evaluated), where zero in the field indicates that it is not applicable and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group Wetland_02_21_2014_all	CR_Wetland	Short	0, 1

Group Wetland_02_21_2014

This feature class was created from the Group Wetland_02_21_2014_all feature class. The values equal to 1 in the CR_Wetland field were selected and features were exported to a new layer Group Wetland_02_21_2014.

This feature class supports the criteria information for the wetland group.

Zero in the field indicates that it is not applicable to criteria or information and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Wetland	WTL_CR_Valleyland	Short	0, 1
	WTL_CR_ANSI	Short	0, 1
	WTL_CR_Watercourse	Short	0, 1
	WTL_CR_Wetland	Short	0, 1
	WTL_CR_Total	Short	1 to 4

Group Connecting Features all

This Feature Class was created by exporting Connecting Features from the Community_MNHS_24_03_2014 Feature Class. Using values equal to one in the Connecting Featues field, data was exported to a new Feature Class and all communities were dissolved using the Connecting_Features field equal to one to create a seamless polygon Group_Connecting_Features_all, Feature Class.

Feature Class	Field Name	Type	Parameters
roup_Connecting_Features_all	Connecting_Feature	Short	0, 1

Group Connecting Features

This feature class was created from the Group_Connecting_Feature_all,feature class. The values >0.5ha in shape field were exported to a new feature class.
This feature class support the criteria information for the Connecting_Feature group.
Zero in the field indicates that it is not applicable to criteria or information and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Connecting_Features	CNF_CR_Valleyland	Short	0, 1
	CNF_CR_ANSI	Short	0, 1
	CNF_CR_Watercourse	Short	0, 1
	CNF_INF_Wetland	Short	0, 1
	CNF_CR_Total	Short	0 - 3

Group_Waterbody_04-04_2014_all

This feature class was created by exporting Group_Waterbody_21_2014_all from the Community_MNHS_24_03_2014-06-30 Feature Class. Using values equal to one in the Water field, data was exported to a new Feature Class and all communities were dissolved using the Water field equal to one to create a seamless polygon Waterbody feature class.
Zero in the field indicates that it is not applicable to the Information being provided and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Waterbody_04-04_2014_all	Water	Short	0, 1

Group _Waterbody_04_04_2014

This feature class was created from the Group_Waterbody_04-04_2014_all feature class. The values in the >0.5ha in shape field were exported to a new feature class.
This feature class support the criteria information for the Waterbody group.
Zero in the field indicates that it is not applicable to criteria or information and 1 indicates that it is applicable.

Feature Class	Field Name	Type	Parameters
Group_Woodland_Cluster_02_21_2014	WBY_CR_Valleyland	Short	0, 1
	WBY_CR_ANSI	Short	0, 1
	WBY_CR_Watercourse	Short	0, 1
	WBY_CR_Total	Short	0 to 3

Valleylands_02_21_2014

Valley Land data was created according to description in report. This layer represent the major valley areas within the County.

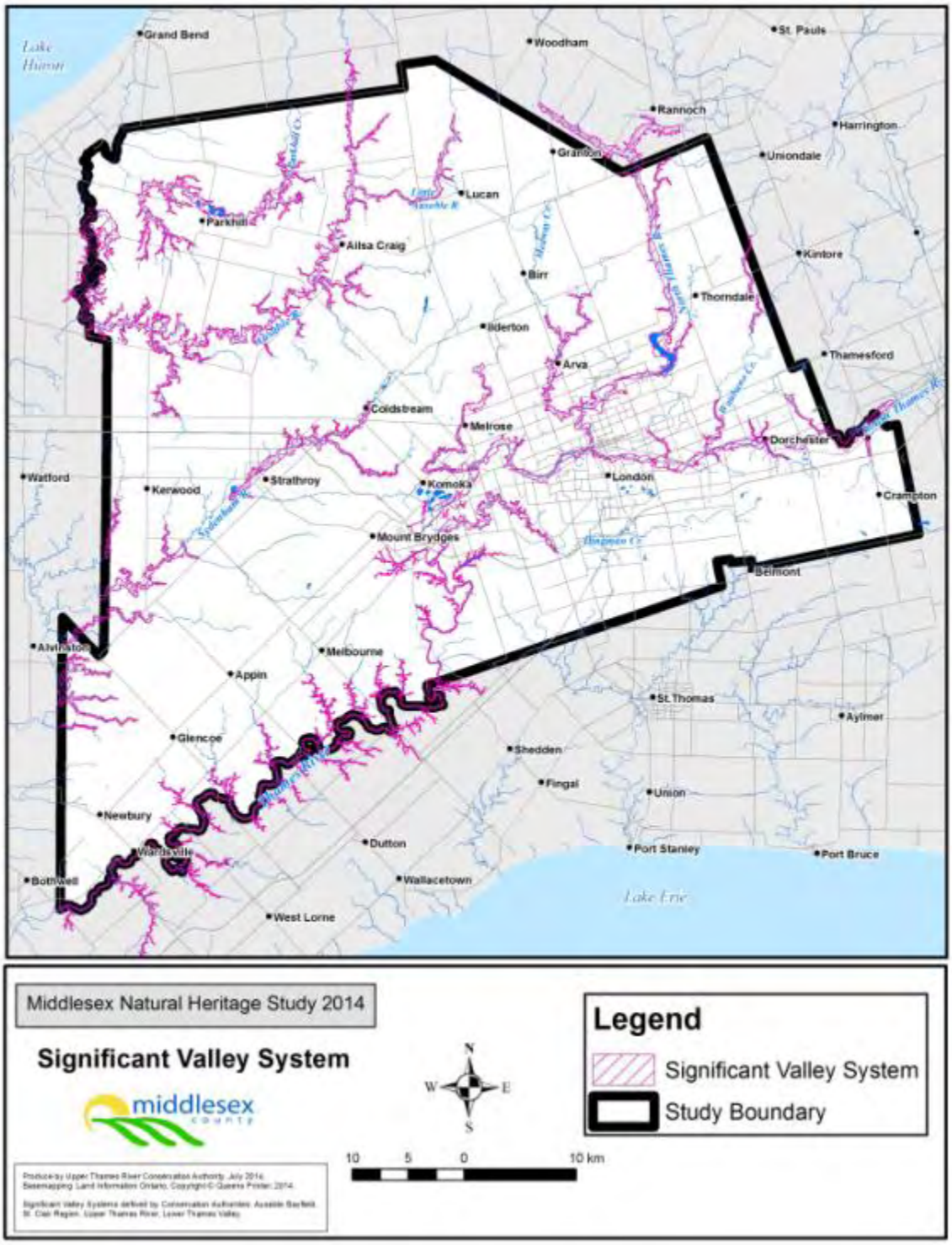
Feature Class	Field Name	Type	Parameters
Valleylands_02_21_2014	CA	Text	AB, UT, LT, SC

Appendix H. Results of significance modeling at the *Vegetation Group* Level

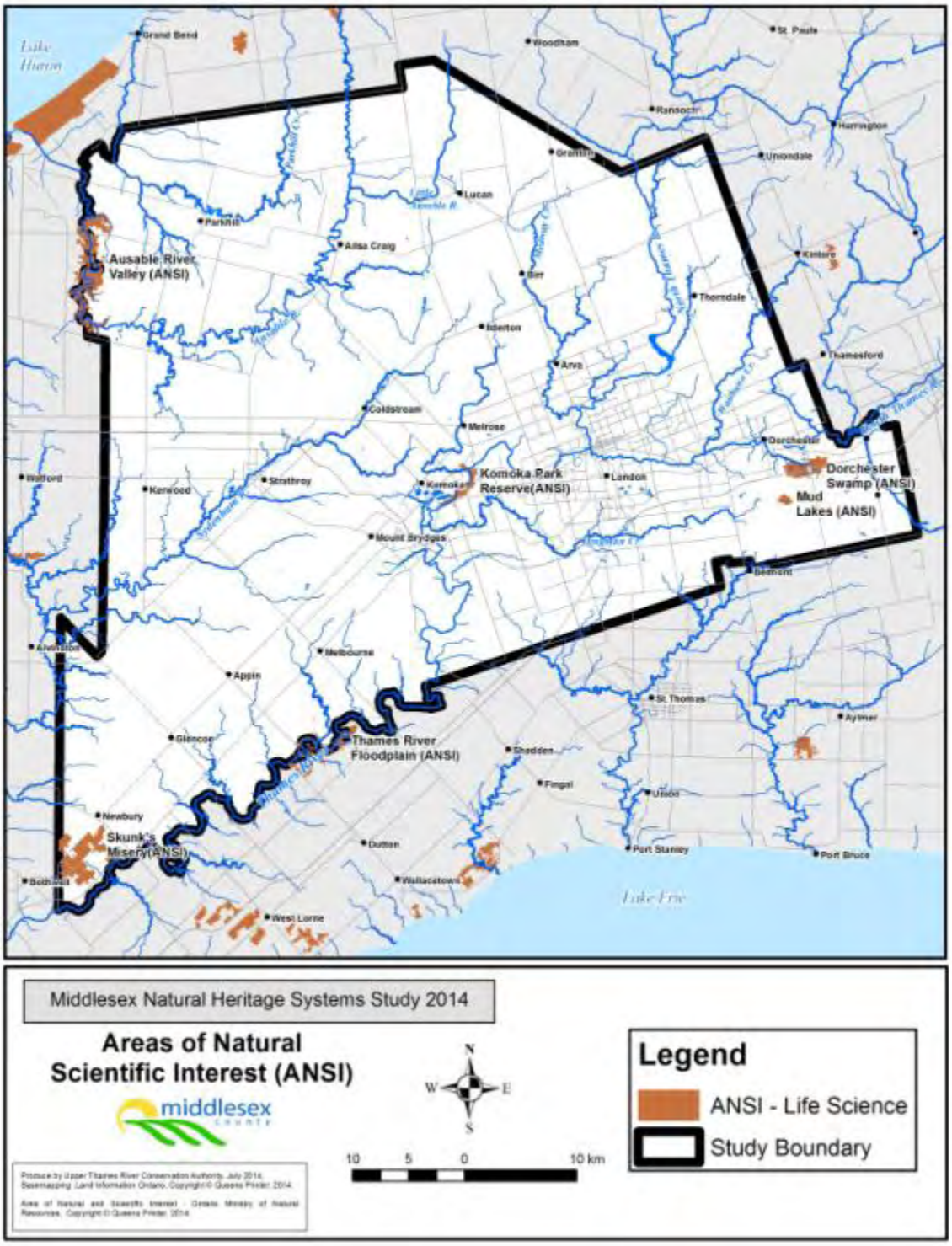
	Number of *Vegetation Groups*			Area of *Vegetation Groups*			% of Study Area (333,330 ha) that is Significant
Vegetation Group ↓	**Number**	**Number that are Significant**	**% Significant**	**Area (ha)**	**Area Significant (ha)**	**% Significant**	
Woodland	4,123	**3,200**	77.6%	52,748	**51,200**	97.1%	15.4%
Meadow	3,040	**2,785**	91.6%	8,319	**7,925**	95.3%	2.4%
Thicket	1,365	**999**	73.2%	3,205	**2,830**	88.3%	1.0%
Water Feature	284	**156**	54.9%	2,205	**1,756**	79.6%	0.7%
Connected Vegetation Feature	124	**94**	75.8%	97	**78**	80.4%	<0.1%
Total	**8936**	**7234**		**66,574**	**63,789**		**19.1%**
Wetland	1,919	**1,919**	100.0%	11,729	11,729	100.0%	3.5%

Note: Wetlands include woodland meadow and thicket and so are part of the total instead of being additional

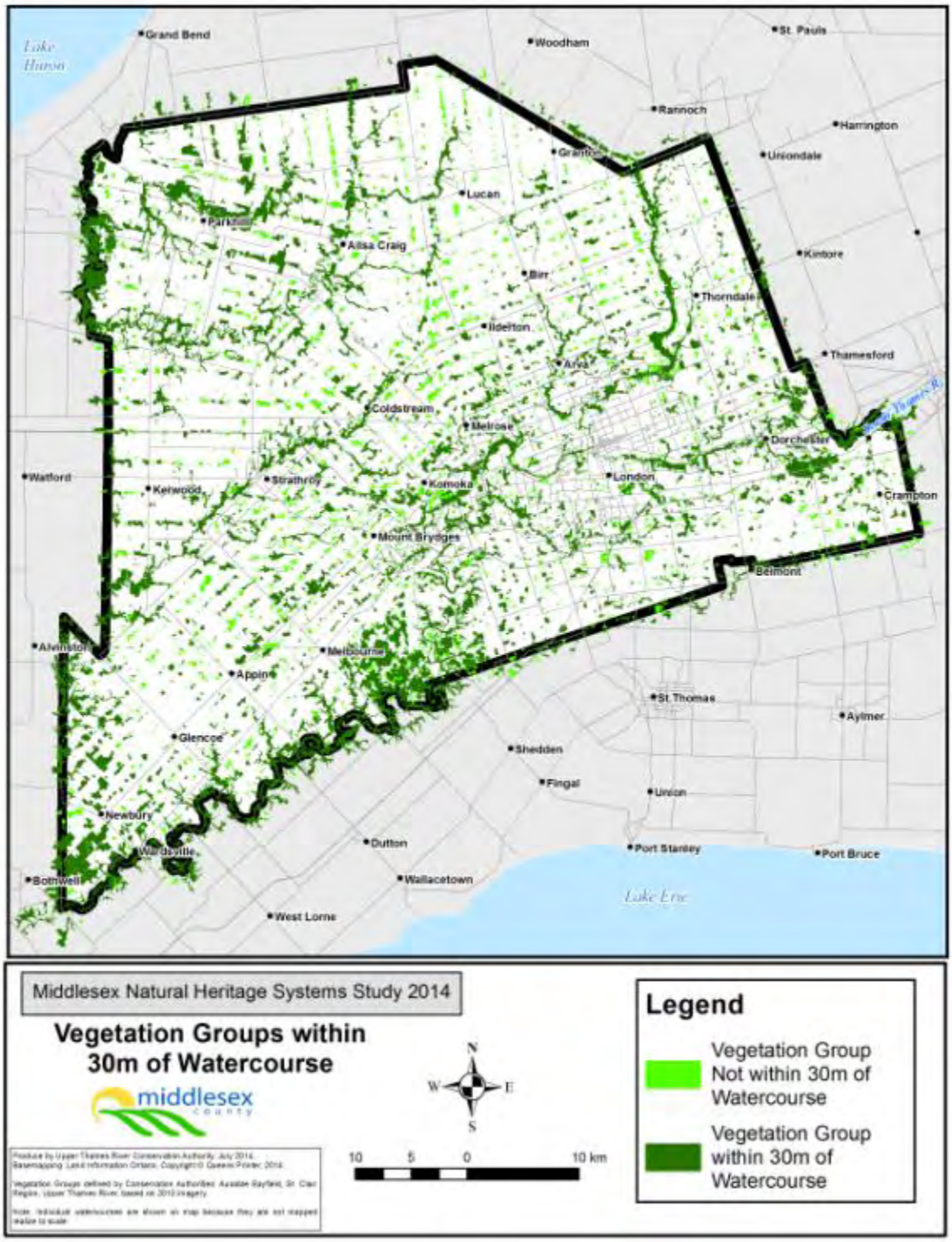
Appendix I-1. Criteria 1 Map, Significant Valley Systems



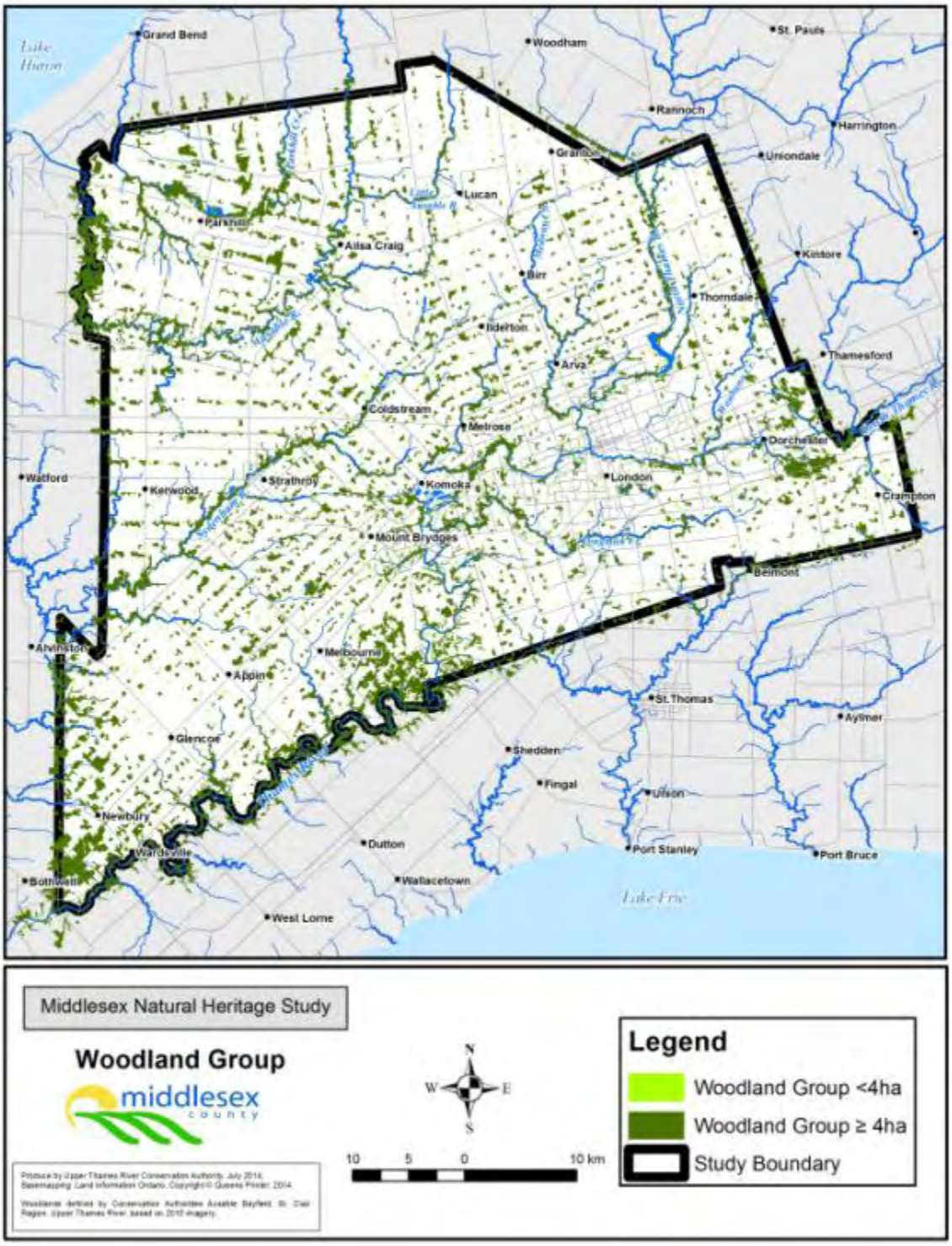
Appendix I-2. Criteria 2 Map, ANSIs.



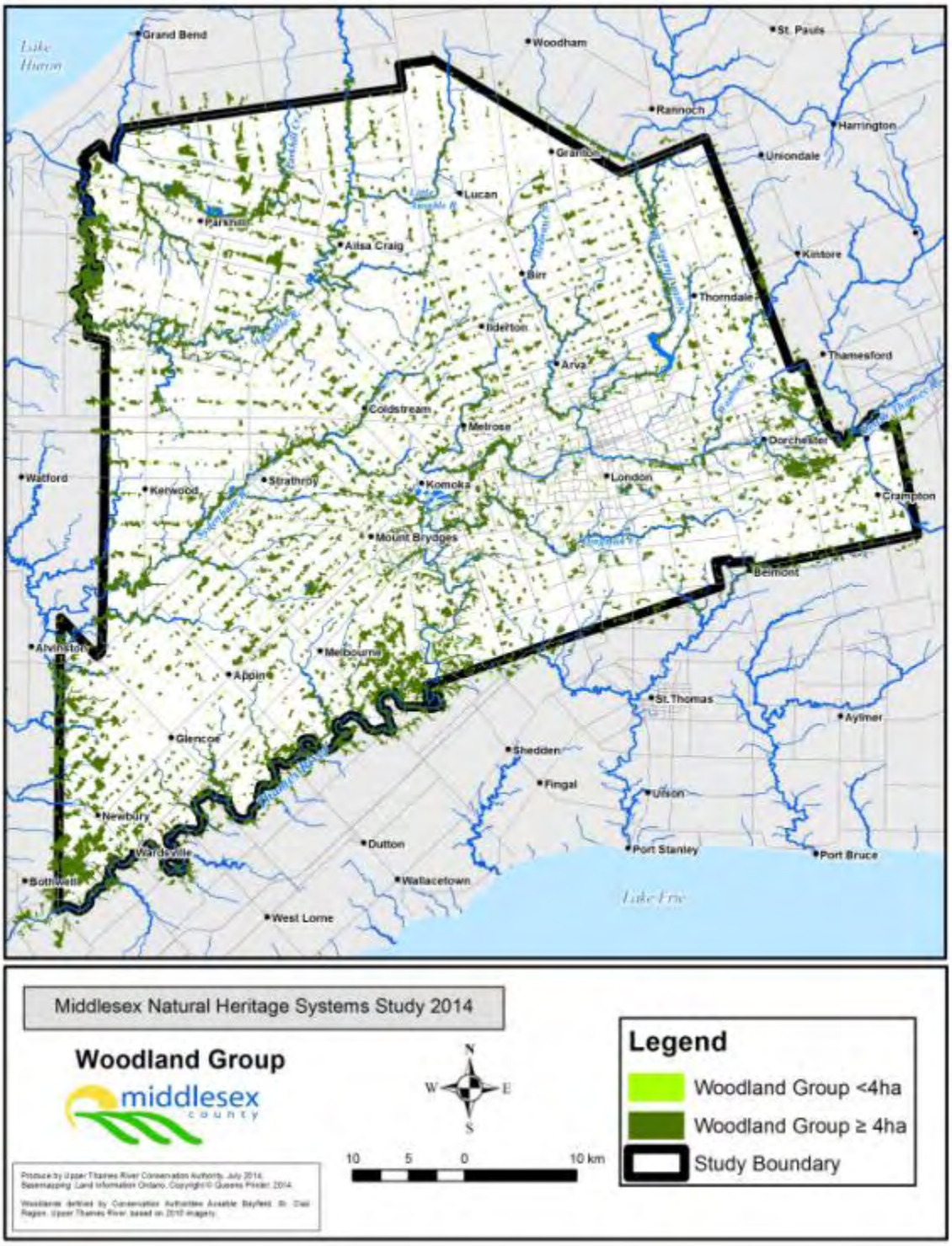
Appendix I-3. Vegetation Groups Within 30 m of an Open Watercourse



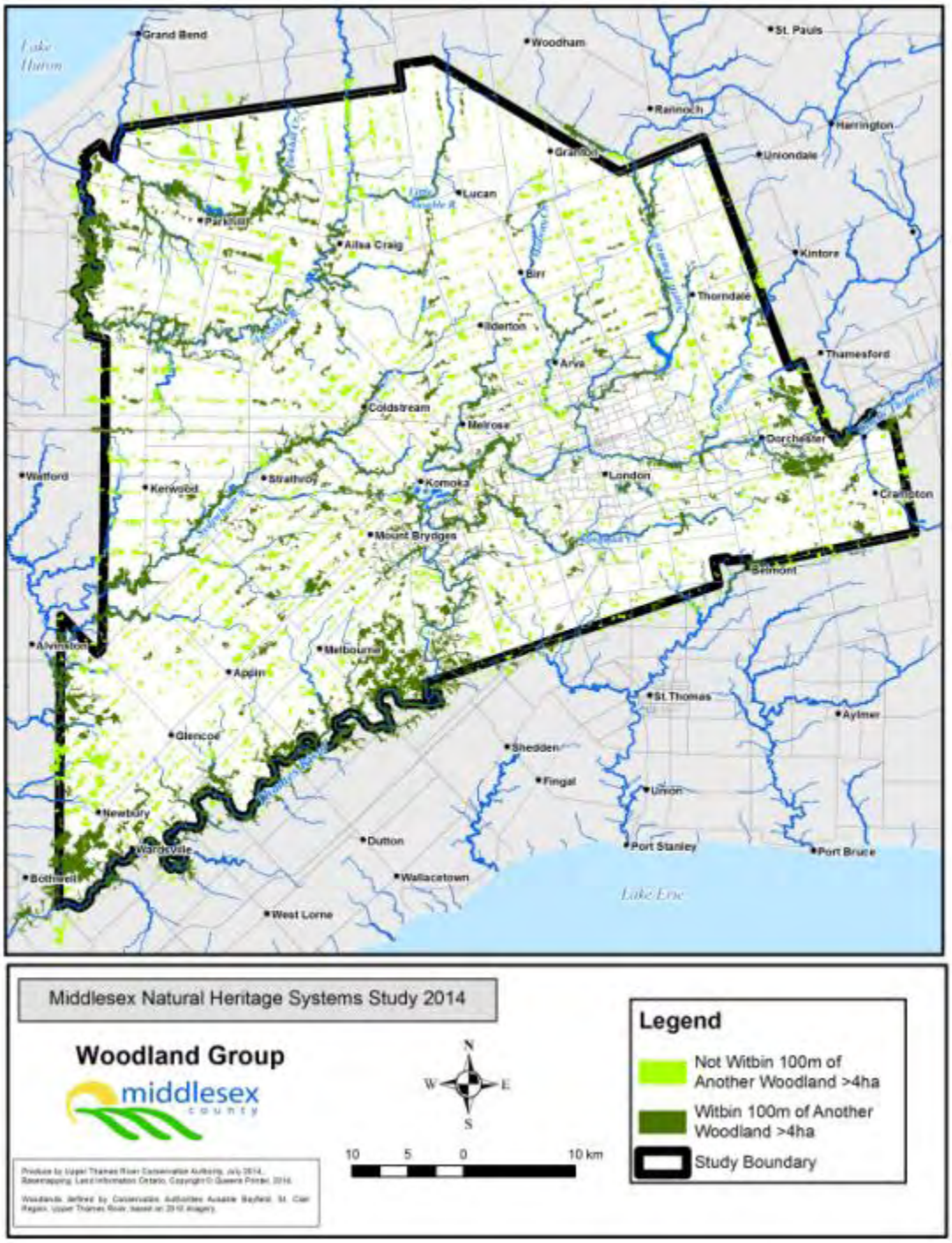
Appendix I-4. Criterion 4 Map, Wetlands



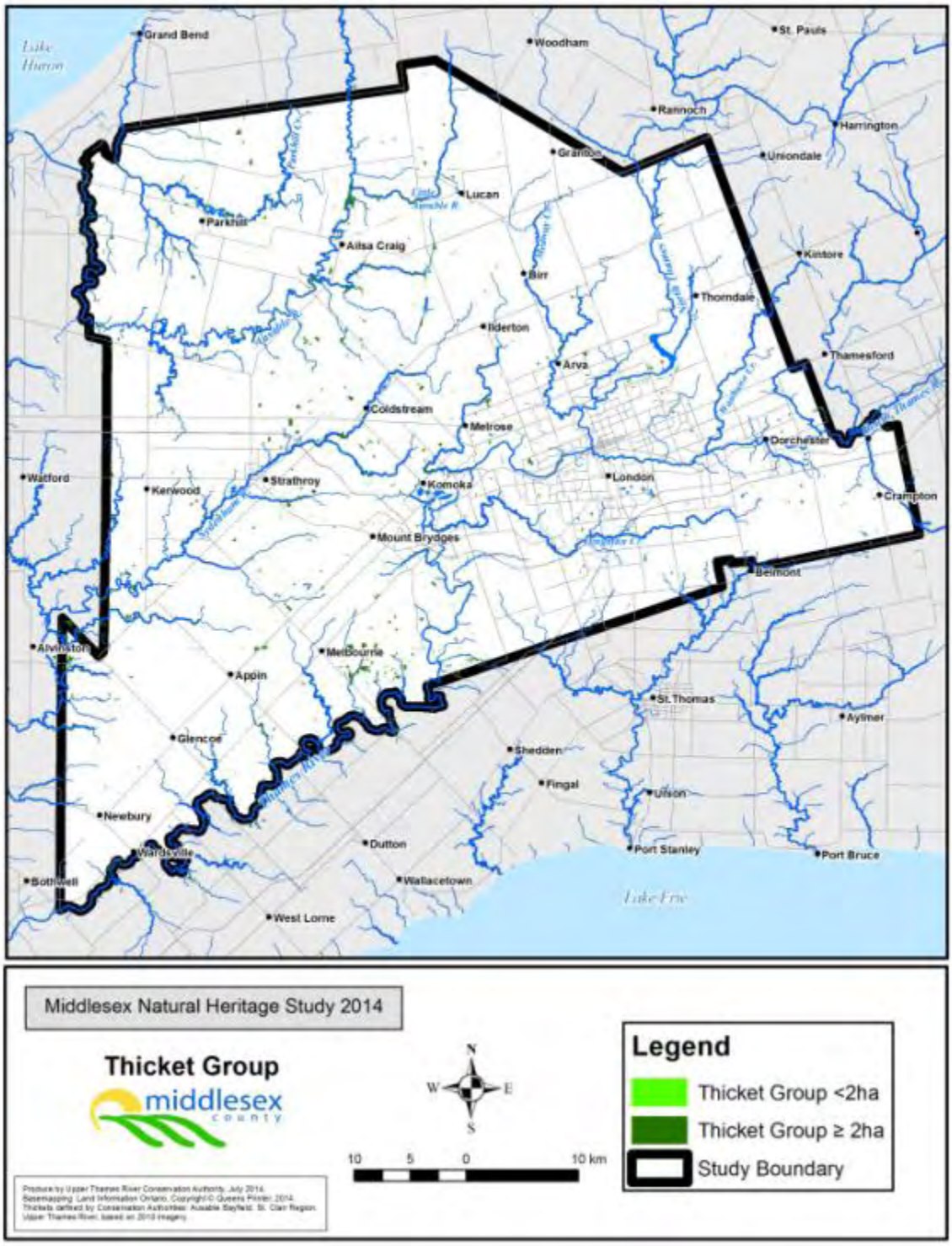
Appendix I-5. Criterion 5 Map, Woodland Size ≥4 ha



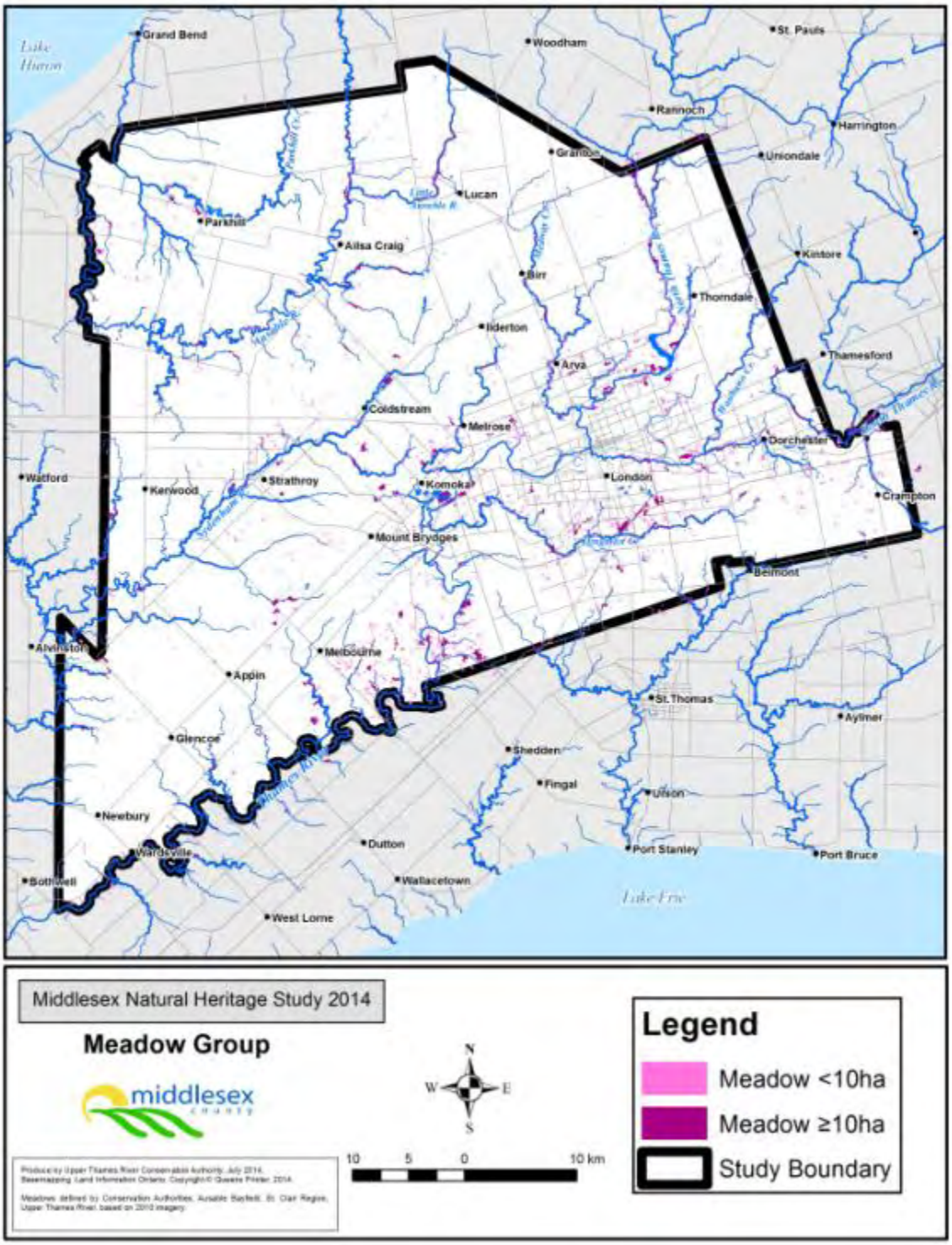
Appendix I-6. Criterion 6 Map, Woodland proximity



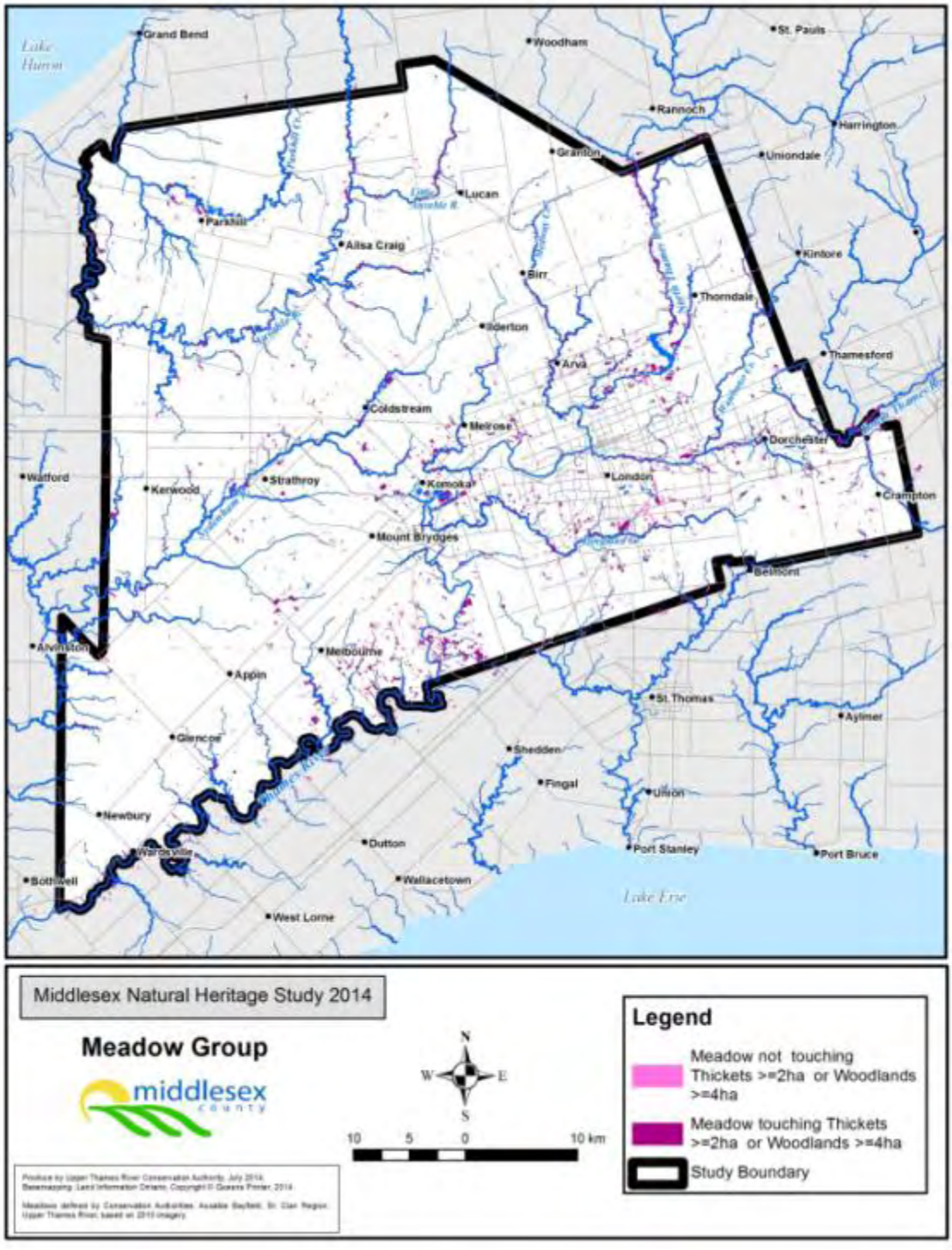
Appendix I-7. Criterion 7 Map, Thicket Size ≥2 ha



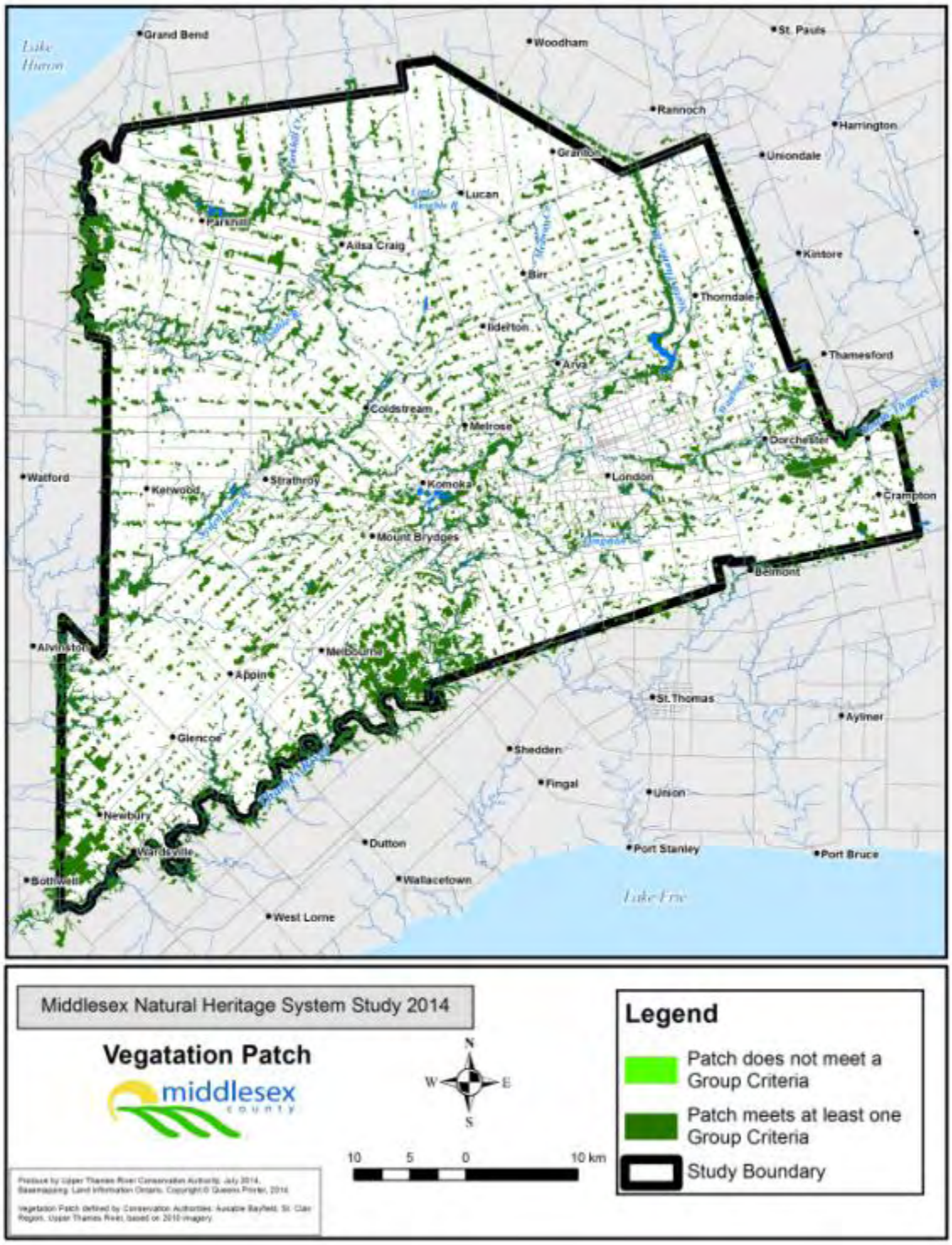
Appendix I-8. Criterion 8 Map, Meadow Size ≥10 ha



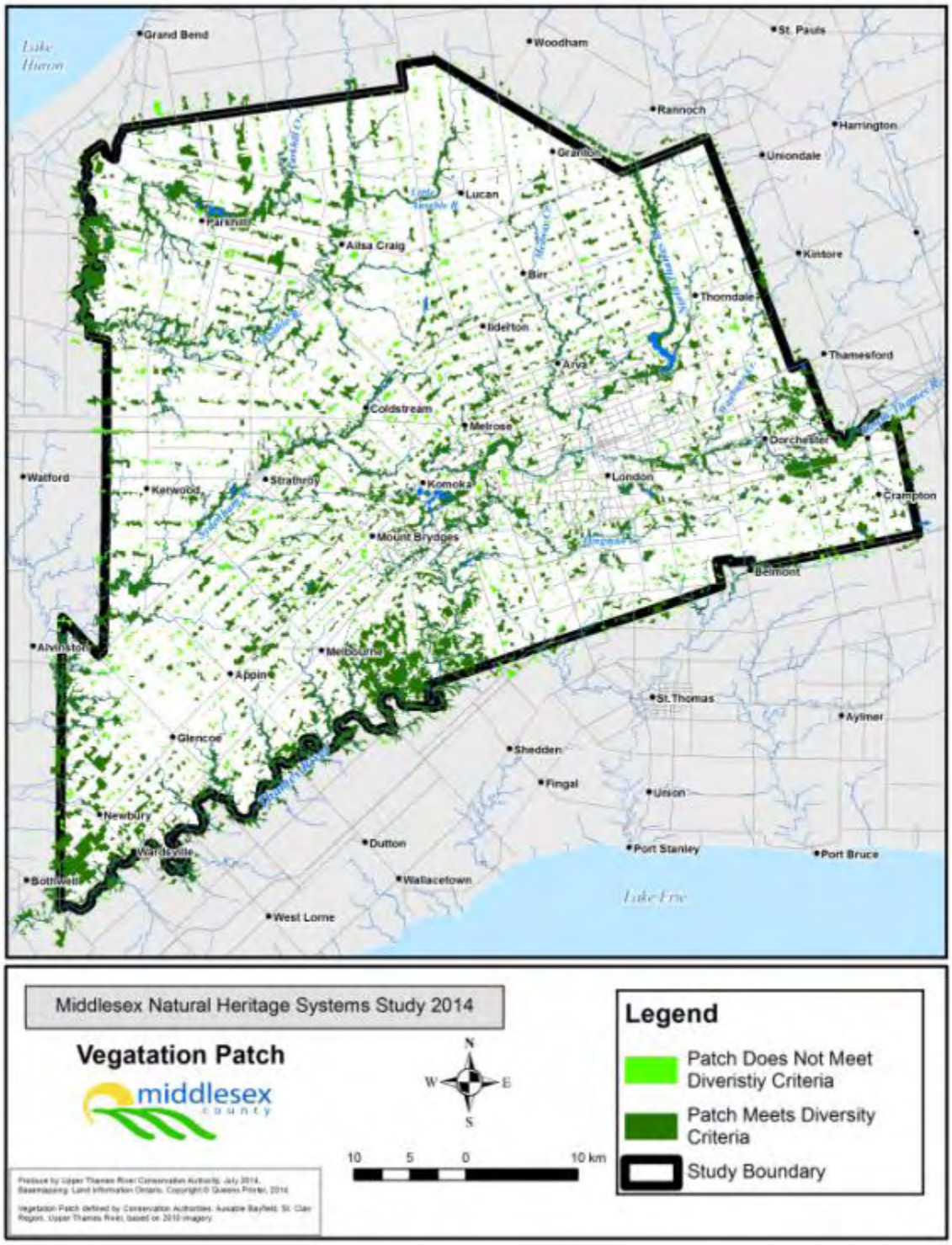
Appendix I-9. Criterion 9 Map, Meadow Proximity



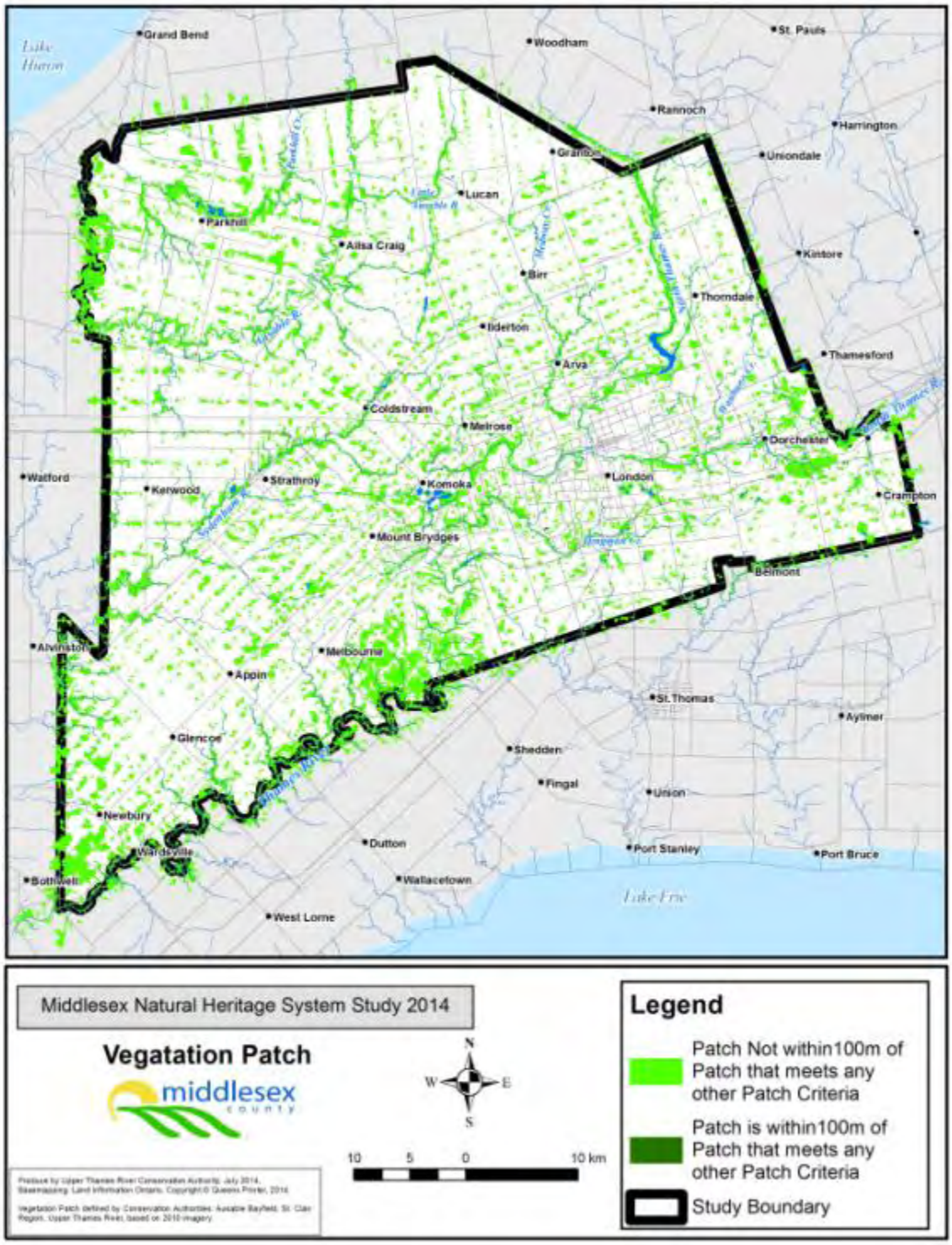
Appendix I-10. Criterion 10 Map, Patches that meet a Group Criteria



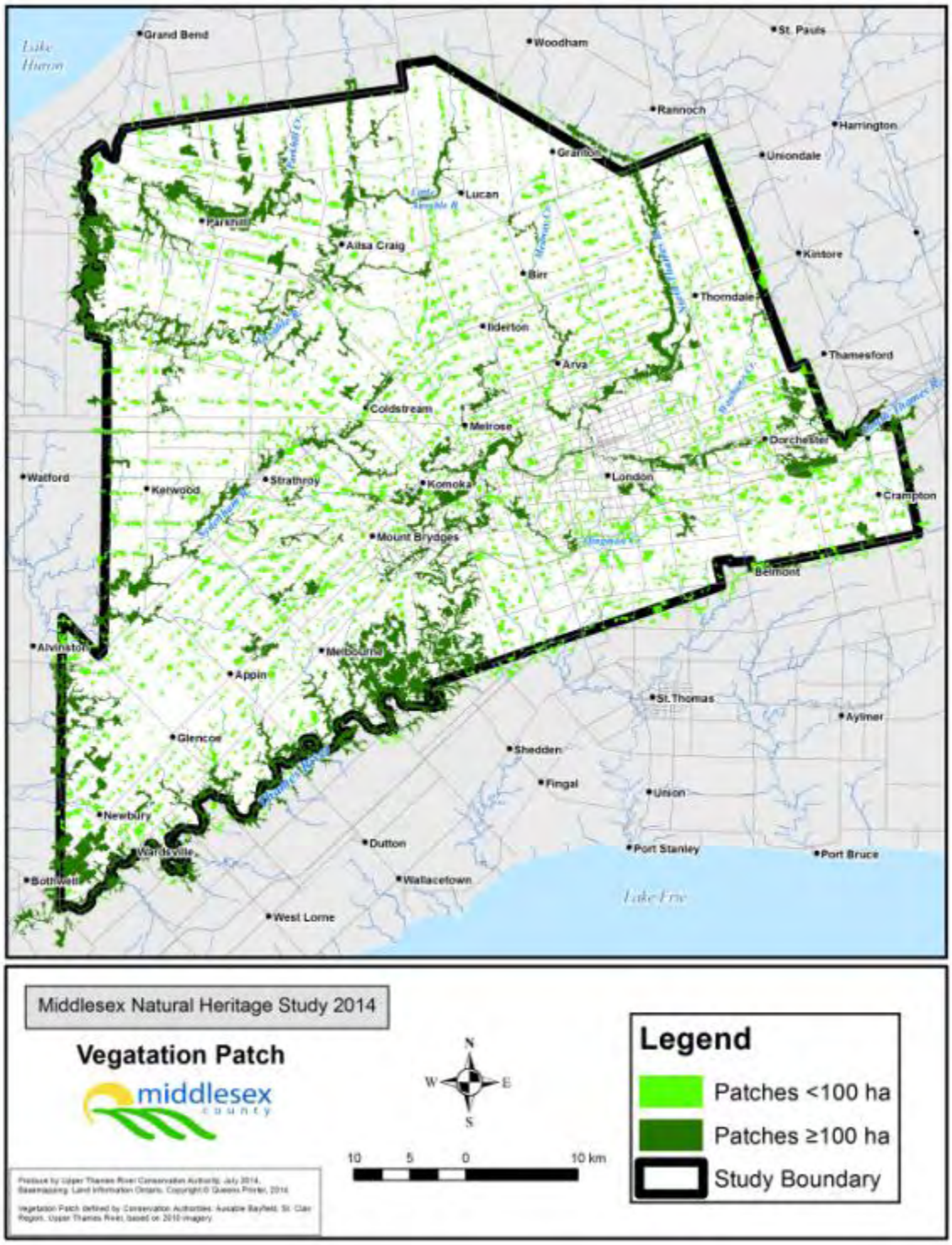
Appendix I-11. Criterion 11 Map, Diversity



Appendix I-12. Criterion 12 Map, Proximity



Appendix J-1. Patches 100 ha or larger



Appendix J-2. Map showing patches with woodland interior