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, as 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 because 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.

Site level analysis (i.e., biological inventory) is not feasible at a county level. Therefore, 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. Appendix D provides a more detailed summary table that includes rationale and a list of other studies that have used the criteria.

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 Patch*. Three criteria are applied to the *Vegetation Group*, but the information is not currently mapped. Therefore, while there are 15 criteria, only 12 were run in the model as three are not currently mapped. These significance criteria are the test of PPS.

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 as 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 all 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 (≥4 ha) Woodland or ≥2ha 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* (i.e., meets Criteria 10 or 11 above)
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 <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 <0.5 ha. 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.

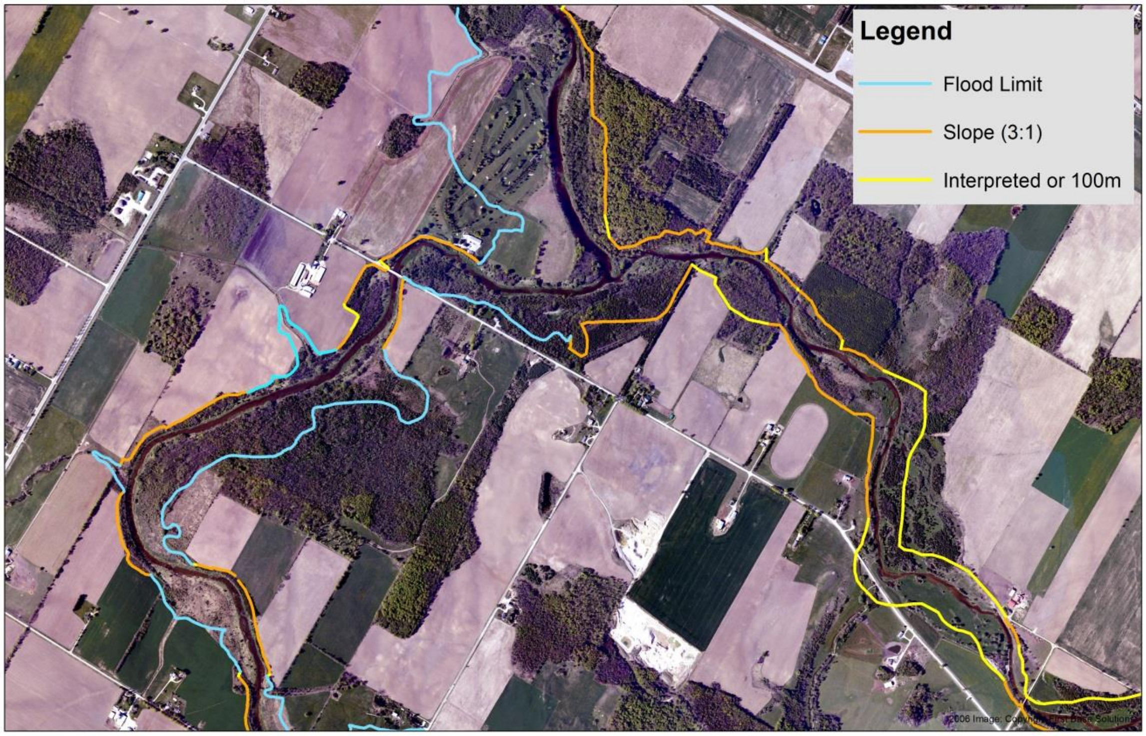
Permanent vegetation on valley lands improves water holding capacity and reduces river erosion. Actively eroding valleys have unstable slopes with little or no vegetation cover. As they erode, valleys deepen, widen and land area is lost. Valley land erosion is exacerbated by human activity. Excess weight 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.

Figure 6. Criterion 1, illustration of Significant Valley System boundary delineation using flood limit, steep slope and 100 m from watercourse edge



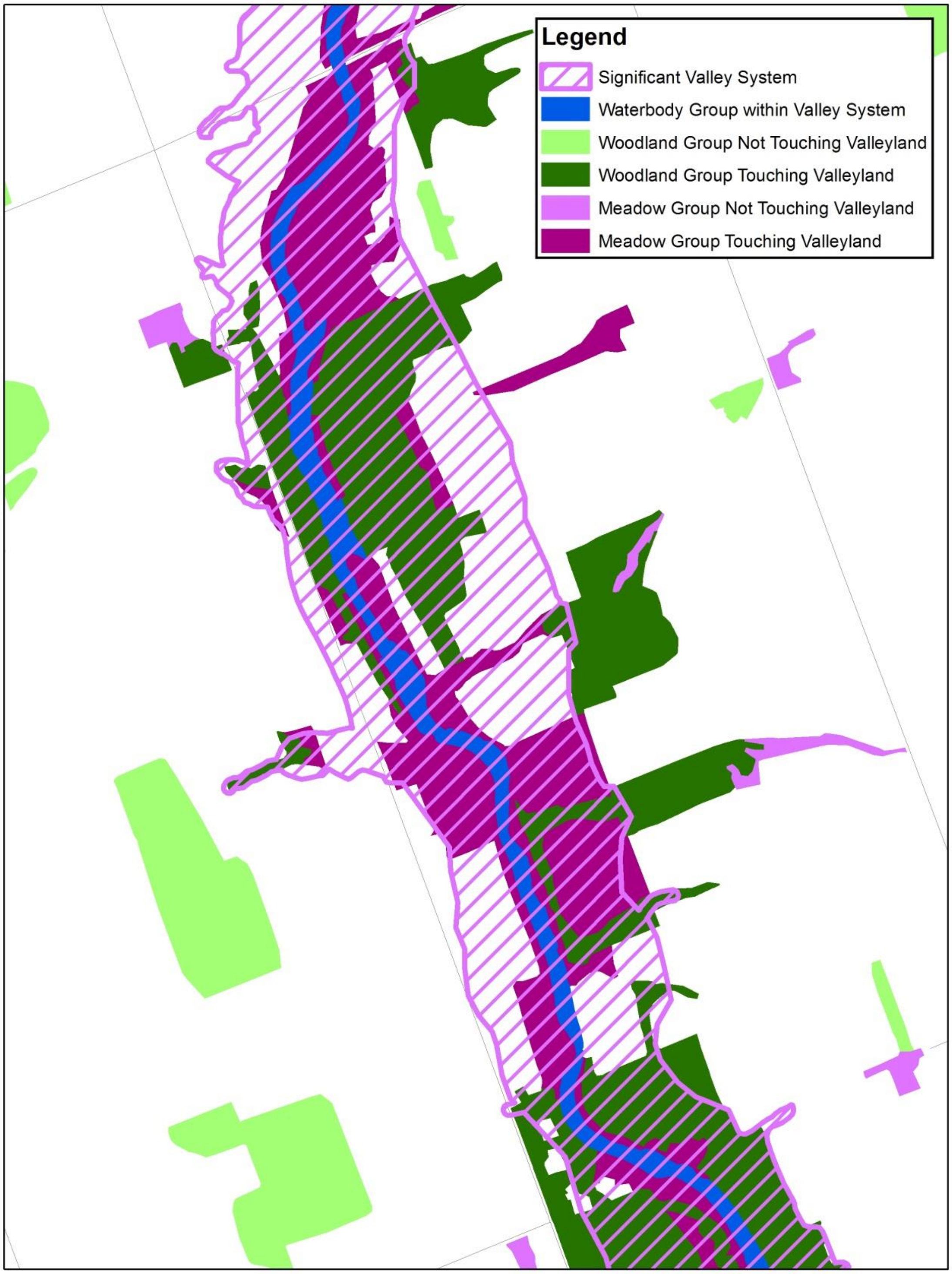
For well-defined valleys, the following components of the Conservation Authority riverine erosion and flooding hazards boundaries were used to identify the stable top of bank (top of slope):

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 centre line 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 (see Figure 7).

Figure 7. Criterion 1, illustration showing *Vegetation Groups* on or touching a 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 Criterion 1, accounting for 41.7% 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 Criterion 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 publicly 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 or those touching the ANSI meet Criterion 2 (see 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.

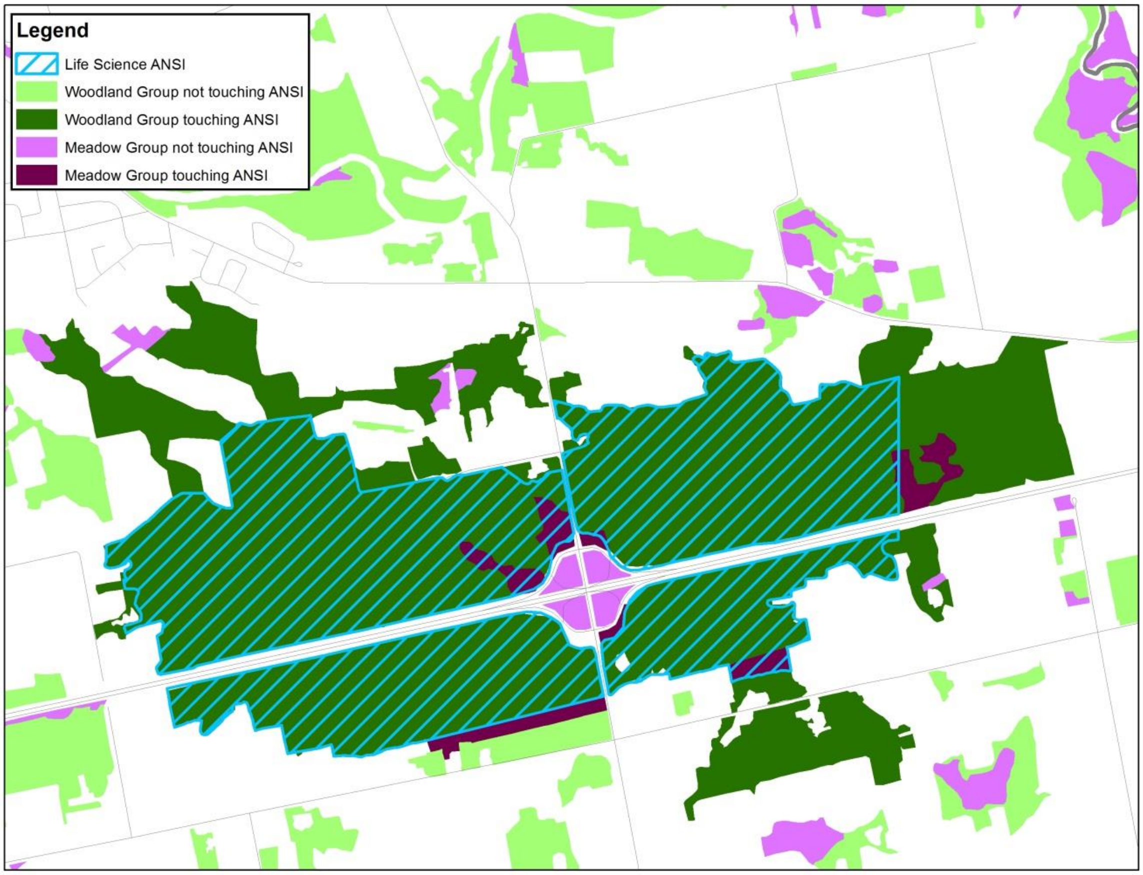
Results

Table 11 below summarizes the mapping results for Criterion 2. Not surprisingly, only a small number of *Vegetation Groups* (142) meet Criterion 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* within or touching 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 Vegetation 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 as 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 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. Permanent vegetation near waterways protects water quality by reducing 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 m 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 within 30 m from the edge.

Terrestrial *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* meet this criterion.

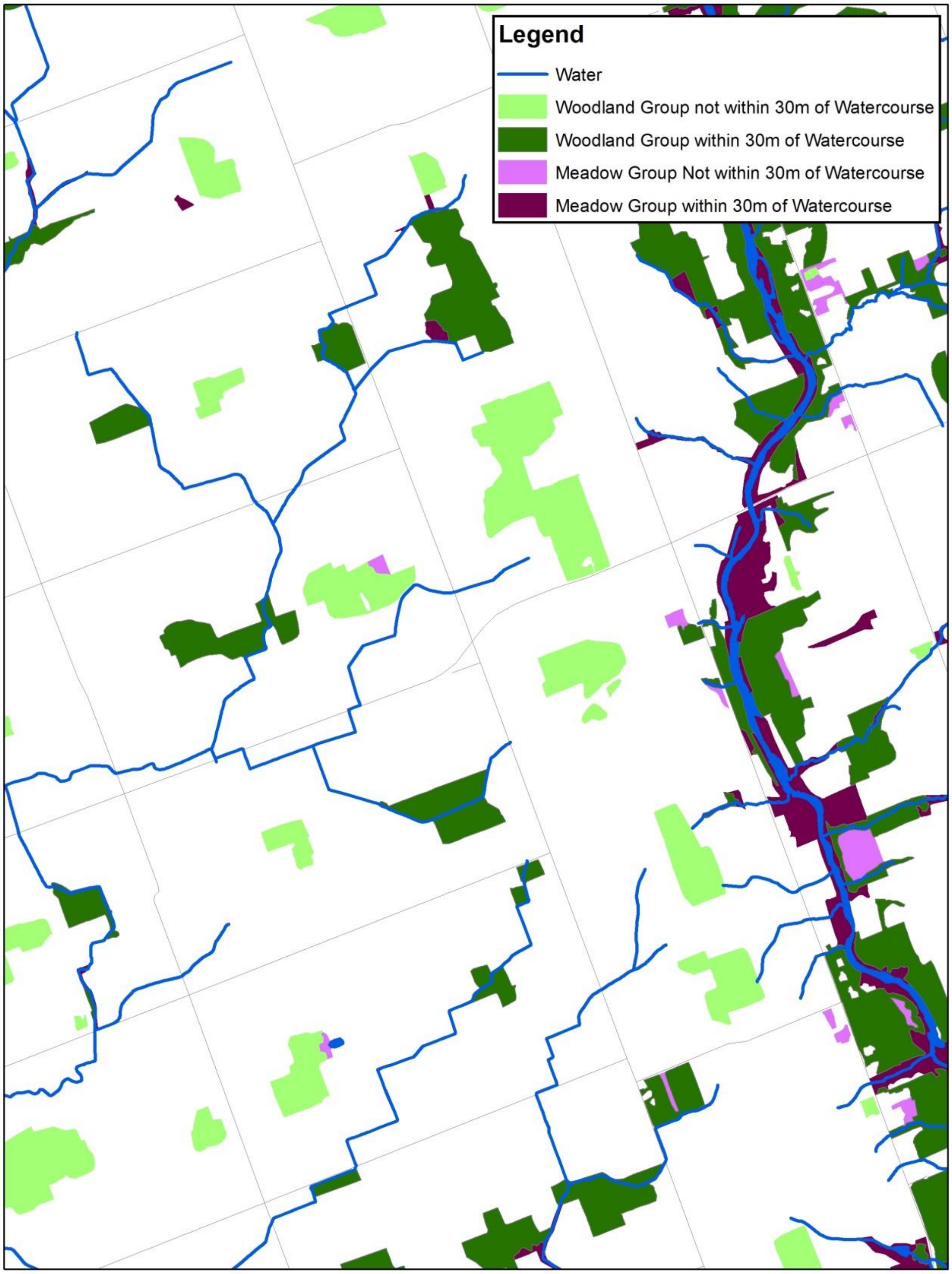
Results

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 much of the natural areas on the landscape are near a watercourse because the land is harder to farm or develop and because 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 <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% 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 favourable 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 water tolerant plants (herbaceous and woody) 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 *Vegetation 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 6-10% wetland cover recommendation of Environment Canada (2013).

Table 13. Criterion 4 Results -- *Vegetation Groups* that contain wetland *Vegetation 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 woodlands 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 woodland can be relatively small. Studies indicate that smaller woodlands (<10 ha) can be considered significant and worth 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 1-4 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. Slightly fewer than half the woodland *Vegetation Groups* (1,924 of 4,123) met this criterion but account for almost 93% of the woodland area. Thus, the remaining woodland *Vegetation 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 large 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 140 m 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.

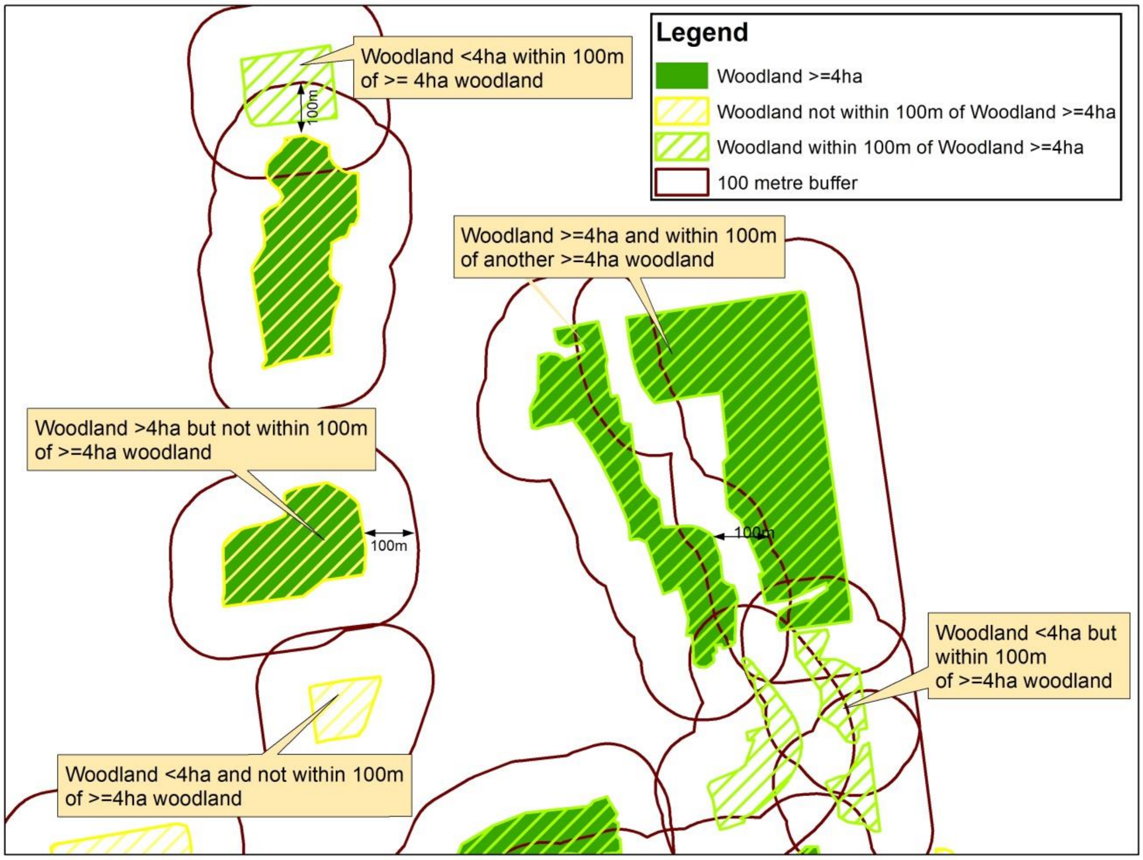
Results

The findings are shown in Table 15 and in Appendix I-6. Over a third (37.6%) of all the woodland *Vegetation Groups* are within 100 m of a woodland *Vegetation Group* ≥4 ha, amounting to 60% of all woodland area. Of the 1550 woodland *Vegetation 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 *Vegetation Group* within 100 m of a Woodland *Vegetation Group* ≥4ha	1,550	37.6 %	31,528	60.0%	9.5 %
Woodland *Vegetation 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 Vegetation 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 and 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 because 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. Thicket habitats 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 criterion. 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. However, they do account for 28% of the meadow area, a very large amount. Of the 135 meadow *Vegetation Groups* that meet the criterion, only two meet this criterion alone, thus the vast majority meet other criteria as well. The map in Appendix I-8 shows the meadows that meet this criterion.

Table 17. Criterion 8 results ─ 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 U.S. Department of Agriculture (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 the 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 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 (≥4 ha) woodland *Vegetation Group* (see Criterion 6) or large (≥2 ha) thicket *Vegetation Group* (see Criterion 7) 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 relatively 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. Criterion 9 results ─ meadow *Vegetation Groups* within 100 m of a large 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 (≥4 ha) woodland or large (≥2 ha) 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 Criterion

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 *Vegetation Group* criteria 1-9 and 13-15 into a single *Vegetation 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 criterion (i.e., Criterion 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 met 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. Criterion 10 results – *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 Criterion**	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* Containing 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*.

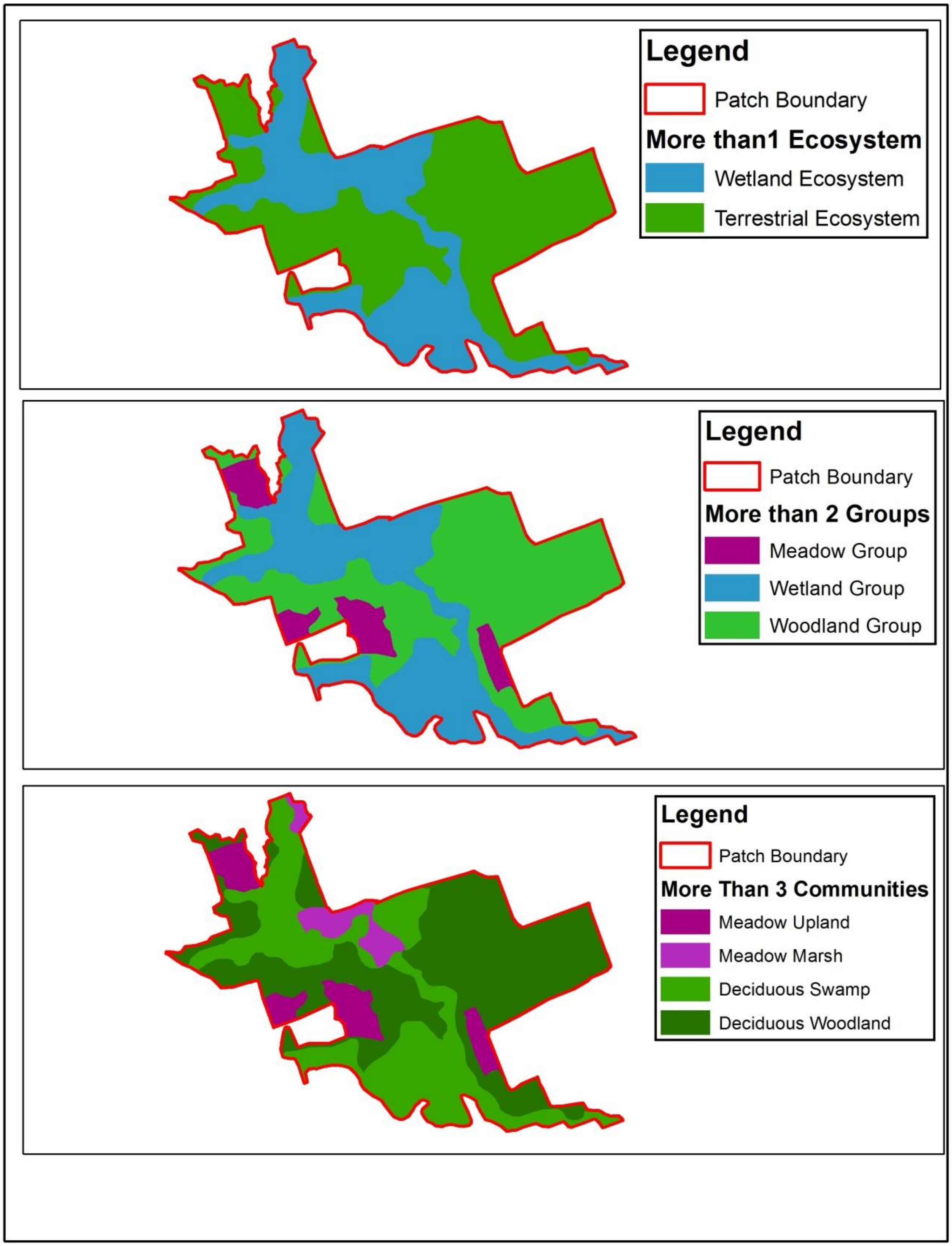
Results

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. Criterion 11 results ─*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 Vegetation Ecosystem and/or** **> 2 Vegetation Groups and/or** **> 3 Vegetation 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 do not meet a criterion but are within 100 m of a *Vegetation Patch* that does meet a criterion, meet Criterion 12. 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 many 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. Criterion 12 results ─*Vegetation Patch* 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 100 m 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 does not 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).

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. 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 narrow 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.

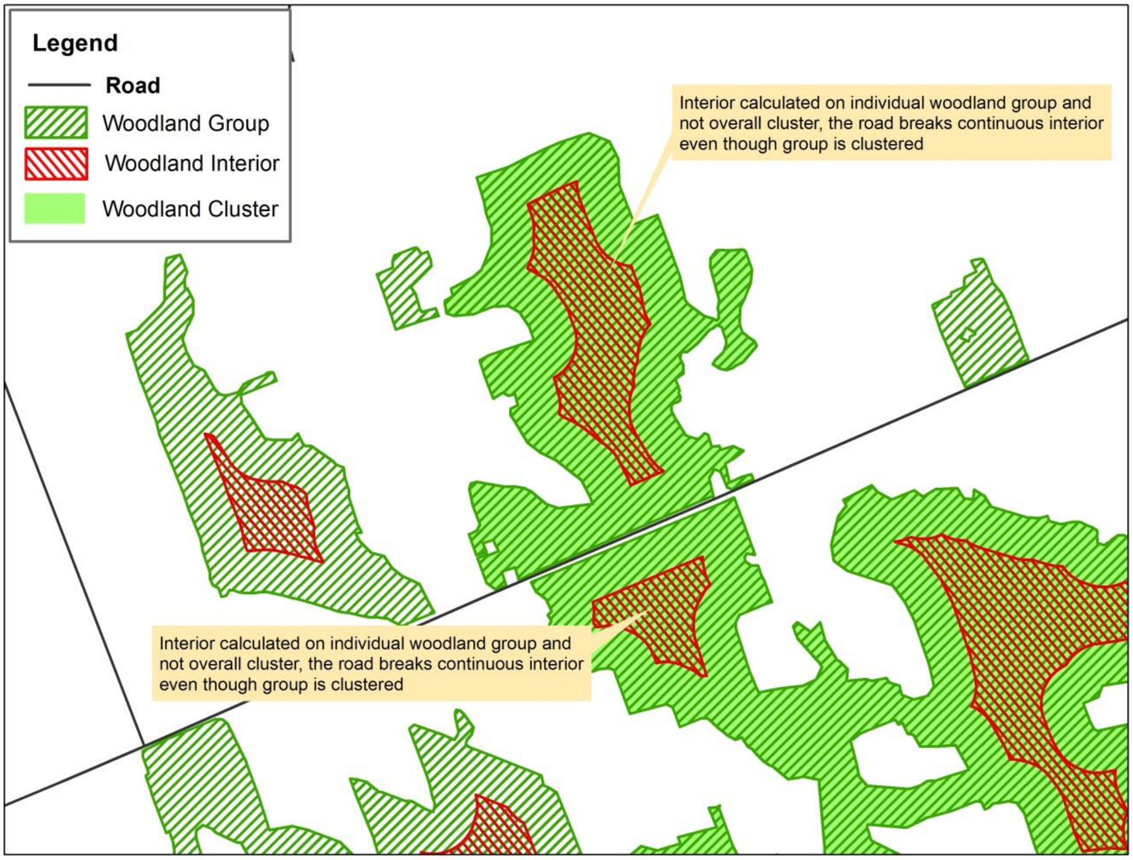
Results

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 *Vegetation Group* area. See map in Appendix J-2.

Table 23. 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 *Vegetation 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 peer reviewer as part of this study. Some criteria were used in the 2003 MNHS, 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 was 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* (i.e., closest to a round shape)
- Adjacent to an OMNR evaluated wetland or life science ANSI
- Contains an area identified in the local official plans such as the Locally Significant Natural Areas identified by Hilts and Cook 1982
- Unique intrinsic characteristics (i.e., site level characteristics)
- 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 >4 ha based on Environment Canada (2013),
    - wetland meadows and marshes >10 ha 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 ≥0.5 ha in size of continuous habitat
- Species at Risk

4.0 Results of Running the Significance Criteria

Each significance criterion 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 criterion 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 do not meet any criteria.

Tables 26-33 and Figures 15-22 show the patches that meet at least one significance criterion 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 criterion in geographic Middlesex

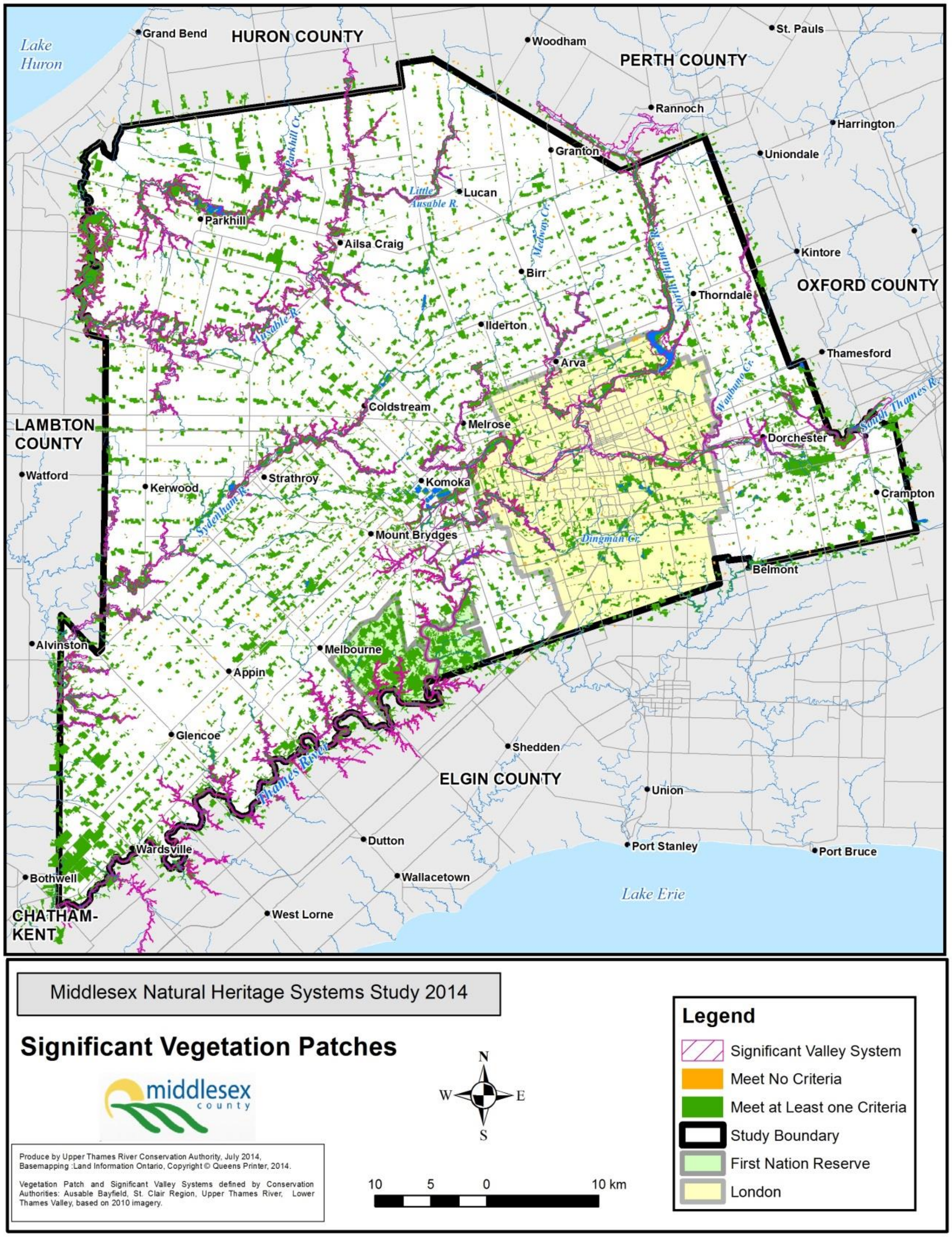


Figure 15. Patches that meet one or more criterion in Middlesex Centre

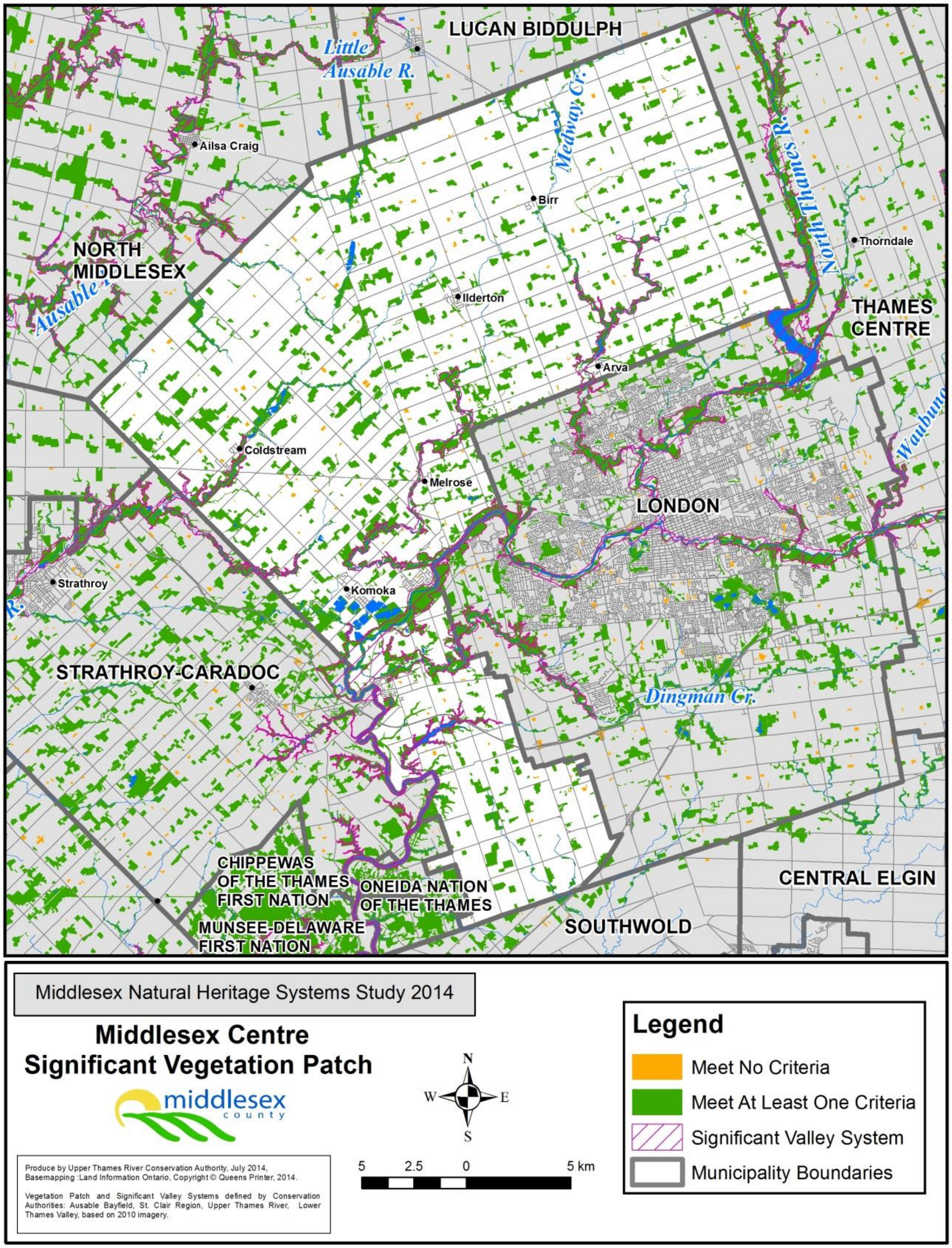


Figure 16. Patches that meet one or more criterion in Thames Centre

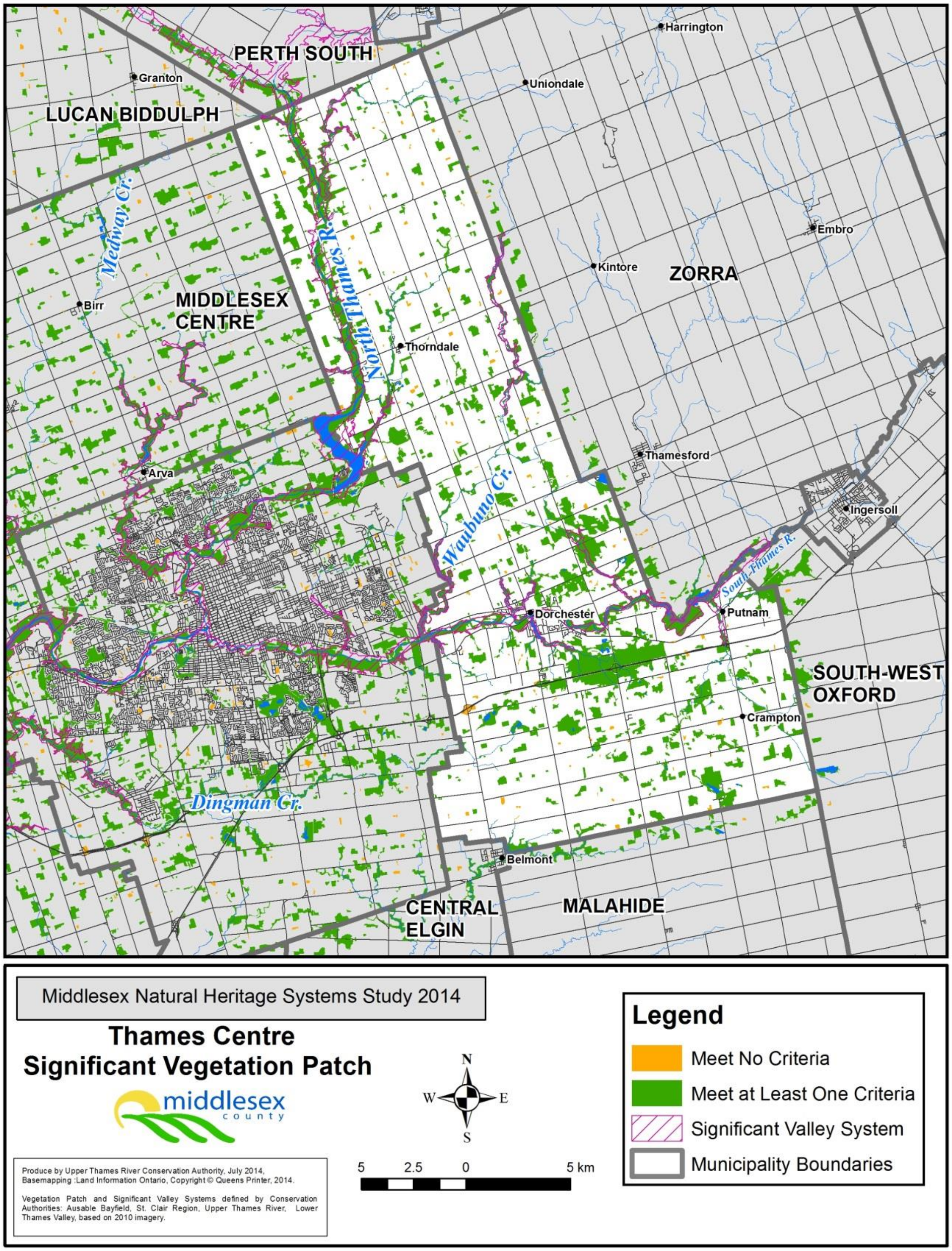


Figure 17. Patches that meet one or more criterion in Strathroy-Caradoc

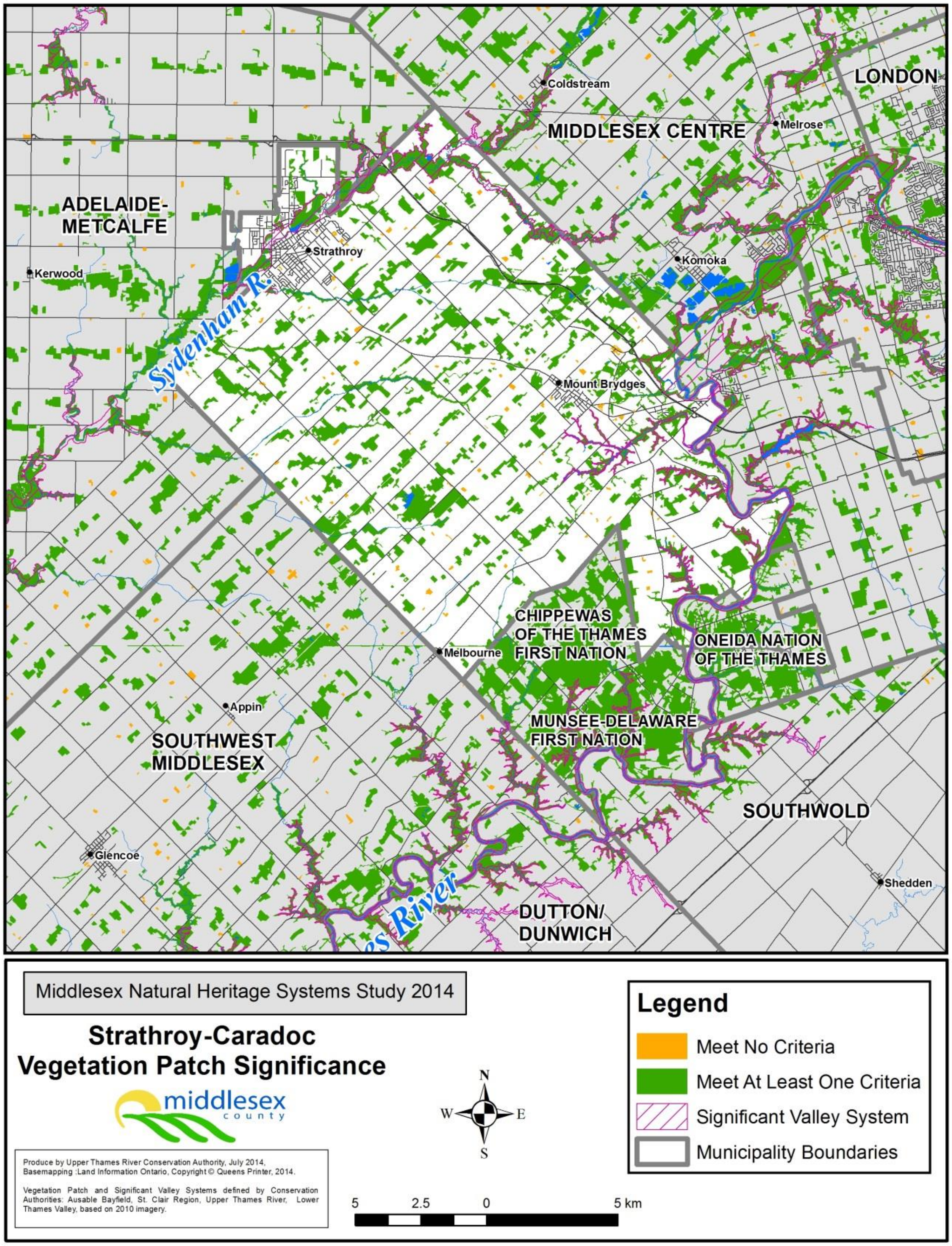


Figure 18. Patches that meet one or more criterion in North Middlesex

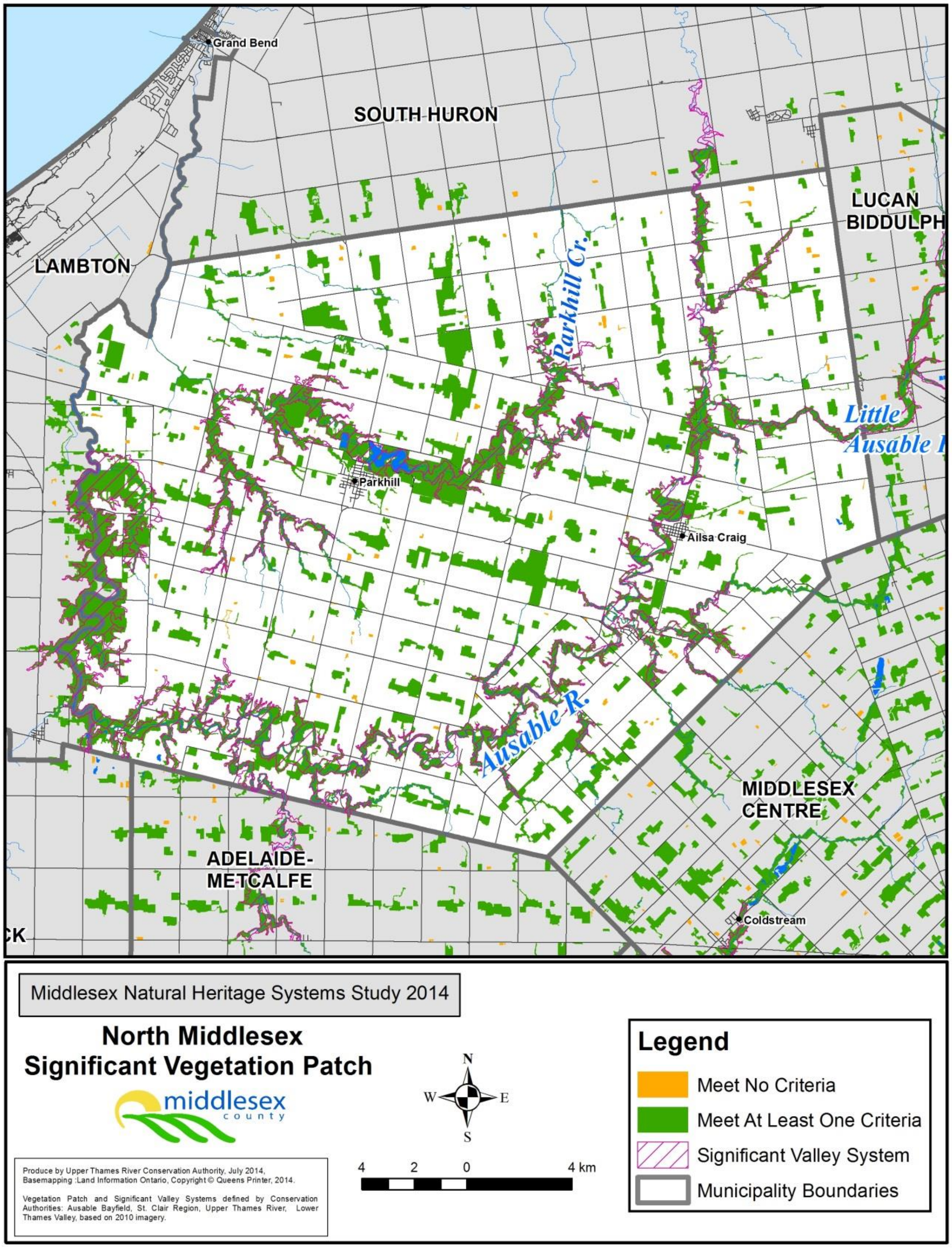


Figure 19. Patches that meet one or more criterion in Lucan Biddulph

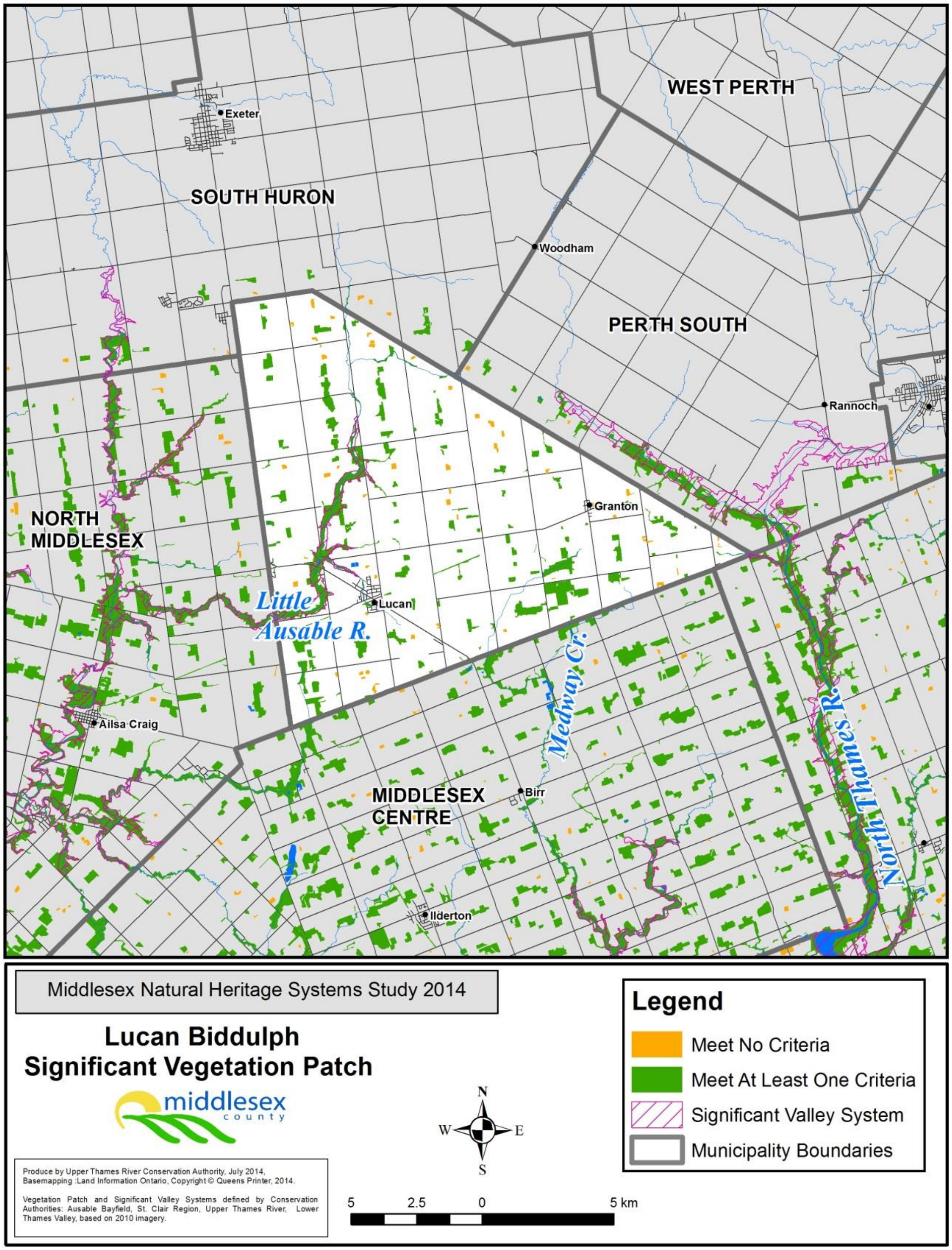


Figure 20. Patches that meet one or more criterion in the City of London

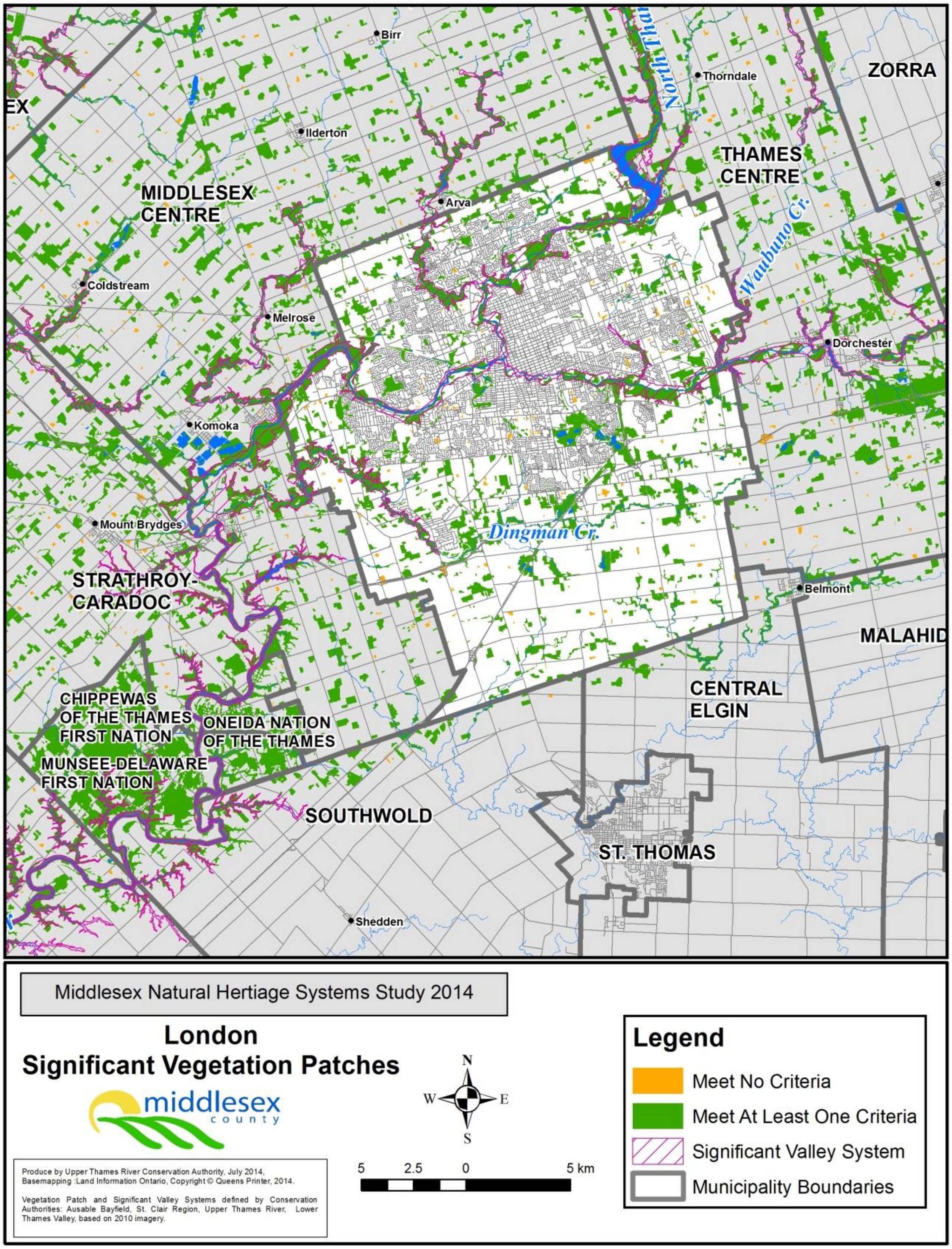


Figure 21. Patches that meet one or more criterion in Southwest Middlesex

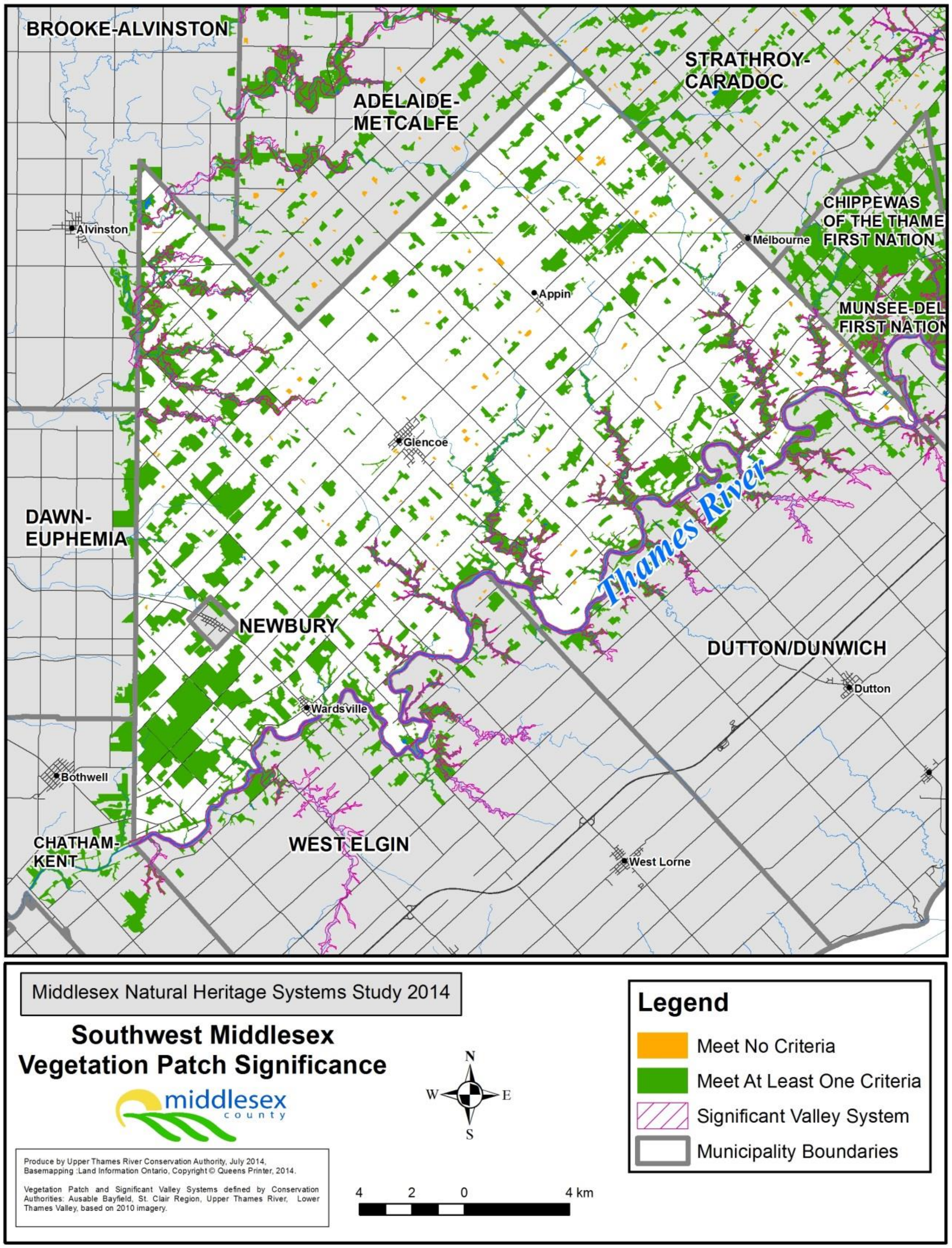
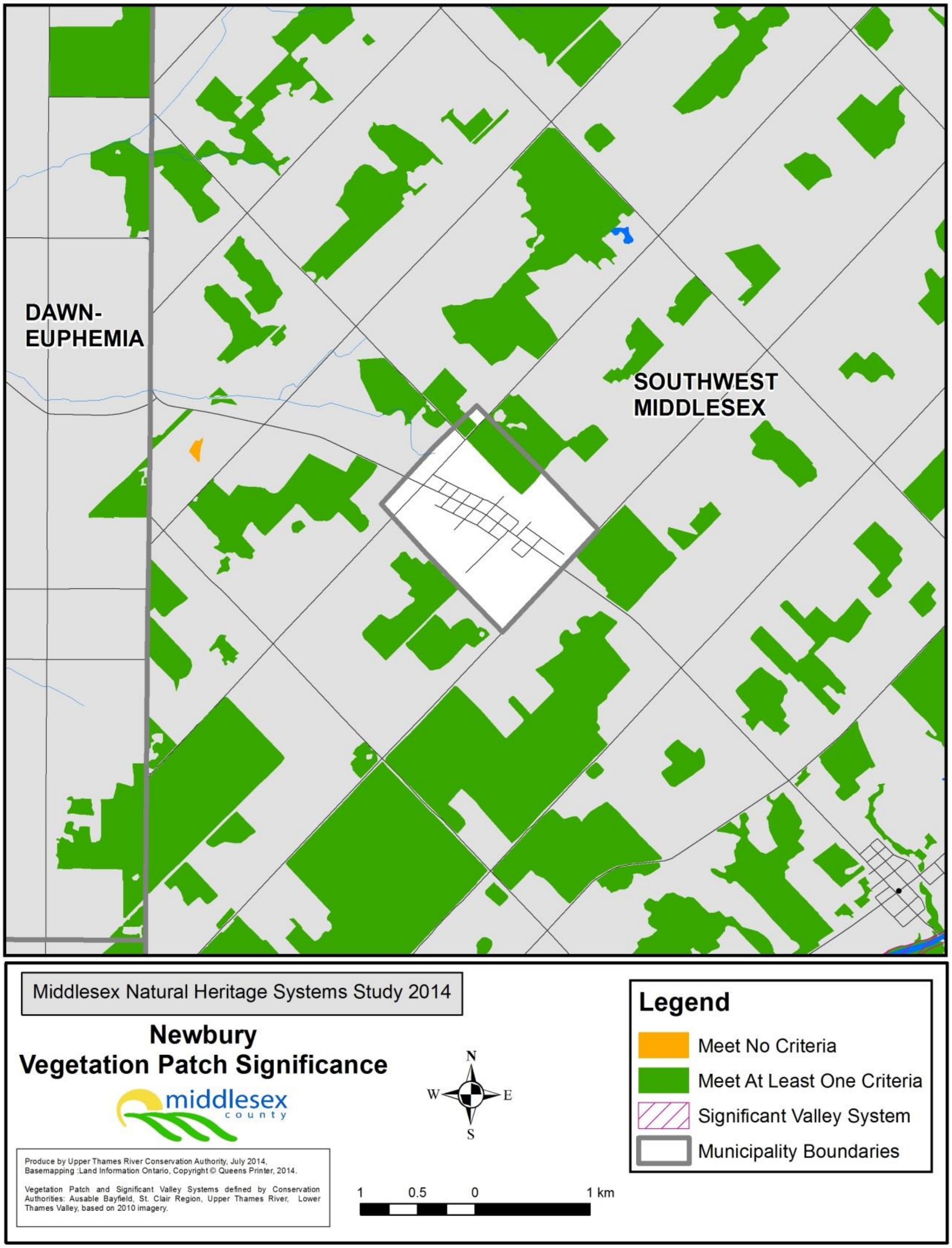


Figure 22. Patches that meet one or more criterion in Newbury



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 Feature *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 criterion.

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 Do Not 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, and
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

The Thames Talbot Land Trust's Tiedje Woods 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. Ensure that the 3 unmapped criteria (i.e. significant wildlife habitat, groundwater dependent wetlands and watercourse bluffs or depositional areas) are evaluated as part of the site specific field work. 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.

e. Policies should be included in the official plan to protect and restore the existing natural heritage system. Note that the MNHSS does not determine if we have enough natural heritage features, whether they are in the right places or of the right type. Also, this study does not determine whether the existing natural heritage system 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 publicly 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 publicly 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 and Forestry 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 becomes 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 becomes 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.

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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