The Oxford County Terrestrial Ecosystems Study (OCTES)

A Natural Heritage Study for Oxford County

Developed by:
Upper Thames River Conservation Authority, June 1997

PHOTO: MARY GARTSHORE

Like forests everywhere, Canada's forests play an important role and are a vital link in the planet's life support system. The forest as a habitat is home to countless numbers of known and unknown plants, animals and microorganisms. In fact, forests sustain more species of animals, plants and other organisms than all other ecosystems combined. The forest as an ecosystem has a regulating effect on the environment: it contributes to the quality of our atmosphere, the moderation of climatic conditions, and the recycling of nutrients in the soil. The forest as a resource offers today's human population a huge variety of materials essential to our existence.

In short, as biodiversity is a crucial factor in the success of human life on earth, biodiversity in forest-dominated ecosystems is a key link in the chain of biodiverse life forms that inhabit all of our planet.

The Richard Ivey Foundation, 1993

The Oxford County Terrestrial Ecosystems Study Summary

The Oxford County Terrestrial Ecosystems Study (OCTES) began in 1995 with the intent of providing state-of-the-environment information related to the health of woodlands and wetlands (forest-dominated ecosystems) in Oxford County. This information would act as "baseline" information for a natural heritage framework. The OCTES is based on the premise that biological diversity and ecosystem health depend on maintaining ecological functions in the landscape over time.

Many partners were involved throughout the project. The primary partners included the Upper Thames River Conservation Authority (UTRCA) as the project coordinator, Grassroots Woodstock and the County of Oxford. Collateral partnerships were established with other agencies including the Ministry of Natural Resources and the Grand River, Long Point Region and Catfish Creek Conservation Authorities, which also have jurisdiction in Oxford County. Contacts were made with the community at large during the study through the media and specific efforts were made to target the agricultural community through the Ontario Federation of Agriculture.

The findings of the OCTES (summarized in attachment and in Appendix D) provide the basis for setting priorities for natural heritage protection and enhancement in the County, implementing the natural heritage portion of the *Provincial Policy Statement*, 1996, and refining the Oxford County Official Plan environmental targets. The results are also a benchmark with which to compare new results arising from any future individual site assessments and studies such as Environmental Impact Assessments.

The OCTES:

1) Identifies impairments of Oxford County's forested landscape over the last 200 years of settlement.

2) Describes the current state of the County's woodlands and wetlands.

3) Documents the perceptions and attitudes of County landowners related to natural heritage.

4) Provides a framework for ecosystems management in the County.

Due to the size of Oxford County, stratified sampling methods were applied. Eight unique study areas ("abiotic groups") were identified in the County and a sub-sample area ("trial landscape") was selected for each study area. Geographic Information Systems (GIS) were used to calculate landscape variables such as regional and local vegetation cover, patch size and supply of interior habitat.

Field assessments were carried out in 71 woodland patches in the eight trial landscapes. The condition of individual woodland patches was assessed based on the presence of vascular plant and breeding bird species. For vascular plant species, OCTES provided an opportunity to test the Floristic Quality Assessment (FQA) methodology recently adopted for southern Ontario (Oldham *et al*., 1995). The FQA has been used in the Chicago area for approximately 15 years as a method to assess site quality. Breeding birds were chosen because considerable study has been undertaken on birds in forest patches in fragmented landscapes in southern Ontario, allowing for data interpretation and comparison.

The study provided a number of interesting insights into the terrestrial ecosystems of Oxford County. While some findings were consistent with other studies, others were unique to the County. For example, some of the findings pointed to the value of small woodlots. Woodland patches between 4 and 10 hectares in area stood out as having higher than expected floristic quality for their size, comparable to the quality of woodland patches 40 hectares or larger. A number of both plant and bird species were recorded in only one surveyed patch during the study and several native species were only found in the smallest patches (<4 hectares).

The woodland patches surveyed were generally young or in a disturbed successional condition; most appeared to have been logged since the 1950s. Older forest communities were found to be of higher quality, supporting more conservative species. Considering the fact that most woodland patches were young, the older forest communities are especially significant in the Oxford County landscape.

Abiotic Group 1, which encompasses Blandford-Blenheim Township in the northeast section of the County, is unique in Oxford County both in terms of its abiotic setting and its biotic characteristics, which include some boreal elements. Abiotic Group 3, which covers part of Norwich Township, is also unique due to the extent of riparian vegetation cover and the diversity and quality of habitats found there.

Other key landscape level findings from the OCTES were consistent with other studies. For example:

- The species richness of both vascular plants and breeding birds increases as the amount of regional forest cover increases.

- Vegetation community richness and plant and bird species richness increase as patch size increases.

- Species richness of forest interior birds increases as patch core area increases.

A survey of private rural landowners' values and attitudes towards natural heritage conservation was completed by the University of Guelph Land Resource Science Department to complement the OCTES (Vanderschot, 1997). A selection of landowners within the eight trial landscapes were surveyed and/or interviewed. The results suggest that a cooperative approach in dealing with landowners on conservation initiatives is imperative. Many are opposed to land use designations and cited the need to be involved early in the planning process. In addition, landowners are concerned with imposed restrictions that may affect the management of their woodlots or infringe on their perceived property rights. Landowners feel that greater integration of ecological goals with economic benefits and incentives is also necessary to assist them in carrying out conservation. Recommendations arising from the survey included the following:

- Designations are most appropriate where development pressures exist. Alternatives to designation, such as land donations and conservation easements, require further investigation.

- Landowners wish to be involved in reaching agreements regarding property restrictions.

- A landowner contact program is needed to identify landowners owning significant woodlands, educate them about their properties' significance and ensure that existing compensation mechanisms (such as tax rebate programs) are being fully utilized.

- Extension services to landowners, which were supported in the survey, should be expanded to include education about biodiversity and ecological goals for woodlot management.

The full set of OCTES reports includes the following:

- Bowles, J., 1997. *Oxford County Terrestrial Ecosystems Study: Life Sciences Report.*

- UTRCA, 1997. *The Oxford County Terrestrial Ecosystems Study (OCTES): A Natural Heritage Study for Oxford County*.

- UTRCA, 1997. *Oxford County Terrestrial Ecosystems Study: Supporting Methods.*

- Vanderschot, I., 1997. *The Role of Landowners in Natural Heritage Systems Planning: An Oxford County Case Study.* Graduate Thesis, University of Guelph.

In addition, the database, which is the property of the County of Oxford and the UTRCA, contains the mapping layers produced using Geographic Information Systems and the data collected in the eight trial landscapes linked according to patch centroid.

Summary of Key Results

Key Result	Interpretation
1) A significant positive relationship exists between the number of breeding bird species and the percent forest cover in trial landscapes.	Total forest cover is important in maintaining overall diversity of breeding bird species in the landscape.
2) A significant positive relationship exists between the number of native vascular plant species and the percent forest cover in trial landscapes.	Total forest cover is important in maintaining overall native plant species diversity in the landscape.
3) A significant positive relationship exists between patch size and breeding bird species richness.	Large patches are important in maintaining overall breeding bird diversity in the landscape.
4) A significant positive relationship exists between patch core area and forest interior bird species richness.	Forest patches with large core areas are important for maintaining diversity of forest interior birds.
5) A significant positive relationship exists between community/habitat richness and both native plant and bird species richness.	Community/habitat diversity is important for maintaining both plant and bird species diversity.
6) Nineteen breeding bird species (21%), including seven forest interior species, were recorded in only one vegetation patch during the survey.	Individual patches are important for maintaining bird species diversity across the landscape.
7) Community age across trial landscapes in the study was generally young with only 34% of communities described as mid-age or older.	Forest management has not included maintaining mature forests.
8) The number of vegetation communities was significantly different among different patch size classes and increased with patch size.	Large patches are likely to support more diverse habitat.
9) Seventy-nine native plant species (16%) were recorded in only one vegetation patch in the survey.	Individual patches are important for maintaining native plant species diversity across the landscape.
10) There was a significant positive relationship between native plant species richness and the amount of forest cover within a 2 km radius of the patch.	Local forest cover is important for maintaining plant species richness.
11) Native plant species richness was greater in patches <4 ha if they were adjacent to other larger patches.	Connectivity and linkages are important for maintaining biodiversity.
12) Mean conservatism was as high in patches of size class 4-10 ha as in any other larger size class.	Some of the "best quality" patches are small.
13) Mean conservatism was significantly positively related to the age of the oldest vegetation community in a patch.	Mature communities are required for maintaining conservative species.
14) Forty-six percent of the patches surveyed contained no interior forest habitat. All of the forest patches in the study were comprised of at least 52% edge.	Patches in Oxford County are generally small and lacking core area and the potential for forest interior.
15) Patch mean wetness scores were significantly different among trial landscapes with trial landscape 1 containing the wettest patches and trial landscape 2c containing the most mesic patches.	There are significant differences in habitat type between the eight abiotic groups.
16) Weed species richness increased with increased overall patch disturbance.	Disturbance events promote non-native weedy plant species.

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1.0 Introduction

1.1 Study Development

The Oxford County Terrestrial Ecosystems Study (OCTES) was initiated in 1994 with the submission of a proposal to the Richard Ivey Foundation for 50% of the funds required to complete a study of woodlands and wetlands in Oxford County. The proposal, submitted under the *Biodiversity in Forest-Dominated Ecosystems* grant-making program, involved as its three major partners the County of Oxford, the Upper Thames River Conservation Authority (UTRCA) and Grassroots Woodstock, a local environmental group. The project evolved out of the review and update of the County's Official Plan and the simultaneous provincial review of the Planning Act and provincial policies issued pursuant to this legislation. The three parties came together out of the recognition of the need to set targets, guidelines and programs to complement the new Official Plan in the protection, restoration and enhancement of the natural environment.

The County of Oxford Official Plan was adopted by Council in December, 1995, and approved by the Ministry of Municipal Affairs and Housing in August, 1996. Its purpose is to "guide and manage the extent, pattern, and type of settlement and the use of land and resources desired to maintain and improve the quality of the environment and the quality of life for County residents and to address matters of Provincial interest" (County of Oxford, 1995, p.1-2). The policies address growth and settlement to the year 2011. However, there are no specific time frames for natural resources, natural environment or infrastructure policies. The guiding principles for natural heritage in the Official Plan are consistent with the *Comprehensive Set of Policy Statements* (CSPS) approved in 1994 pursuant to Bill 163, which was made under Section 3 of the Planning Act of Ontario. Since that time, the new government replaced the CSPS with the *Provincial Policy Statement* in May, 1996 , pursuant to Bill 20. Among other things, the new policies place more onus on municipalities for natural heritage protection.

The purpose of the natural heritage component of the County's Official Plan is to create a green space system which will sustain and enhance natural processes and the health and diversity of native plant and animal communities. The plan commits to monitoring the health of the environment through state-of-the-environment reporting and to update the plan as new environmental information becomes available. The intent of the OCTES is to assist the County in meeting these goals.

Funding approval was received from the Richard Ivey Foundation in March, 1995, to complete two phases of the OCTES during 1995 and 1996. The final funding arrangement provided half of the funds from the Richard Ivey Foundation and one quarter each from the County and the UTRCA. This funding arrangement provided invaluable savings to the municipality in completing the natural heritage study.

Phase A, a planning phase that involved compiling existing available data, provided a general assessment of the terrestrial resources in Oxford County. Phase B involved collecting and analysing data utilizing Geographic Information Systems (GIS) technology and data from sample areas across the County. Merging phases A and B provides the basis for developing strategies to sustain and enhance the natural processes, health and diversity of the landscape. A possible phase C would see the implementation of the OCTES recommendations, such as policy development and stewardship initiatives, for management on private and publicly-owned lands.

1.2 Study Purpose

The purpose of the Oxford County Terrestrial Ecosystems Study (OCTES) is to provide state-of-the-environment information related to the health of the woodlands and wetlands (forest-dominated ecosystems) in Oxford County. This is accomplished through four main steps:

1) Identify any impairments to the landscape related to the last 200 years of settlement by:
   • reviewing historical literature and records of flora and fauna,
   • assessing forest composition and structure using historical sources.

2) Determine the current state of the woodlands and wetlands through:
   • Geographic Information Systems (GIS) analysis of forest cover, spatial distribution of forest patches, patch size and shape, using historical and current data,
   • field assessments of representative sample areas across the County.

3) Document the perceptions and attitudes of landowners related to natural heritage by:
   • conducting mail surveys of landowners across the County,
   • conducting interviews of a subsample of landowners across the County.

4) Develop a framework for ecosystems management in Oxford County that:
   • provides benchmark data,
   • provides additional Criteria for Local Significance,
   • identifies planning and management scales for the implementation of the OCTES.

1.3 Primary Partners

Grassroots Woodstock
Grassroots Woodstock is a volunteer, non profit citizens' group based in Oxford County. Members are concerned about the environment at both a local and a global scale. The group, established in 1989, is actively involved in conservation issues affecting the natural environment. The participation of Grassroots Woodstock has centred around land use planning issues affecting water quality and the terrestrial environment including wetland and upland forest areas. In addition, Grassroots Woodstock presents speakers, prepares information material and organizes forums and fairs which address environmental issues and increase public awareness. Members of the group continue to participate in government initiatives and lobby for positive environmental change.

Oxford County
Prior to 1975, Oxford County consisted of 33 municipalities. In 1975 legislation was enacted restructuring the County to its current eight municipalities and establishing responsibilities between the County and its lower-tier municipalities. As a result of restructuring, the responsibility for the creation of land use planning policy is vested in the County. This means that the County has only one Official Plan to integrate and coordinate planning and development activities within and between municipalities. This political structure effectively addresses natural resource issues by allowing consistent County-wide standards to be established.

The Upper Thames River Conservation Authority
The Upper Thames River Conservation Authority (UTRCA) is a locally based environmental agency, established under the Conservation Authorities Act of Ontario. The UTRCA aims to further the conservation, restoration and management of natural resources in partnership with the member municipalities of its watershed and the Province of Ontario. The loss of watershed resources, including forests and wetlands, and subsequent floods in the 1930s provided the impetus for establishing the UTRCA in 1947. The UTRCA's area of jurisdiction is based on the drainage area or watershed of the upper Thames River, which is approximately 3500 square kilometres in size. More than 50% of Oxford County is within this watershed, and comprises 30% of the watershed area. The majority of the UTRCA watershed is rural with the exception of the City of London and other urban centres including Woodstock, Ingersoll and Stratford.

1.4 Study Premises

The OCTES is based upon two premises. The first is the foundation for the "ABC" Resource Survey Approach explained in section 3.1 and the second relates to the creation of a healthy natural heritage system.

1) Understanding terrestrial ecosystems and the biological communities they nurture requires understanding both the supporting abiotic conditions and the cultural impacts acting on these systems. Land form processes give rise to the geology and soils found in a given area. In turn, the floral composition and structure across the landscape indicate ecosystem health and correspond to faunal diversity. Flora or biotic conditions can be considered as the bridge between subsurface processes, such as geology and soils, and faunal capability. Human land use and spatial patterns dictate the arrangement of abiotic and biotic features which, in turn, affects the health of these systems. The relationships between the abiotic, biotic and cultural landscapes are key to understanding the state of that landscape.

2) Traditionally, life science studies in Oxford County have focussed on spatially extensive, biologically diverse sites with significant plant species. These lands have generally been defined as Provincially Significant Wetlands (PSWs), Areas of Natural and Scientific Interest (ANSIs) and Environmentally Significant Areas (ESAs). However, current ecological theories suggest that the perpetuation of healthy ecosystems cannot depend solely on the maintenance of these islands, and these areas are now more commonly referred to as "core areas" in planning documents. In the absence of surrounding vegetation patches and linkages, the long-term stability of these areas is questionable. It is apparent that we need to protect more than just the "jewels" of the terrestrial landscape.

2.0 Background

2.1 Southern Ontario Context

Prior to European settlement in the early nineteenth century, much of southwestern Ontario was covered with more or less continuous tracts of closed canopy hardwood forest. Disturbances such as fire and windstorm, small coniferous tracts, prairie and savannah communities, isolated pockets of flood plain, and extensive swamp forests created the only gaps in this canopy. Archival records suggest that this rich, forest-dominated ecosystem supported abundant populations of mammals, birds, reptiles and amphibians.

Between 1825 and 1875, increased settlement led to a large portion of the original forest being cleared for agriculture, timber, fuelwood and railway construction. Large artificial drainage systems, which simplified stream dynamics, were developed in the early 1900s as more marginal lands were converted for production. The outcome of these processes was fragmentation of the forests and wetlands into isolated components or "islands," and a reduction in the habitat that supported the life cycle requirements of floral and faunal populations.

During the depression of the mid-1930s, second-growth forests were cut for fuelwood and timber, increasing pressure on the remaining plant and animal populations. Following World War II, increased urbanization led to additional clearing of forested land and the draining of wetlands. Agricultural practises relied on straightening watercourses to improve drainage. Larger equipment and increasingly specialized and mechanized operations resulted in the removal of hedgerows and the squaring off of remnant forest patches. Mechanized timber harvesting also increased over time. All of these practises have degraded the ecosystem stability and health which, in turn, has affected floral and faunal biodiversity.

More recently, urban expansion has had a greater impact on the environment in southern Ontario. Urban sprawl has resulted in many smaller communities being absorbed into city boundaries and more servicing demands for more roads, pipelines, hydro, sanitary servicing, sewage treatment plants and land fills. The creation of impermeable landscapes associated with the urban environment has created exaggerated flood regimes. These changes point to the need for natural heritage systems planning.

2.2 Study Area

2.2.1 History of Oxford County

The following information was compiled from the *Upper Thames Valley Conservation Report*, Department of Planning and Development, 1952.

Originally, Oxford County's forests were dense with a few openings created by marshes, bogs and willow meadows. Sugar maple was the principle tree species followed by beech and elm. Near streams, hemlock and cedar prevailed. Swamps and poorly drained soils were chiefly treed with white elm, cedar and soft maple. These swamps formed large natural surface water storage areas, usually at the head waters of rivers and streams. Tamarack was common until 1890 when larch sawfly disease took its toll. Pine and oak were found on the lighter soils or sand plains in the south. Pine was scattered or sometimes found mixed with hardwoods on well-drained soils. A traveller in 1837 described a park-like setting that was probably oak savannah habitat, a type which is very rare today: "In Oxford, or rather Ingersoll . . . we stopped to dine and rest previous to plunging into an extensive pine forest . . . . The forest land through which I had passed was principally covered with hard timber as oak, walnut, elm, basswood. We were now in a forest of pines, rising dark and monotonous on either side. . . . These seven miles of pine forest we traversed in three hours and a half; then succeeded some miles of open, flat country called the oak plains . . . covered with thickets and groups of oak dispersed with park-like and beautiful effect . . . ." (Winter Studies and Summer Rambles in Canada, Anna Jameson, 1837).

Since European settlement began in 1794, Oxford County has undergone land use patterns and pressures similar to those historically exhibited across southern Ontario, resulting in the overall degradation of ecosystem health. In the late 1700s, surveys show that 75% of Oxford County was forested. Early settlement involved clearing forests for agriculture, timber production and ship building, and Ontario began exporting timber to Britain in the late 1820s. The timber industry thrived in the 1830s and 40s, and major deforestation occurred in Oxford County between 1850 and 1890. Historical data suggests that between 1837 and 1860, 60% of Oxford's forests had been cut. By 1910, 90% of the original forest had been cleared.

Timber played an important role in Oxford County's history. White pine, the most sought after species, was found mostly in southern parts of Oxford County. Evidence suggests that the sand plains in the Norfolk area were home to very large oaks and pines that were in great demand, probably supplying much of the surrounding area. The *Upper Thames Valley Conservation Report* (1952) refers to "white pine at a mill [that] measured a trifle over 170 feet high and 7 feet in diameter and 200 feet high and 6.5 feet in diameter." Oaks were recorded that were 3 to 5 feet in diameter.

The use of firewood peaked in 1880 and dropped by 1940. Evidence suggests that Oxford County used more fuelwood than surrounding counties. When the Great Western Railway between London and Toronto arrived, fuelwood became more valuable, resulting in many woodlots being cleared. Roads were laid out regardless of physiography, many cutting through wetlands and woodlands. Wood was used for bridges and, where gravel was unavailable, corduroy roads were made.

Cedar was first used for split rail fence and later, when wire fences came into use around 1900, for fence posts. By 1890, telephone poles and railway ties had been added to the list of wood products as well as exterior and interior house trim, mostly made of pine and oak, and implement handles made from hickory, ironwood, and rock elm. Tanbark was also used by shoemakers for dressing leather.

Oxford County's maple syrup production, which was the highest of area counties, peaked in 1860. As a result, only small quantities of sugar were imported into the area during the mid- to late- 1800s. By 1910, maple syrup production had become an industry in the County. Lye or potash was used to make soft soap in the early 1900s. Records show that 60 large maple trees could make 650 to 700 pounds of potash. Sometimes this was a primary income source for families, resulting in more land being cleared than could be cropped.

Agriculture was another major land use. In south Oxford, the sandy soils were soon exhausted of their humus and fertility and abandoned farms were common in the early 1900s. These lands naturally reverted to second growth forests over time. The introduction of tobacco-growing in the 1930s made it profitable to clear these lands again.

Many species of wildlife which are now rare or extirpated were abundant in the County before European settlement, including: beaver, timber wolf, black bear, marten, fisher, wolverine, otter, lynx, elk and eastern cougar. By 1846 wildlife populations were diminishing so rapidly that the Province passed a bill to close hunting seasons for most game species.

White-tailed deer disappeared from Oxford County in 1910 but made a come back by 1925. Red squirrel and chipmunk were more common historically than they are today, as were pileated woodpeckers and rattlesnakes. Bobwhite were also common historically; this species actually increased in numbers when the County was first settled, peaking in about 1860, but few remained by 1930. Records suggest that by 1842 the wild turkey had also almost disappeared. It is unknown whether bobcat still survive in the County. In the newly settled and cleared environment, species such as cottontail, woodchuck, fox, raccoon and skunk flourished.

2.2.2 Oxford County Today

The County of Oxford is located in the agricultural heartland of southwestern Ontario between the Regional Municipality of Waterloo to the east, Middlesex County to the west, Perth County to the north and the Regional Municipality of Haldimand-Norfolk and Elgin County to the south (Map 1). The County comprises eight municipalities covering an area of 2028 square kilometres (783 square miles) and is in the watersheds of four Conservation Authorities: the Upper Thames River, Grand River, Long Point Region and Catfish Creek. The largest municipality in the County is the City of Woodstock with a population of approximately 32,000.

Oxford County lies in the transition zone between the Great Lakes - St. Lawrence forest region to the north and the Carolinian zone of the deciduous forest region to the south. Remnant forests contain plants and animals of both northern and southern or Carolinian affinities.

Map 1: Study Area: Southern Ontario Context

Oxford County is predominantly agricultural (Table 1). In 1991, 84% of the land base was associated with farming activity, approximately 12% was associated with natural features and 4% was associated with urban development. The County's population in 1991 was 93,000 with half of the population living in the three major centres (Woodstock, Ingersoll and Tillsonburg). The rest of the population was rural or located in hamlets and small villages.

Over the next 30 years the increase in population is expected to continue; the estimated population by the year 2011 is 114,000. The County has established a growth strategy in the Official Plan which directs settlement to serviced urban centres. The main areas of growth are identified around the larger urban centres because of the availability of servicing and because of policies restricting rural development in Oxford County. Tillsonburg is currently experiencing the highest growth rates and pressures on natural resources for water and sewage servicing and development. Boundary adjustments are also anticipated for the City of Woodstock and possibly Ingersoll. Although Oxford County has not been subjected to the same levels of urban pressures as other parts of southern Ontario, population growth and increased urban expansion is expected around the major city centres as well as in smaller urban centres such as Tavistock, Drumbo, Mount Elgin and Norwich.

Table 1: Oxford County Land Use, 1983

Built Up Areas	Corn	Hay	Tobacco	Mixed	Continuous Row Crop	Swamp/Bog	Woodlot	Other
4%	30%	5%	5%	20%	18%	2%	10%	10%

Source: Agricultural Land Use Mapping, 1983. Ontario Ministry of Agriculture and Food, Resources and Regulations Branch, Geographic Information Systems Unit.

3.0 Methods

3.1 ABC Approach

The overriding methodology applied throughout the OCTES is known as the "ABC" Resource Survey Approach (Bastedo *et al*., 1984). This approach involves analysing and integrating abiotic, biotic and cultural information with equal weighting placed on all three components.

The ABC method was originally developed for use in significant areas, national parks planning and management concerns, and to delineate park boundaries. The levels of analysis of the A, B and C information layers include: reviewing raw data including the creation of structural and functional mapping for each; data interpretation to identify areas of significance and constraints to study goals; data synthesis to integrate the information; and management recommendations arising out of all of these steps (Bastedo *et al*., 1984).

The application of the ABC method to OCTES assumes that abiotic conditions must be understood in order to understand the biotic characteristics and cultural patterns such as settlement and land use (premise 1). These three components are interdependent. The method creates a multidisciplinary framework that simplifies relatively complex ecological data and large geographic scales, allowing information to be relayed to both technical and lay audiences.

The results of the abiotic, biotic and cultural components of the OCTES are integrated throughout this report. A separate report entitled *Oxford County Terrestrial Ecosystems Study Supporting Methods*, 1997, is available as a supplement. It provides additional detail on the methodologies used for the A, B and C components.

3.2 Sampling Methods

The County of Oxford is estimated to be 2028 square kilometres in size with approximately 24,000 hectares (297 square kilometers) of natural features including woodlands and wetlands. The County's large geographical area, the amount of natural vegetation cover, and the practical considerations of staffing, project scheduling and financial resources all influenced the sampling methodology chosen to meet the study's goals.

Premise 1 states that underlying abiotic features in the landscape (soils, physiography, etc.) influence the composition and structure of the overlying vegetation. Based on this, Oxford County was divided into eight major areas or groups, using GIS. These groups were based on abiotic features including: glacial landforms, physiographic region, dominant soil texture, topography, soil drainage, recharge potential and estimated depth to water table. Areas with similar characteristics were grouped, giving priority to soil texture due to this factor having the greatest influence on biotic characteristics.

In each of the eight major abiotic groups, a sample area, comprising approximately 10% of the total area of that group, was selected to allow more detailed study of the attributes and function of patches. These areas were called "trial landscapes" and represented samples or subsets of the larger abiotic groups. The location of each trial landscape was based on specific criteria: the selected area had to be representative of the group as a whole in terms of patch size, shape and pattern and had to include cultural features representative of the group such as roads, railways, towns and agricultural activities. Trial landscape 6 was selected to include abiotic group 6 as well as parts of groups 2b and 2c. This sample crosses abiotic group boundaries in order to make comparisons in a more diverse landform setting.

The boundaries of the trial landscapes were roads and lot lines for the following reasons:

- roads create physical breaks in patches ensuring there would be no partial patches within the trial landscapes,
- roads and lot lines offer a recognizable boundary and access for field staff,
- the landowner contact program is simplified given that roads and lot lines are also typically property boundaries.

In each of the eight trial landscapes, forest patches were selected to represent the range of patch size classes present in the trial landscape. Landowner permission was sought to survey the selected patches. When landowner permission was not obtained for all or most of a patch, an alternate patch was substituted. Some patches originally identified as single units were divided for the purpose of the life science surveys along gaps such as roads, railways, service corridors and rivers. This allowed patches to be surveyed at a finer level of detail as smaller units. For logistical reasons, some larger patches were also surveyed in separate areas, such as single properties, but were later combined for analysis.

3.3 Geographic Information Systems (GIS)

GIS is an invaluable tool in providing visual interpretation of a complex series of variables. GIS was used to understand historical and contemporary landscape patterns in Oxford County such as regional and local cover variations, spatial distribution of vegetation patches, patch size and shape, and to relate these to the data collected in the eight trial landscapes. Other layers were created in order to complete the ABC Approach. GIS information alone, however, does not provide the local field level information needed to make planning and management level decisions. As stated by Lautenschlager, 1995, "GIS does not replace the need for detailed field studies but rather redirects and places those studies into a more meaningful context."

GIS was used to synthesize abiotic characteristics and to identify the abiotic groups from which the eight trial landscapes or sample areas were chosen. Forest and wetland patches were defined and categorized into size classes and representation was selected from each size class. Field work was conducted in vegetation patches defined by GIS, within the eight trial landscapes. Analytical queries were applied which further assessed the biological attributes of vegetation patches using landscape parameters such as: patch size, shape, spatial distribution and total area of vegetation either by county, abiotic group or trial landscape. Landscape parameters were combined with the field data results to define the state of the Oxford County landscape. Field data was linked to the GIS using the patch centroid.

A variety of queries were completed to assess the state of Oxford County's terrestrial landscape:

- total county-wide vegetation cover,
- the area of vegetation in each abiotic group and trial landscape using historical and present data,
- the percentage of different woodlot sizes in each abiotic group and landscape,
- the area of interior forest based on a 100 metre edge/buffer around the perimeter of each woodlot for each abiotic group and trial landscape,
- the area of vegetation within a 2 km radius of the patch centroid for visited patches within the trial landscapes, using historical data,
- the area of forest community types in each woodlot visited using historical data,
- the area of different agricultural land uses in each abiotic group,
- the area of forest classifications (soil moisture and stage of succession) to calculate dominant forest cover type in each abiotic group.

3.4 Historical Forestry Assessment: 1951 to 1957 and 1978

Historical forestry information was digitized and then categorized into ecological units based on soil moisture and stage of succession. This identified general trends and patterns in terms of ecosystem composition and structure across the landscape. Two historical forest inventories were located for Oxford County: Conservation Reports produced by Conservation Authorities during the 1950s, and Forest Resource Inventories (FRI) produced by the Ministry of Natural Resources in 1978.

Conservation Reports were used to assess the forest resource in the following watersheds: Nith River, 1951; Thames River, 1952; Big Creek, 1953; Central - Whiteman's Creek, 1954 and Otter Creek, 1957. FRI mapping, 1978, was used in the Catfish Creek Conservation Authority watershed area. A review of the methodology used for Conservation Reports concluded that all forest patches greater than 0.5 hectares were ground-truthed by forestry crews. The accuracy of this source has been tested through other studies by both the Upper Thames River and the Grand River Conservation Authorities and has yielded a high degree of correlation in the vegetation communities and species documented.

Patches were generally categorized as upland, wetland or riparian according to the available dominant tree species information. Upland habitats were defined as forest patches which occur on mesic soils. Wetland types included vegetation patches on wet or hydric soils. Riparian habitats were those associated with a stream order of 2, 3 or 4. Species information was further interpreted to determine each patch's soil moisture affinity and level of succession or age. Soil moisture affinity categories included Mesic and Wet Mesic. Age categories were Young, Subclimax, Climax, and Subclimax-Climax. The stage of succession was not determined by the age of the woodlot or trees but rather by whether the dominant species was considered a climax, sub-climax or young species according to its ability to tolerate shade. For example, if the dominant cover of a forest patch was a shade tolerant species, the patch was identified as a climax forest.

The various combinations identified for these two classifications were coded (Appendix B). The results of the classification process included the following possible combinations: Mesic Young (MY), Mesic Subclimax (MS), Mesic Climax (MC), Wet Mesic Young (WY) and Wet Mesic Subclimax-Climax (WSc). An additional classification, Transitional (T), was used to describe Hickory-Ash associations due to the range of interpretations of age and soil moisture affinity which were possible for this type. Plantations were identified by a separate symbol (P).

3.5 Field Assessments

Cost/benefit was carefully considered in selecting a field method that would provide a reasonably detailed level of field data over a large area to complement the GIS analysis. Indicators were selected as the best approach to assessing the state of the natural environment in Oxford County. Vascular plants and birds were chosen as the two key indicators because of the relative ease with which they can be sampled and because much is known about both in southern Ontario. In addition, indicator species tell us more about current environmental conditions. For further information regarding the field level methodology, refer to the *Oxford County Terrestrial Ecosystems Study: Life Sciences Report*, Bowles, 1997. Copies of the field forms used to record data are attached in Appendix C.

The Floristic Quality Assessment (FQA) was chosen to assess the quality of forest patches in Oxford County. The FQA method was first developed in the Chicago region (Wilhelm and Ladd, 1988) and has more recently been employed in Ohio (Andrea and Lichvar, 1995) and Michigan (Herman *et al.,* 1996). In 1995, a similar system was developed for Ontario (Oldham *et al.,* 1995). The FQA is applied to a full native plant species list for a site. Each plant species is assigned a score ("conservatism coefficient") between 1 and 10 which indicates the likelihood that the plant will be found in a pristine or undisturbed site. The mean conservatism score for all plants in a site reflects the number of conservative species. An overall score of site quality is given by the Floral Quality Index (FQI), calculated by multiplying the mean conservatism score by the square root of the total number of native species (species richness). The method has been found to have many advantages for natural heritage planning in the Chicago area, the most important one being that it provides an objective and quantitative method of assessing site quality. The OCTES is one of the first applications of the method in Ontario.

In addition, a weediness score between -1 and -3 was applied to non-native vascular plant species. This is another measurement which reflects the quality of a natural area because weedy species have the ability to displace native flora. The degree of weediness of the plant is indicated by a lower score. Invasive weeds such as Garlic Mustard receive a score of -3. The mean weediness score and the weed richness provide another indication of site quality.

Birds were selected as the key faunal indicator of health and biodiversity. The birds present during the breeding season (breeding birds) were recorded in order to gain an understanding of how the various woodland patches are used for breeding. Habitat requirements have important implications for natural heritage planning. Out of this information, specific data can also be extracted related to particular species or guilds such as neotropical migrants, which are experiencing declining populations.

A description of the vegetation community structure, including its horizontal and vertical structure (dominant species, strata, age, moisture regime), and a disturbance checklist provided additional information about the condition of each patch. The UTRCA employed a checklist of culturally-induced disturbances such as: logging, tracks and trails, and impacts such as canopy blow-down. The presence or absence of thirteen disturbances and their extent were recorded as part of the field assessment (Appendix C). For the purpose of evaluating ecosystem health, disturbances are generally considered to be human-induced. According to Lautenschlager (1995), "Major human-caused environmental modifications include: 1) altered natural frequency, intensity, and spatial extent of stress-inducing and/or mortality-causing disturbances (insects and fire); 2) changing the availability of environmental resources such as soil nutrients, temperature, water, atmospheric gases, or biologically-produced resources; and 3) introduced plants, animals and microbes, to which local organisms are not adapted. These have led to local and widespread range extension and use-pattern changes, species displacement, and extirpation."

3.6 University of Guelph Landowner Survey

In 1995, the UTRCA was approached by a University of Guelph masters student, working under the direction of Dr. Stewart Hilts, to combine her research proposal with the OCTES. The intent was to integrate landowners' values and attitudes about their woodlands and wetlands into the planning process and provide the basis to develop solutions which balance goals for improved ecosystem health between local government and the community.

The two-fold landowner contact process adopted consisted of distributing mail surveys and conducting personal interviews. The mail survey was distributed to all private rural landowners within the eight trial landscapes. The surveyed landowners were selected from the same database used for OCTES landowner contact program with the exclusion of non-farm corporate owners and any duplicate ownerships.

The survey included five sections which addressed the following about the landowner: their property profile, their personal profile, their views towards natural areas, their opinions on conservation and enhancement approaches, and their response to the OCTES. To avoid any potential biases in the completion of the survey, the researcher remained independent from affiliation with the UTRCA, Oxford County, or Grassroots Woodstock.

Sixteen interviews (two within each trial landscape) were conducted during 1996. Each interview took between 60 and 90 minutes. Using mapping sources, landowners with natural features on their properties were identified. For the purpose of the interviews, natural features included: designated Areas of Natural and Scientific Interest (ANSIs) or Environmentally Significant Areas (ESAs), designated wetlands, non-designated woodlands and streams. The content of the personal interview was specifically geared to the unique situation of each landowner and focussed more on how their property fit into the larger landscape and on conservation approaches used than the survey had. A series of maps was used as a visual aid to assist the landowners.

For more information about the detailed methods and results of the survey, refer to *The Role of Landowners in Natural Heritage Planning, An Oxford County Case Study*, Vanderschot, 1997.

4.0 Results

4.1 Abiotic Characteristics

A copy of the synthesized map illustrating the boundaries of the abiotic groups is included as Map 2. The attributes of each abiotic group are outlined in the following paragraphs, which are numbered to correspond to the abiotic groups on the map.

1. More than half of Blandford-Blenheim Township in eastern Oxford County is covered by the Waterloo Sand Hills physiographic region. This distinct landscape is characterized by kame moraines subdivided by glacial spillways. Sandy soils provide high groundwater recharge potential and good drainage to the subsurface. Undulating topography creates low-lying wet environments where the water table intersects the surface, contrasting with the well-drained hills.

2a. The central portion of the Oxford Till Plain physiographic region, between the Middle and South Branches of the Thames River, has a greater proportion of sand in the soil than the other two thirds of the plain. The higher sand content creates a loam soil with moderate drainage and moderate ground water recharge potential. The drumlins and spillway channels provide moderate to undulating topographic relief across the area. The water table is influenced by artificial drainage systems in many areas; however, within the woodlots, the depth to the water table was rated as moderate.

2b. The northern third of the Oxford Till Plain physiographic region is bounded by the Trout Creek Spillway and the Middle Branch of the Thames River. Silty soil provides moderate drainage and ground water recharge potential. The topography is variable, especially where spillways have carved deep channels into the overburden. Overall the topography was rated as undulating due to the spillways. The depth to the water table is neither extremely high or low; however, drilled wells are used to obtain water from deep aquifers.

2c. The southern third of the Oxford Till Plain physiographic region, between the South Branch of the Thames River and County Road 46, contains the majority of the drumlins which comprise the Woodstock Drumlin Field. Drumlins create a more undulating topography where the steep slopes are occasionally maintained as woodlot. Silty soil provides moderate drainage and groundwater recharge potential, and the depth to the water table is rated as moderate.

3. In the southeastern corner of the County, the Norfolk Sand Plain provides a distinct physiographic region. Sandy soils are well drained with high recharge potential and a low water table. The topography across this deltaic deposit is generally smooth except where rivers and creeks have eroded channels.

4. Clay-rich soil fills the area between the Ingersoll and St. Thomas Moraines south of County Road 46. According to the Oxford County soil map, this area has moderate drainage and ground water recharge potential despite the fine-grained soil texture of the till moraine. Erosion has carried the fine-grain soil particles into this area, creating a smooth topography during the process. Depth to the water table is expected to be moderate.

5. The southern half of the Mount Elgin Ridges physiographic region exhibits silty soil with moderate soil drainage and ground water recharge potential. Erosion has leveled the typically knobby recessional moraines to produce a smooth topography across the till plain. The water table is expected to be at a moderate depth under these soil and topographic conditions.

6. A variety of glacial landforms centred around Lakeside combine to create a unique area in the County. Till plain, kame moraine and spillway are all represented within the trial landscape in this area. Soil texture is mainly sandy but silt is also represented. Soil drainage is good to moderate and ground water recharge potential will be controlled by the soil texture. Topography ranges from rolling to undulating across this area. Other portions of the County were included in this abiotic group due to the similarities in soil texture and glacial landform.

Table 2: Abiotic Groups Description

Abiotic Group	Physiographic Region	Glacial Landform	Topography	Soils Texture	Soil Drainage	Recharge Potential	Estimated Depth to Water Table
1	Waterloo Sand Hills	Kame Moraine Spillway	Undulating	Sand	Good	High	Moderate
2a	Oxford Till Plain	Till Plain	Undulating	Loam	Moderate	Moderate	Moderate
2b	Oxford Till Plain	Till Plain Spillway	Undulating	Silt	Moderate	Moderate	Moderate
2c	Oxford Till Plain	Till Plain Numerous Drumlins	Undulating	Silt	Moderate	Moderate	Moderate
3	Norfolk Sand Plain	Delta, Beach deposit	Smooth	Sand	Good	High	Low
4	Mount Elgin Ridges	Till Moraine	Smooth	Clay	Moderate	Moderate	Moderate
5	Mount Elgin Ridges	Till Plain	Smooth	Silt	Moderate	Moderate	Moderate
6	Various	Spillway Kame Moraine	Undulating	Loam	Good	Good	Moderate

4.2 Historical Forestry Assessment: 1951 to 1957 and 1978

A review of the forestry information reveals that the most abundant forest communities present across the County, fifty years ago, were sub-climax or climax communities: mesic* to dry-mesic beech/sugar maple forests and wet to wet-mesic silver maple/elm forests. In addition a higher percentage of young forests existed at that time, evident in the percentages of wet or dry shrubs shown in Table 3 and identified as young (Map 3 shows the results of the forest classification for soil moisture and stage of succession, described in section 3.4, and complements this section of the report).

The presence, shape and spatial distribution of the remaining patches of dominant forest types may have been influenced by economic considerations. For example, the value of mesic climax forest stands for timber and maple sugar production may have been an important factor in preserving these remnants. Areas with very wet soils, most prominent in abiotic group 1, may have been left, in many cases, due to the high cost and effort required to drain them for agricultural uses.

Across the County, the vegetation located along watercourses during the 1950s and 60s was predominantly early successional. This may be because historically, riparian corridors or flood plains were used for pasturing livestock if they were unsuitable for cash crops. As the farm industry changes and feedlots become more common, more lands are being left idle to regenerate.

The uniqueness of each of the eight abiotic groups in terms of their biotic characteristics becomes apparent using historical information, reinforcing both the OCTES sampling methods used and the foundation for the ABC Approach. Abiotic group 1 is the most visually distinct area in the County. Wetland vegetation is most abundant compared to any other cover type in that group. In addition, the percentage of total vegetation cover is more than fifty percent higher in abiotic group 1 than all other groups except group 3. The differences among the other seven abiotic groups are more subtle. All seven groups are fairly equally dominated by both wet and dry mesic sub-climax to climax successional forest communities. Abiotic groups 3 and 6 stand out in terms of vegetation diversity. The lowest total vegetation cover is found in group 2c which is comprised of well drained soils, most suitable for agriculture. Relatively speaking, groups 2a and 2b are very similar.

Site characteristics are also evident in the shape of remaining woodlots and wetlands and their spatial distribution across the landscape. Patterns can be observed in all eight abiotic groups. Abiotic group 1 is dominated by wetlands and irregularly shaped vegetation patches and higher overall cover. Irregular spatial patterns also exist in abiotic group 3 which is a riparian landscape; patches are clearly associated with the river corridors. The other six abiotic groups show similarities in terms of the geometrically shaped patches. Vegetation patches are, in many cases, aligned with roads, and are located between lot boundaries at the rear of farms ("back 40" woodlots). This pattern is most notable in abiotic groups 2a, 2b, 2c, 4 and 5 where prime agricultural soils exist (Table 3).

* mesic: Soil moisture regime that is intermediate between wet and dry.

Table 3: Historical Forest Composition and Structure: 1951 to 1957 and 1978

Abiotic Group	Dominant Species Associations (%)							Dominant Site Type Cover Types	Dominant Forest	Patch Shape*	Community Diversity within Patches**	Total Vegetation Cover (%)
	AS	SM	WC	AEO	BSM	SME	WDS					
1	12	4	9	12	8	27	18	Riparian Wetland	**WSc**, WY, MC	Irregular	high	22
2a	4	7	3	0	15	16	35	Upland	**MC/WSc** MY, WY, T	Geometric	low	11
2b	2	6	5	1	23	18	24	Upland	**MC/WSc** MY, WY	Geometric	low	17
2c	2	15	7	2	13	7	28	Upland	**MC** Wetland	Geometric	very low	4
3	5	2	7	1	14	16	11	**Riparian** Upland	**MC/WSc** Wsc, MSc, MY, WY	Irregular	high	9
4	4	7	2	3	18	18	22	**Riparian** Upland	mixed +	Geometric	medium	14
5	5	8	3	4	24	23	8	Riparian Upland	mixed +	Geometric	medium	10
6	5	7	11	3	13	16	25	**Wetland** Upland	**WSc**, MC	Irregular, geometric	high	11

N.B. Species association data does not include the Catfish Creek watershed area and only includes dominant species associations. Caution should be applied in using cover statistics due to the limitations of the survey criteria.
AS=Aspen, SM=Sugar Maple, WC=White Cedar, AEO=Black Ash-White Elm-Red Oak, BSM=Beech/Sugar Maple, SME=Silver Maple/White Elm, WDS=Wet or Dry Shrubs
WM=Wet Mesic, WMC=Wet Mesic Climax, WSc=Wet Sub-climax, MS=Mesic Sub-climax, MC=Mesic Climax, WY=Wet Young, MY=Mesic Young, T=Transitional
+mixed: no obvious dominants
MC - bold is dominant
*general pattern observed to be dominant, geometric refers to squared lines, straight edges
**refers to the number of community codes within a single patch (low = 1)
Data generated from UTRCA GIS services
Source: Department of Planning and Development, 1951 to 1957, Ontario Ministry of Natural Resources, 1978

4.3 Forest Cover Statistics

Both Riley and Mohr (1994) and Reid *et al*. (1996) provide forest cover comparisons for counties in southern Ontario. Using the 1981 Forest Resource Inventory (FRI), forest cover totals range from just 3% in Essex County to 21.6% in Brant County. Oxford County's forest cover is similar to Middlesex County (13.5%), higher than Perth County (9%) and lower than the other abutting municipalities including the Regional Municipality of Waterloo (14.8%) and Haldimand-Norfolk (16.2%).

Estimates of Oxford County's forest cover vary according to the source used. Based on Conservation Report forest surveys (1950s) and the 1978 Forest Resource Inventory (FRI) information, the County's forest cover appears to have increased since the 1950s. These sources reveal that the total forest cover in Oxford County was approximately 11.6%. However, according to Reid *et al*., Oxford County had 13.1% and 13.4% forest cover respectively using FRI 1958 and 1981.

According to Riley and Mohr, forest cover in Oxford County is 13.4% based on FRI 1979-1981. National Topographic Series (NTS) mapping, dated 1990, indicates that the total vegetation cover in the County today equals approximately 14%. Ontario Base Mapping (OBM), 1991, shows that approximately 12% of the land area was associated with natural features such as wetlands, woodlands and riparian corridors. In addition, Reid *et al*. (1996) note that forest cover has dropped by 1990 to 11.3% according to Ontario Hydro LANDSAT imagery, 1990.

While it is difficult to define changes in total forest cover over time due to varying mapping criteria and the limitations of each source, it seems reasonable to assume that current forest cover in Oxford County is within the range of 12 to 14% (Map 4). Using a consistent source such as the 1990 NTS, it is interesting to compare total cover by abiotic group (Table 4). When these statistics are compared to other municipalities in southern Ontario (above), it becomes apparent that abiotic group 1 in Blandford-Blenheim Township is unique in Oxford County.

Table 4: Contemporary Vegetation Cover (%) by Abiotic Group

Abiotic Group	1	2a	2b	2c	3	4	5	6	County-Wide
Percentage	32	12	11	10	17	10	10	11	14

Source: National Topographic Series, 1995, based on 1990 aerial photography. Includes areas with at least 35 percent tree or shrub coverage having a minimum height of 2 metres.

4.4 Field Assessments

The supporting document to this section is the ecologist's technical report entitled *Oxford County Terrestrial Ecosystems Study: Life Sciences Report*, Bowles, 1997. This report includes the complete set of data, scientific interpretation and details on the methods including the Floristic Quality Assessment (FQA) (Oldham *et al*., 1995). A summary of key results is located in Appendix D.

4.4.1 Patch Selection/Landowner Contact

A total of 71 forest patches in Oxford County were visited to complete the field assessments in the eight trial landscapes. This equates to 96 landowners. The number of patches surveyed for 1) breeding birds and 2) flora in each size class in each trial landscape is presented in Table 5. Although most of the patches are the same for both surveys, some differences are apparent among the smaller patches. These differences are accounted for in that linked patches were broken down into separate sections more often for the floral survey. The majority of patches originally identified in the 30 to 40 hectare size class were divided by a road or service corridor and therefore surveyed as smaller patches. This explains the lack of patches surveyed for this size class in Table 5.

Table 5: Patch Selection/Landowner Contact

Number of patches surveyed for birds and flora in each size class in each Trial Landscape. Totals in parentheses represent the original target number of patches prior to pursuing landowner consent.

BIRDS

Trial Landscape	<4 ha	4-10 ha	>10 - 20 ha	>20 - 30 ha	>30 - 40 ha	>40 ha	TOTAL
1	1	3	2			3	9
2a	3	4	1	2			10
2b	2	5	2	1			10
2c	6	1	1			1	9
3	1	1	1	2		1	6
4	2	2	1			1	6
5	1	4	2	2			9
6	4	2	2			1	9
TOTAL	20	22	12	7	0	7	68
	(22)	(19)	(16)	(5)	(5)	(9)	

FLORA

Trial Landscape	<4 ha	4-10 ha	>10 - 20 ha	>20 - 30 ha	>30 - 40 ha	>40 ha	TOTAL
1	4	3	1			3	11
2a	3	4	1	2			10
2b	2	5	2	1			10
2c	6	1	1			1	9
3	1	1	1	2		1	6
4	2	2	1			1	6
5	1	4	2	2			9
6	4	2	2			1	9
TOTAL	23	22	11	7	0	7	70
	(22)	(19)	(16)	(5)	(5)	(9)	

4.4.2 Biotic Characteristics

Community age across the eight trial landscapes was found to be generally young, with only 34% of communities described as mid-age or older. Specifically, of 145 communities, 34% were characterized as young and 32% as pioneer. According to Bowles (1997) this suggests that most of the forests examined in this study are in a disturbed successional condition, either still recovering from heavy logging or forming second growth from previously cleared land. Older, more mature community types appear to be relatively uncommon in Oxford County.

Most (88%) vegetation communities surveyed were deciduous, with only 7% mixed (deciduous and coniferous) and 6% coniferous. Many of the coniferous communities recorded were associated with plantations with the exception of trial landscape 1 which contained coniferous stands containing boreal elements not found elsewhere in the County. The dominant tree type overall was ash (white, red or green), with 36% of vegetation communities having ash as one of the dominant species. Sugar maple and beech tree types followed dominating 28% and 9% of vegetation communities respectively. The remaining 27% of communities contained other species or a mixture of tree types. Although some caution must be applied in comparing this information with the historical data, it appears that Oxford County's forests may be less mature than they were in the 1950s, probably due to logging. Beech and sugar maple are mesic climax tree species which were recorded as dominant in the 1950s.

In terms of species composition within the trial landscapes, trial landscapes 1, 3 and 6 are unique whereas trial landscapes 2a, 2b, 2c, 4 and 5 are more similar to each other. Trial landscape 1 has more mixed and coniferous communities than other landscapes.

This reflects the cooler, wetter micro-habitats found in this abiotic group. Trial landscape 1 was also distinguishable because most communities were dominated by red/green ash and trembling aspen compared with sugar maple in other landscapes. Trial landscape 3 contained a high proportion of communities reflective of river corridors; communities such as hemlock, Manitoba maple and American elm were found. Some similar community types were also present in trial landscape 1. Trial landscapes 1 and 3 were the only sample areas influenced by rivers. Trial landscape 6 contained treed communities dominated by apple and hybrid willow, both of which are introduced species which tend to invade early successional habitats.

4.4.3 Importance of Forest Cover

A clear relationship emerged between total forest cover and species diversity in the trial landscapes. This relationship is evident in both the plant and bird data collected. A strong positive correlation exists between the total number of breeding birds species and the total forest cover in each trial landscape (Figure 1). Similarly, a strong relationship also exists between the number of native plant species recorded and total forest cover in the trial landscapes (Figure 2). For birds, trial landscape 4 stood out as having a higher than expected number of species for its forest cover. This may be attributed to the Zenda Tract, a single large contiguous block of forest with a rich bird fauna. Weedy (non-native) plant species also increased with total forest cover. This information points to the relationship between total regional forest cover and total biodiversity in the landscape.

Evidence for the importance of local forest cover also arises from the field data. GIS was used to calculate the amount of forest cover within a 2 kilometre radius of the centroid of each visited patch. Native plant species richness was shown to be significantly related to local forest cover. The residuals arising from a plot of FQI versus patch size were plotted against local forest cover (residuals refer to the distance away from the line of best fit in a regression plot). Patterns were apparent in the different trial landscapes (Figure 3). Patches with greater forest cover within 2 kilometres tended to have higher floral quality for their size than similar but more isolated patches. On average, patches within trial landscape 2c had lower than expected floral quality for their size. Patches in trial landscapes 3 and 4 scored higher than expected while patches in the remaining trial landscapes showed no consistent pattern.

4.4.3.1 Importance of Linkages

Another analysis was applied to small patches (< 4ha) in isolated and linked situations. Small patches contiguous to other patches or separated only by a road or utility line showed significantly higher native plant species richness than small isolated patches. In addition, native plant species richness was significantly related to the size of linked patches (Bowles, 1997). These data show that species richness or biodiversity increases with patch proximity to other patches.

Figure 1: Bird Species Richness Plotted Against Regional Forest Cover by Trial Landscape.

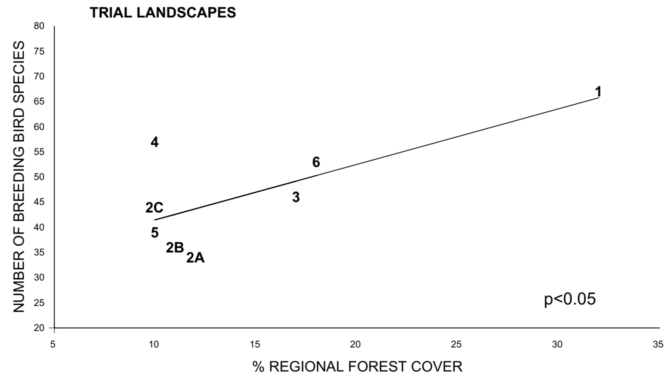


Figure 2: Native Plant Species Richness Plotted Against Regional Forest Cover by Trial Landscape.

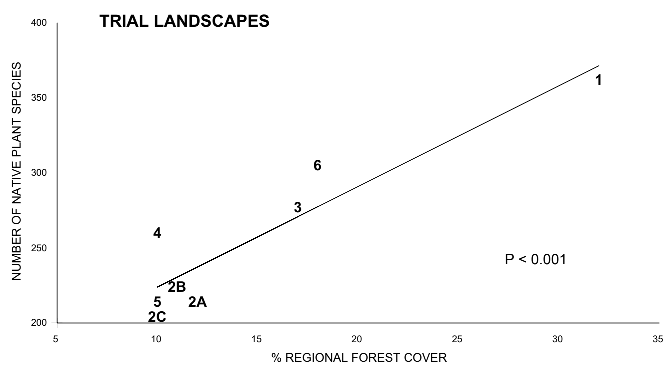
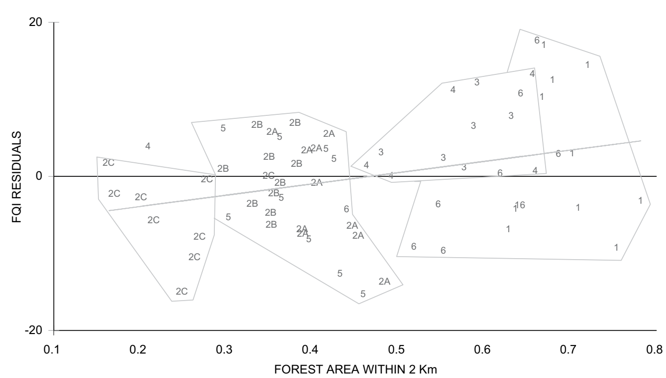


Figure 3: FQI versus Patch Size Residuals Plotted Against Local Forest Cover within 2 Km.



4.4.4 Floral Quality, Patch Size and Diversity

The Floral Quality Index (FQI) is a measurement of site quality based on plant conservatism and species richness. A strong positive relationship was found between FQI and patch size, vegetation community richness and the age of the oldest community in the patch. The age of the oldest community in the vegetation patch was a significant independent variable influencing mean conservatism but having little effect on overall species richness. Older vegetation communities are generally of higher quality than younger communities and support more conservative species. Older communities are relatively scarce in Oxford County, but appear to be important in maintaining floral quality.

Floral quality, measured by mean conservatism and FQI, was generally lowest in patches of 4 hectares or less (Table 6). In slightly larger patches between 4 and 10 hectares, FQI was higher and equal to that in any other size class except for greater than 40 hectares. Mean conservatism was not significantly different among patch size classes greater than 4 hectares. Patches less than 4 hectares should be examined and assessed on their individual merit. Generally though, both the floral quality and species richness increased with patch size. Patches between 4 and 10 hectares had unexpectedly high floral quality and species richness. Native plant species diversity was found to be related mainly to the number of communities in the patch and to patch area but also to local forest cover (within 2 kilometres), whereas weed richness was related only to community diversity and disturbance.

The analysis of species richness (diversity) for both native plants and birds among the different patch size classes showed significant relationships with patch size (Tables 6 and 7). Few forest interior birds were found in patches under 4 hectares and none were found in patches under 2.5 hectares (Bowles, 1997). The total number of breeding birds in a patch was significantly related to patch area, but also to core area (available interior forest) and to habitat diversity (number of vegetation communities) in a vegetation patch. The number of forest interior birds was found to be significantly influenced by the size of the core area and habitat diversity, but not to total patch area *per se*.

Further evidence was found supporting the value of small vegetation patches. Specifically, 19 out of a total of 91 breeding bird species recorded in this study (21%), including 7 forest interior species, were recorded in only one vegetation patch (Bowles, 1997). Similar results were found for plants: 79 native plant species out of 491 recorded for this study (16%) were recorded in only one patch. Species were found in a variety of sizes of patches. Some unique species were found in patches less than 4 hectares in area.

Table 6: Comparison of Mean Numbers of Native Plant Species, mean conservatism and FQI by Patch Size Class

Variable	Patch Size Class					F	Significance
	<4	>4 - 10	>10 - 20	>20 - 30	>40		
Native Species Richness	66.0	96.9[a]	110.5[a]	128.0[a]	207.9	32.73	<0.001
Mean Conservatism	3.91[a]	4.27[b]	4.20[ab]	4.08[ab]	4.52[b]	5.58	<0.05
Floral Quality Index	31.4	43.6[a]	46.0[a]	46.0[a]	64.8	31.33	<0.001

Means in the same row, followed by the same letter, are not significantly different from one another at p=0.05.

Table 7: Comparison of Mean Numbers of Breeding Birds and Forest Interior Birds by Patch Size Class

Variable	Patch Size Class					F	Significance
	<4	>4 - 10	>10 - 20	>20 - 30	>40		
Mean number of breeding birds per patch	11.1[a]	16.4[ab]	20.3[bc]	25.1[c]	34.8	18.88	<0.0001
Mean number of forest interior species per patch	0.5[a]	1.3[ab]	2.8[ab]	4.7[b]	5.4[b]	4.14	<0.01
n	18	23	12	9	8		

Means in the same row, followed by the same letter, are not significantly different from one another at p=0.05.

4.4.5 Forest Edge and Interior

The data analysis took into account the importance of patch shape and supply of interior forest habitat. Core area in patches was determined by measuring a 100 metre buffer from the patch margin. The proportion of the patch which was composed of edge habitat was then calculated as a ratio of edge area/total area (Bowles, 1997). Forty-six (46) percent of all of the patches surveyed in the OCTES contained no forest interior more than 100 metres in from the edge, and all of the patches studied in the OCTES were at least 52% edge.

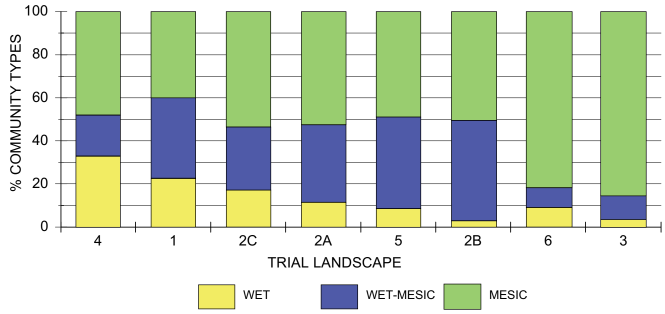
4.4.6 Disturbance

When native species richness, mean conservatism and weed species richness were analysed in relation to disturbance, weed species richness was the only variable that had a significant relationship with disturbance. Thirteen disturbance factors were assessed in the field including human-induced activities such as logging, tracks and trails, maple syrup production, etc., as well as natural disturbances such as wind storm (Appendix C). Weedy species were shown to increase with increased overall patch disturbance. Native plant species and mean conservatism had a negative association with disturbance, but the relationships were not statistically significant. This result suggests that disturbance events, as measured through the OCTES, increase the number of non-native, weedy plant populations in a patch, but may not have a significant direct effect on the native flora (Bowles, 1997). The extent of invasion between trial landscapes was not significantly different.

4.5 Correlations between Abiotic and Biotic Characteristics

Differences in moisture regimes were found by the vegetation community assessments completed in the eight trial landscapes (Figure 4). Variations in moisture regime are related to the differences in soil and physiographic characteristics, or the abiotic setting, as defined through the sampling method. Fifty-four (54) percent of the vegetation communities surveyed were mesic and the other 46% were wet-mesic or wetter. Mesic communities represent a moderate or medium degree of wetness. Trial landscapes 1, 2b, 4 and 5 showed higher proportions of wet-mesic to wet community types than the other trial landscapes. Trial landscapes 3 and 6 had the lowest proportion of wet-mesic to wet communities. Moisture regime may account for differences in biodiversity of species and habitat types across the County.

Figure 4: Proportion of Mesic, Wet Mesic and Wet Community Moisture Regimes in the Eight Trial Landscapes



Significant differences between trial landscapes were evident for both the number of bird species and the number of native plant species. These differences were related to the percent forest cover for the trial landscape (Figures 1 and 2). Significant differences between trial landscapes were not found for interior bird species specifically. Trial landscapes 1, 3, 4 and 6 had relatively high native plant species richness. These trial landscapes occur in the sandy soils of spillways and kame moraines. Trail landscapes 2a, 2b, 2c and 5 had relatively poor diversity in comparison with the other groups. These abiotic groups represent the till moraines and plains where the dominant soil texture was clay, silt or loam. Although abiotic group 4 has only 10% forest cover, the total number of native plant species in trial landscape 4 was similar to that found in trial landscape 3; abiotic group 3 has 17% forest cover. It is probable that the results for trial landscape 4, particularly in bird species, were influenced by the diversity in one very large forest patch (Zenda Tract).

The differences in moisture regimes show the most direct relationship with abiotic characteristics, confirmed through the data. Total forest cover also varies among trial landscapes and the eight abiotic groups and was found through this study to positively affect both vascular plant and breeding bird species richness or diversity. Both moisture regime and total forest cover are directly related to abiotic characteristics including soil type and topography. These factors have also been influential on human land use and spatial patterns affecting such things as the accessibility of land, drainage regime and the practicality for use.

4.6 University of Guelph Landowner Survey

A survey of landowner perceptions and attitudes toward natural heritage and conservation was conducted under the premise that the majority of woodlands in Oxford County are in private ownership and that as such, it is necessary to understand the needs of rural landowners as managers of the landscape (Vanderschot, 1997) . The overall sentiment of landowners to current conservation approaches is encapsulated in statements like the following: "The people with the best woodlots have already been taking care of or improving them for years; that's why they are there still. They assume that if a good woodlot is there, the person had nothing to do with it. Great, you've done this on your own accord and now we will take it from you" (Vanderschot, 1997, pers. com. with a landowner, p. 85).

Generally, landowners value woodlands for their ecological functions, such as shelter for wildlife, wildlife reproduction and wildlife movement across the landscape, and for their scenic function. These values were placed ahead of the economic values associated with timber and firewood management and recreational values. However, harvesting firewood was one of the most common activities, followed by allowing non-treed areas to regenerate naturally.

Although landowners recognized the value of woodlands in the landscape context, they were not always aware of the importance or significance of their woodlot within the broader context, for example, if their woodlot was designated as an ESA. Related to this, Reid *et al.* (1996) found that only 11% of eligible landowners in Oxford County are currently utilizing the Conservation Land Tax Reduction Program.

In addition, landowner understanding of biodiversity may be limited as may be reflected by the types and extent of woodlot management being undertaken. For example, Vanderschot (p. 108) states that, "To several landowners, the concept of a healthy woodlot often meant active woodlot management to remove deadwood and thorn trees and encourage specific species such as maple." Furthermore, wildlife was generally perceived to be larger mammals, and flora was perceived as major tree species or common plants. However, 65% of landowners indicated an interest in learning more about the ecological aspects of their woodland.

Landowners were supportive of the conservation and enhancement of existing woodlands with 70% of landowners willing to make improvements on their own properties. However, they had concerns surrounding the implementation of enhancement approaches related to the time and effort required, associated costs, the loss of farm land from production and a fear of potential loss of property control. Landowners were generally not interested in linking their woodlots to their neighbours', for example, because they felt that this was not practical or cost-effective. Wind breaks, shelter belts and stream buffers were preferred as conservation measures that complement agriculture. Wildlife damage was not seen as inhibitive to making improvements by the majority of landowners.

The most favoured conservation approach to encourage improvements on private property was financial and tax incentives that would assist lower income landowners and act as compensation for the loss of productive lands. Landowners also preferred the outright purchase of land over designation; ". . . where specific properties of ecological value are being considered agencies should work together with landowners to achieve a mutually beneficial arrangement or, where this is not possible, ultimately the property should be purchased" (Vanderschot, 1997, p. 113).

Designation was supported if the landowner was involved in the site assessment and the decision-making. Zoning by-laws and regulations were seen as the least effective mechanisms to protect land. Landowners generally felt that rural woodlots were protected through the existing County Tree Cutting By-law and local stewardship. They were concerned, though, about development in woodlots including golf courses and residential development and felt that designation was appropriate under these types of pressures.

Many interviewees felt strongly about their land ethic as stewards of the land. The results of the questionnaire suggested that, next to financial incentives, landowner recognition programs such as landowner contact programs, where landowners are recognized for past stewardship efforts, were highly favored. They were also very supportive of educational approaches, particularly through extension services, that would provide technical services on an individual basis. During the interviews landowners preferred education over recognition programs.

The landowners surveyed also felt it most appropriate that they carry out conservation and enhancement initiatives. Many indicated they felt their conservation efforts had not been adequately respected. A lack of trust of agencies, particularly government and non-government environmental groups (NGOs), was expressed related to perceived infringements on property rights. Vanderschot suggests that this sense of hostility toward agencies actually affects landowner willingness to make improvements to their property. The main reason cited for denying access to property for the OCTES was due to fears about loss of property rights.

5.0 Discussion

5.1 Natural Heritage Planning

Riley and Mohr (1994) suggest three key concepts in natural heritage planning: landscape retention, which refers to the protection of core areas or the key building blocks of the landscape; landscape restoration, which refers to the identification, retention and restoration of primary corridors associated with streams and rivers; and landscape replacement, which refers to the restoration and replacement of connecting links. They state, "The remnant network of natural and semi-natural areas on the landscape constitutes a linked mosaic that surrounds, connects and sustains the historic character of the landscape and its 'species and spaces at risk.' To succeed on fragmented landscapes, conservation must be systematic. Protection and conservation of natural features and functions should be considered for all the remaining natural components of the landscape. Core natural areas can be knit back together, and buffered by upland and valley corridors, and by restored lands where none exist." (Riley and Mohr, 1994, p. 32).

These concepts provide a framework to integrate and implement the OCTES findings and recommendations. The OCTES results point to the need to retain the remaining forest cover in Oxford County for its contributions to biodiversity and to increase forest cover over time, in terms of patch size and linkages between patches.

Traditionally, restoration or management has not been encompassed within the realm of planning. However, the discussion to follow will address the need for some integration of the two in order to achieve "net environmental gain." The existing remnants of once larger systems of woodlands act as the building blocks of the Oxford County landscape, upon which to restore some integrity and build a healthier natural heritage system. Data collected from the OCTES indicates that the following variables are important to maintaining biodiversity and ecosystem health: total forest cover, local forest cover, patch size, core area, habitat richness and the age or maturity of vegetation communities. These factors influence the health of the natural heritage system and, at the County level, provide the specific targets needed to achieve natural heritage goals.

5.1.1 Net Environmental Gain

As discussed in section 4.3, the current forest cover in Oxford County is in the range of 12 to 14%. The County's forest cover target is 15% over the life of the recently approved Official Plan, to the year 2011. Given the current forest cover statistics and this cover target, it is reasonable to conclude that, at minimum, existing forest cover should be preserved and net gain is needed to meet the 15% target. The County has also recognized the need for net environmental gain in Chapter 1 of the Official Plan:

> Net Environmental Gain is a working principle which strives to achieve a relative increase in environmental features and natural system functions resulting from new development or new land uses or natural resource extraction rehabilitation over the long term. Net Environmental Gain will be determined using such measures as biological diversity including species diversity, ecosystem diversity and genetic diversity within a species, system function and wildlife habitat. Net Environmental Gain will be determined by comparing the state of the local environment at a base year prior to development or rehabilitation to the long term expected results of measures taken to protect and enhance the environment given the technical feasibility of the measures proposed. The concept of Net Environmental Gain does not mean that there will be no changes in the state of the environment or tolerance for unavoidable loss on a project by project basis.
> (County of Oxford, 1995, p.1-11).

The concept of net environmental gain is key in designing and phasing in natural heritage strategies including retention, restoration and replacement. Time windows are important in assessing the effectiveness of a variety of strategies. For example, given the amount of time it takes for a forest to mature (minimum of 100 years, Gallagher, pers. com.), caution must be applied in "trade off" situations. Time is an important factor in the evolution of complexity and richness of natural areas. Monitoring is an important mechanism to ensure a net gain.

5.1.2 Retention

In the terms outlined by Riley and Mohr (1994), almost half of Oxford County's woodlots and wetlands fall into the "micro" category, between 4 and 40 hectares. More significant, is the fact that over 50% of the County's woodlots are less than 4 hectares (Table 8). Relative to patch size distribution further north in Ontario, the Oxford County fragments are considerably smaller and more isolated. The lack of meso (40 to 100 ha), meta (100 to 400 ha) or mega (more than 400 ha) patches in the landscape increases the value of smaller patches in Oxford County because these are the only remaining patches. In other words, smaller patches become elevated in status as core areas in the Oxford County landscape. Compared with other Counties located in the agricultural heartland of southwestern Ontario, Oxford County is about average in terms of overall forest cover, and considerably higher than the County of Essex which has the lowest forest cover in the region.

Some planning documents cite 4 hectares as a threshold for protection unless certain criteria are met. The recently completed City of London Subwatershed Studies did not map or assess vegetation patches less than 4 hectares (Terra Geographical, 1994). The draft *Natural Heritage Training Manual* (Ministry of Natural Resources, 1997) suggests that in planning areas with forest cover between 5 and 15 percent, woodlands 4 hectares and larger should be evaluated for significance. However, the manual suggests that woodlands below 4 hectares should be considered significant if they meet certain criteria including: size, shape, proximity to other woodlands, linkage functions, uncommon characteristics, diversity, management value and other. It is obvious from the Oxford County statistics that a lack of consideration of these small woodlots in planning decisions could result in the loss of over half of the County's current forest cover.

Table 8: Oxford County Patch Size Distribution (% cover)

<4 ha	4-10 ha	10-20 ha	20-30 ha	30-40 ha	>40 ha
52	22	15	4	2.5	5

Source: National Topographic Series, 1995.

Riley and Mohr (1994) also suggest that biodiversity may be under-represented by just preserving large patches in the landscape. Patches of varying sizes can hold rare species and contribute to overall biodiversity. Further, smaller patches may not maintain their ecological functions in the absence of the larger patches. The OCTES findings support these statements: 1) a number of both bird and native plant species were recorded in only one patch during the OCTES survey. Several species were found only in small patches; and 2) small patches contiguous to other patches or separated by only a road or utility line showed significantly higher plant species richness than small isolated patches; native plant species richness was significantly related to the size of linked patches.

In addition, the OCTES found relatively high mean conservatism scores in patches between 4 and 10 hectares in size. Statistical analysis has revealed the importance of community age in affecting mean conservatism; conservative species are native, site specific plants that are susceptible to disturbance, which is why they are likely to be found in older, better established forests. Conservative species are less common than generalist plants. The fact that more of these were found in patches between 4 and 10 hectares suggests that the patches have been preserved and managed as farm woodlots (Bowles, 1997, Vanderschot, 1997). These woodlots are the products of good stewardship; they may have been selectively logged but are generally more pristine and contain older vegetation communities than the larger patches, many of which have been heavily logged for commercial purposes.

In summary, the removal of individual patches could result in the loss of species from Oxford County. The intrinsic and the actual value of smaller vegetation patches is high in the Oxford County landscape. Although the successional state of County-wide vegetation is generally young to mid-age, the majority of patches have been intact for over 100 years and many are remnants of the original pre-settlement forest cover. The ecological complexity of these areas is not well understood and cannot be easily duplicated.

5.1.3 Restoration and Replacement

When dealing with restoration and enhancement objectives, it is important to recognize that traditionally these have not been incorporated into planning. Management techniques which include practices like tree planting, naturalization and woodlot management have traditionally been the responsibility of conservation groups or private landowners. However, planning must be involved in targeting restoration objectives in order to make decisions about existing natural areas and ensure that net gain is achieved.

Current wisdom suggests that 30% forest cover is the minimum to maintain healthy ecosystems. Abiotic group 1 is the only area in the County which has natural vegetation cover close to 30%. However, even within group 1, gaps and openings exist within the existing vegetation cover and requires in-filling either through allowing areas to regenerate or through naturalization techniques. Some patches are isolated or unconnected; riparian corridors are discontinuous and in need of linkages and corridors.

Riparian settings are important priorities for restoration because the interface between water and land provides a variety of ecotones or habitats, fulfills faunal life cycle requirements and is critical for improved water quality. Buffers provide a filtering affect from adjacent land uses. Riparian corridors are also often more practical locations for restoration work. For example, riparian areas are often unsuitable for development, have marginal agricultural uses and are preferred by landowners as areas to create linkages (Vanderschot, 1997) rather than joining woodlots separated by agricultural land. It is important to plan for contiguous riparian corridors which are not interrupted by other forms of land uses. Welsh (1991) suggests that a sufficient riparian buffer should range from 75 metres to 150 metres to protect and enhance water resources. In order to contain interior forest a riparian buffer would have to be over 200 metres wide. However, 30 metres is an accepted and realistic minimum requirement and any riparian buffer is beneficial for some ecological functions.

Creating linkages between isolated vegetation patches requires some caution. It is necessary to consider whether high quality sites should be connected to low quality sites. There is debate among ecologists about the overriding benefits for biodiversity and populations stability compared to the risks of invasion by alien species. However, the term linkage does not have to be interpreted literally. As shown by the OCTES results, patch proximity to other patches benefits native species richness (section 4.3.3.1). It may be equally beneficial to decrease patch isolation without physically connecting patches.

Buffering or "bulking up" is the restoration approach which protects natural areas from adjacent land uses and increases patch quality. This approach is often incorporated at the Environmental Impact Study stage of development. Increasing patch size should also occur proactively. The highest priority sites for applying this technique are vegetation patches which have the potential to contain forest interior based on size (4 to 30 hectares) and shape (closest to a circle) and which are located among a cluster of other vegetation patches. It is preferable to use similar native species found in the existing forest patch for this purpose. By adding area to existing patches the amount of edge habitat is reduced, forest interior can be created and local forest cover increases, benefitting wildlife movement.

5.1.4 Determining Local Significance

Section 3.2.4 of the County of Oxford Official Plan identifies criteria for local significance and allows for the designation of lands as Environmental Protection Areas (EPAs) where environmental features meet one or more of the identified criteria. According to the Provincial Policy Statement, made pursuant to Section 3 of the Planning Act: "Significant means in regard to other features and areas in policy 2.3, ecologically important in terms of features, functions, representation or amount, and contributing to the quality, diversity of an identifiable geographic area or natural heritage system. Criteria for determining significance may be recommended by the Province, but municipal approaches that achieve the same objective may also be used."

The previous discussion identifies the importance of existing vegetation patches of all size classes in the Oxford County landscape. The OCTES provides the baseline information from which local significance can be measured and determined. Baseline data shown in Tables 6 and 7 provide quality and diversity criteria for future site evaluations. Sites with quality and diversity measures which exceed the County means identified in the Tables can be considered more significant than those below the means. From this perspective, local significance is a function of relative comparison to the typical Oxford County landscape. Table 6 provides means for the vascular plant data collected in the eight trial landscapes including mean conservatism, species richness and overall Floral Quality Index. Table 7 provides means for the bird data collected in the eight trial landscapes including breeding bird and forest interior bird species richness. The Bowles (1997) report and associated database provide the detailed results and species lists for vegetation patches in the eight trial landscapes which should be referred to upon the completion of site assessments/ evaluations or impact studies, particularly when they employ the Floristic Quality Assessment method.

Other OCTES results are relevant for assessing local significance such as: the maturity (mid-age or older) of the area and the vegetation communities; whether the site contains forest interior or has the potential to contain forest interior; and whether it is located in close proximity to other vegetation patches. These are all important factors to consider. A consideration of these factors also provides some indication of restoration and replacement needs, as defined by Riley and Mohr (1994).

5.1.5 Implementation Options: University of Guelph Landowner Survey

Riley and Mohr (1994) describe natural heritage as, ". . . a concept that expresses collective and individual roles and responsibilities in relation to biodiversity. As such, it recognizes the role of humans as the critical agents of change who, at the same time, are the stewards responsible for their natural inheritances and legacy." (Riley and Mohr, 1994, p. 10).

According to Vanderschot's results (1997), private landowners in Oxford County generally feel that woodlands are protected through the existing mechanisms including the County Tree Cutting By-law and through private land stewardship. Landowners do not see tree clearing as a specific threat to rural woodlots because they do not anticipate any major changes to their management approaches in the near future. While they are supportive of the Tree Cutting By-law, they were not in favor of regulation or designations which impose on rights to property management without compensation. However, at the same time, landowners are concerned with residential housing or golf courses being permitted in woodlots and are supportive of broader controls on development if the landowner is involved in reaching the agreement. Overall, designations were seen as the least effective tool for conservation by landowners.

These results may be interpreted in two ways. First of all, it is apparent that landowners are not satisfied with the approaches taken in the past which did not involve landowners in the process to establish restrictions. Secondly, it appears that landowners' concerns about loss of property rights may be attributed to being unaware of the limitations imposed by designations. For example, landowners are not opposed to restricting development in woodlots; they are supportive of the Tree Cutting by-law. Landowners may not be aware that designations do not affect management and logging permitted under the by-law. In addition, landowners are distrustful of agencies and top-down approaches to conservation and they are generally unaware of tax incentives available to them such as the Conservation Land Tax Reduction Program. These two points together indicate the vital need for stewardship information for landowners.

Where designations are necessary, it is recommended that owners of the sites be involved at the outset; from the study to the designation stage. Through this process, efforts should be made to educate landowners about the significance of the property, the implications of and reasons for designation, management options and available tax incentives. Where the landowner is not agreeable to the designation, the feasibility of other options should be investigated including acquisition, donation and conservation easements. A more cooperative approach may encourage further conservation initiatives by landowners in future.

Financial and tax incentives were rated by landowners as the most favoured approach to encourage improvements on private property. Financial incentives are seen as the means to assist landowners. Landowners see the need to integrate ecological and economic benefits of natural heritage conservation. They perceive natural heritage stewardship as dependent upon the economic stability of their own livelihood.

Marczyk and Johnson (1993) argue that current economic incentives encourage increased productivity and the use of marginal lands in order to maximize returns. Even farm subsidies, resulting from competitive international markets, have encouraged farmers to put more acreage under cultivation. Agricultural incentives need to be balanced by natural heritage conservation incentives. Vanderschot suggests that these could range from the subsidization of tree planting programs to more market-led conservation initiatives such as those that are becoming common in Britain. The market-led approach is an area needing further investigation for its applicability in Canada as an approach that identifies environmental goods and services that will provide income to the landowner.

Further, the outright purchase of land was suggested by landowners as a means for the municipality to protect significant lands with some benefit to the landowner. Current economic conditions make this option unfeasible. However, the recent changes to the Federal Income Tax Act provide some tax incentives related to land acquisition by allowing donations to be applied against 100% of the donor's annual income. While this benefits the donor, it also has potential to benefit municipalities and conservation agencies by providing an alternative mechanism to acquire land.

Landowners are supportive of recognition for their stewardship initiatives but are generally not supportive of Conservation Easements. This may be due to a lack of information available to landowners about this option because the use of Conservation Easements is very new in Ontario. The Nature Conservancy of Canada has produced the *Landowners' Guide to Conservation Agreements* which describes conservation agreements (easements) as "a legal agreement by which a landowner voluntarily restricts or limits the type and amount of development that may take place on their land to conserve nature features." This type of agreement is registered on the title of the land and therefore exists for perpetuity. What landowners may not yet be aware of is that benefits include both the assurance that their woodlands will be preserved in the future and potential financial incentives. The other benefit of conservation easements is that they are formed in partnership between the landowner and the receiving party with the agreement being negotiated to both parties' terms.

Seventy (70) percent of landowners surveyed said that they were interested in doing enhancement work on their properties such as creating hedgerows, windbreaks and stream buffers. However, most were not interested in joining their woodlot to their neighbours' because it would result in the loss of lands from production. Riparian enhancement, though, was supported by Oxford County landowners in the survey (Vanderschot, 1997). Extension services programs were identified by landowners as the mechanism for implementation. These programs are an efficient use of a farmer's time and a needed tool for restoration to occur.

A number of literature sources have been produced which assist landowners in the areas identified though the Vanderschot survey including:

1) *Woodlands for Nature: Managing your woodland for wildlife and nature appreciation*. Lompart C, J. Riley and, J. Fieldhouse, 1997. This document covers woodlot planning and management principles and techniques related to the Ontario's Managed Forest Tax Rebate Program.

2) *Citizen's Guide to Protecting Wetlands & Woodlands*. Federation of Ontario Naturalists, 1996. This document encompasses land use planning, land acquisition and stewardship topics.

3) *Caring for Your Land: A Stewardship Handbook for Niagara Escarpment Landowners*. Hilts S. and P. Mitchell, 1994, covers ecological concepts in developing a stewardship plan.

4) *Landowners' Guide to Conservation Agreements: A New Option for Private Landowners*. The Nature Conservancy of Canada. This document explains new procedures about donations, conservation easements and the recent changes to the income tax act.

5) Fact Sheets available from your local Conservation Authority.

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Appendix A: Key Concepts for Natural Heritage Planning

Biodiversity

"Biodiversity (or biological diversity), is the variability among organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems" (United Nations Convention on Biodiversity, 1992).

Biodiversity is important at a multitude of scales and all levels within the food chain. Four levels at which to assess biodiversity are generally identified in the literature: 1) the genetic variation within a species; 2) the variation between species or the number of species; 3) structural diversity within an ecosystem such as age or strata; 4) landscape diversity including habitat types, shape and composition. " A higher genetic diversity can mean that, in life-threatening situations, an individual may have a greater chance to have genetic traits to survive the situation. Where there is a higher structural or landscape diversity, there will be a greater variety of living conditions leading to a potentially higher species diversity" (Riley and Mohr, 1994).

Carolinian Life Zone

The Carolinian life zone is the northernmost edge of eastern North America's deciduous forest region. Although it covers less than one quarter of one percent of Canada, the Carolinian zone is one ot the country's most significant regions, mostly due to its warm climate. This region provides habitat for more nationally-rare plant and animal species than any other region. Historically, 90% of the original Carolinian forest in southern Ontario has been eliminated. The remaining habitat supports 40% of all of Canada's endangered species.

Southern Ontario, which is located within both the Carolinian zone to the south and the Great Lakes-St. Lawrence region to the north, is known for the diversity of its plant and animal species. Habitats range from dune communities to marshes and swamps, and from tall-grass prairies to deciduous forests. In addition to the large number of species found in Carolinian communities there is also a large number of rare species unique to this part of the province.

Edge/Interior

The concepts of edge and interior are paramount in assessing the health of landscapes. In a fragmented environment, the abutting land use can have considerable impact on a woodlot. The outermost parts of the woodlot are exposed to increased wind, solar radiation and temperature fluctuation. In addition, species inhabiting edge habitats become vulnerable to increased predation and parasitism or invasion by aggressive plant species, usually non-native. These factors affect flora and fauna within the woodlot and overall woodlot health.

Certain bird species require habitat which is not disturbed by these types of factors in order to breed and nest successfully. They birds, which require a protected area within the forest core, are called "forest-interior birds." Numerous studies have been completed in the United States and Canada attempting to quantify the area or depth into a woodlot that these impacts might occur or in other words, the viable core area. Most studies have shown a range of intrusion depths from 100 to 300 metres into a woodlot's core from "edge effects". As such, the retention of woodlots with large cores is a primary consideration in landscape planning in order to increase the populations species at risk resulting from the loss of interior forest habitat.

Fragmentation

Fragmentation is recognized by ecologists to be one of the key problems affecting biodiversity. The natural landscape has been interrupted and subdivided by human or anthropogenic influences which have been found to reduce total habitat area and even create barriers to species' migration and survival. Through study, it has become apparent that the health and stability of natural systems is largely influenced by the isolation factor. However, the degree of impact is dependent on numerous other variables such as: the types of land uses in between fragments, the distance between patches, the size of the vegetation patches being affected. Different species require different ranges. In southern Ontario the absence of larger mammals is evidence of problems associated with fragmentation of the natural landscape into smaller, disjunct patches. As so effectively stated by Riley and Mohr, 1994, "Some species find fragmented habitats to be acceptable but are still vulnerable to extirpation because of their low numbers. Small populations can then be susceptible to slow decline, to predation or to local "catastrophic" events. Even if there are survivors, other demographic thresholds, such as too few reproductive individuals, may be violated".

Islands of Green

The theory of Island Biogeography was originally pioneered by McArthur and Wilson in 1967 for oceanic islands. Its principles have been applied to fragmented forests or "islands of green" in the terrestrial landscape because, like oceanic islands, these areas are also isolated from other forests. In other words they are islands surrounded by different types of land uses. In the most basic sense, the theory of Island Biogeography suggests that the number and variety of plant and animal species found on the island is related to the patch or island size. Large patches are more likely to contain greater habitat heterogeneity, which is directly related to the variety of species. The degree of patch isolation or the proximity to other patches also affects the number of species found on the island because the potential for immigration of new species between islands is greater. In effect, the smaller and more isolated the island is, the greater the chance that species extinction may occur (Dolan, 1993).

Linkages

Generally, there is controversy over the reconnecting of isolated fragments in the landscape. Connections can result in larger overall patch area and a greater potential for the dissemination of both flora an fauna, adding to population stability and variety. Narrow corridors and linkages (edge) have been shown to funnel invasive (non-native, aggressive, exotics) species or ecological generalists (adaptable to a variety of habitat conditions) into woodlots primarily. Thus, in the case where a high quality natural area exists, caution should be applied in the consideration of reconnecting it with the landscape. Some ecologists argue that more value may be created by "bulking up" or increasing the size of existing fragments and deceasing distance to peripheral vegetation patches.

Woodlot Shape

The shape of woodlots is largely affected by topographic and edaphic characteristics which have made lands more or less valuable and accessible to humans. Agricultural technology has created larger, less manoeuvrable equipment which has contributed to the squaring off of woodlots, leaving predominately geometric, straight-edged patches. Shape is another factor which affects total core area. Elongated or long and narrow woodlots have proportionally more edge to interior. Sizes of the core area is also important and requirements vary according to species. The ratio of these factors is important with a preference for more interior than edge. Ideally, the closer a vegetation patch is to a circle the better.

Appendix B: Abiotic and Biotic Code Systems

Abiotic Code System

Soil Texture

Cl = Clay
Si = Silt
Sa = Sand
Lo = Loam
Or = Organic

Soil Drainage

1 = Good
2 = Moderate
3 = Poor

Recharge Potential

H = High
M = Moderate
L = Low

Si 2 M Tp 1 M

Glacial Landform

Sp = Spillway
Sa = Sand Plain
Tm = Till Moraine
Tp = Till Plain
Km = Kame Moraine
Cp = Clay Plain

Topograpghy

1 = Smooth
2 = Rolling
3 = Undulating

Water Table Depth

H = High<30cm
M = Moderate
L = Low>1m

Biotic Code System

Landscape

U = Upland
R = Riparian
W = Wetland

Soil Affinity

M = Mesic
W = Wet/Mesic

Age

Y = Young
S = Subclimax
Sc = Subclimax - Climax
C = Climax
T = Transitional

U M C 12

Forest Cover Types

MY

DS = Dry Shrubs

MC

11 = Hemlock
12 = Sugar Maple, Beech, Yellow Birch
13 = Sugar Maple, Basswood
14 = Sugar Maple
57 = Beech, Sugar Maple
58 = Beech

T

59 = Ash, Hickory

'P = Plantation

MSc

4b = Cottonwood
5 = Pin Cherry
8 = White Pine, Red Oak, White Ash
9 = White Pine
10 = White Pine, Hemlock
14a = Black Cherry
47 = Black Locust
49 = White, Red & Black Oak
49a = White Oak, Black Oak, Hickory
50 = White Oak
51 = Red Oak, Basswood, White Ash
52 = Red Oak

WY

4 = Aspen
4a = Poplar
WS = Wet Shrubs

WSc

6 = Paper Birch
15 = Yellow Birch
24 = White Cedar
25 = Tamarack
26 = Black Ash, White Elm, Red Maple
45 = Burr Oak
60 = Silver Maple
60a = White Elm
88 = Willow

Appendix C: Field Forms

Standard field card used to record bird species during the OCTES survey.

BIRDS: **TRIAL LANDSCAPE:** . . . . **PATCH:** . . . .

SURVEYOR:. . . . . DATE: . . . . START TIME: . . . . FINISH TIME: . . . .

TEMP(°C): . . . . . WIND (Beaufort): . . . . . CLOUD (1/10ths): . . . . . PRECIP: . . . .

SPECIES	EV	NOTES	#	SPECIES	EV	NOTES	#	SPECIES	EV	NOTES	#
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....
....	...	....	....	....	...	....	....	....	...	....	....

BREEDING EVIDENCE:

Possible:	SH = suitable habitat	SM = singing	P = pair		
Probable:	T = territory	D = display	V = visiting nest	A = anxiety	N = nest building
Confirmed:	DD = distraction	NU = used nest	FY = fledgling	AE = nest entry	FS = food/faecal
	NE = eggs	NY = young			

OTHER EVIDENCE:

	OB = observed	VO = vocalization	CA = carcass	TK = tracks
	DP = distinctive parts	SI = other signs (specify)		

= estimated number of territories

PAGE ____ of _____

Standard field cards used to record vegetation communities.

COMMUNITY TYPES

TRIAL LANDSCAPE: .... **PATCH:** ....

DATE: .... **OBSERVER(S):** ....

START TIME: .... **END TIME:** ....

LEVEL I: T= TREES; S= SHRUBS; H= HERBS; N=NON-VASCULAR
LEVEL II: D= DECIDUOUS; E= EVERGREEN; M=MIXED; H=HERB; G=GRAMINOID; B=BRYOPHYTE
LEVEL III: C=CLOSED; O=OPEN; S=SPARSE
LEVEL IV: TREES: >25; 15-25;3-15;<3A;<3E SHRUBS: >5; >3-5; >1-3; 0.2-1 HERB:>3-5; >1-3; 0.2-1 <0.2

#	I	II	III	IV	DOMINANT(S):	UNDERSTOREY	(CVR)	MOISTURE	AGE	TOPO
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

Standard field card used to record patch disturbances.

TRIAL LANSCAPE:.. PATCH..........................

DATE: .... OBSERVER: ....

DISTURBANCE:	0	1	2	3	TOTAL
Time since logging	>30 years	15-30	5-15	0-5	
Intensity of logging	none	fuel wood	selective	diameter limit	
Extent of logging	none	local	widespread	extensive/throughout	
Livestock	none	historic	5-15 years	present	
Extent of livestock	none	local	widespread	extensive/throughout	
Alien species	none	occasional	important	dominant	
Extent of alien species	none	local	widespread	extensive/throughout	
Gaps in forest canopy	none	small	moderate	large	
Extent of gaps	none	local	widespread	extensive/throughout	
Disease/death of trees	none	occasional	moderate	many	
Extent of disease	none	local	widespread	extensive/throughout	
Plantation plantings	none	few	moderate	heavy	
Extent of plantation	none	local	widespread	extensive/throughout	
Tracks and trails	none	faint trails	well marked	tracks or roads	
Extent of tracks and trails	none	local	widespread	extensive/throughout	
Dumping	none	light	moderate	major	
Extent of dumping	none	local	widespread	extensive/throughout	
Windstorm (blowdown)	none	light	moderate	heavy	
Extent of wind damage	none	local	widespread	extensive/throughout	
Earth displacement	none	light	moderate	heavy	
Extent of earth movement	none	local	widespread	extensive/throughout	
Noise	none	slight	moderate	intense	
Extent of noise	none	rare	occasional	frequent/continuous	
Recreation use	none	light	moderate	heavy	
Extent of recreational use	none	local	widespread	extensive/throughout	
Sugar bush operation	none	light	moderate	heavy	
Extent of sugar bush	none	local	widespread	extensive/throughout	
Other..............................	none	1	2	3	
Extent	none	local	widespread	extensive/throughout	
Other..............................	none	1	2	3	
Extent	none	local	widespread	extensive/throughout	

Appendix D: Summary of Findings and Results

Key Findings/Results	Interpretation
1) A significant positive relationship exists between the number of breeding bird species and the percent forest cover in trial landscapes.	Total forest cover is important in maintaining overall diversity of breeding bird species in the landscape.
2) A significant positive relationship exists between the number of native vascular plant species and the percent forest cover in trial landscapes.	Total forest cover is important in maintaining overall native plant species diversity in the landscape.
3) A significant positive relationship exists between patch size and breeding bird species richness.	Large patches are important in maintaining overall breeding bird diversity in the landscape.
4) A significant positive relationship exists between patch core area and forest interior bird species richness.	Forest patches with large core areas are important for maintaining diversity of forest interior birds.
5) A significant positive relationship exists between community/habitat richness and both native plant and bird species richness.	Community/habitat diversity is important for maintaining both plant and bird species diversity.
6) Nineteen breeding bird species (21%), including seven forest interior species, were recorded in only one vegetation patch during the survey.	Individual patches are important for maintaining bird species diversity across the landscape.
7) Community age across trial landscapes in the study was generally young with only 34% of communities described as mid-age or older.	Forest management has not included maintaining mature forests.
8) The number of vegetation communities was significantly different among different patch size classes and increased with patch size.	Large patches are likely to support more diverse habitat.
9) Seventy-nine native plant species (16%) were recorded in only one vegetation patch in the survey.	Individual patches are important for maintaining native plant species diversity across the landscape.
10) There was a significant positive relationship between native plant species richness and the amount of forest cover within a 2 km radius of the patch.	Local forest cover is important for maintaining plant species richness.
11) Native plant species richness was greater in patches <4 ha if they were adjacent to other larger patches.	Connectivity and linkages are important for maintaining biodiversity.
12) Mean conservatism was as high in patches of size class 4-10 ha as in any other larger size class.	Some of the "best quality" patches are small.
13) Mean conservatism was significantly positively related to the age of the oldest vegetation community in a patch.	Mature communities are required for maintaining conservative species.
14) Forty-six percent of the patches surveyed contained no interior forest habitat. All of the forest patches in the study were comprised of at least 52% edge.	Patches in Oxford County are generally small and lacking core area and the potential for forest interior.
15) Patch mean wetness scores were significantly different among trial landscapes with trial landscape 1 containing the wettest patches and trial landscape 2c containing the most mesic patches.	There are significant differences in habitat type between the eight abiotic groups.
16) Weed species richness increased with increased overall patch disturbance.	Disturbance events promote non-native weedy plant species.