4. General Design Concepts

This section presents a conceptual overview of the design and management concepts for the proposed wetland restoration project. These concepts are based on funda mental principles developed largely by the Lake St. Clair Technical Committee with explicit input and refinement from the Local Advisory Committee (LAC). The concepts presented are not the proposed final or preferred conditions. They do, however, form the "base case" for the economic and biological effects assessment.

4.1 Concept Overview

The primary purpose of the project is to restore 1,000 acres of wetland habitat for staging waterfowl. The secondary purpose is to provide other environmental benefits and to generate social and economic benefits where possible. These benefits are expected to occur over a variety of spatial and temporal scales.

The restored habitat will likely consist of three to six wetland cells separated by dykes. Water levels within each cell will be controllable, thereby enabling independent management of each cell. The project will be designed and implemented to ensure that the existing Agricultural and Rural Development Act (ARDA) dyke and local drainage network and infrastructure will not be negatively affected.

Basic Cell Design

In keeping with the intent to create staging habitats, all cells will likely consist of a mix of emergent marsh and open-water habitats. These cells would provide both resting and feeding habitat for waterfowl and other wetland-dependant species.

Constructed wetland cell

To facilitate the wetland restoration, all cells will be dyked. The dykes are expected to be typical and they will be only as wide as needed to ensure structural integrity and to meet access requirements. These dykes would be vegetated and provide only limited upland habitat values.

Depending upon the topography of the acquired lands, there may be sections of land of various shapes within a cell that do not lend themselves to wetland restoration. These areas will most likely be maintained as upland habitat. Depending upon their size and other factors, they could be managed to create some of the special habitats identified below, or they could be left to naturalize on their own.

Incorporation of Optional Habitat Types

The design and management of the wetland will focus primarily on maximizing benefits to migrating waterfowl. However, the incorporation of ancillary compatible habitats has the potential to greatly increase the biodiversity and socio-economic benefits of the project; therefore, consideration is being given in the final design to the compatible needs of other migratory and non-migratory species, including vulnerable, threatened and endangered plants and animals. Habitat types that have notionally been included in the general design concepts for detailed evaluation include mud flats (approximately 50 acres), tall grass prairie (approximately 20–100 acres), and swamp (approximately 20 acres).

Access and Related Facilities

Public access to the site is important to both the Eastern Habitat Joint Venture (EHJV) partners and local citizens. Potential benefits from incorporating public access into the design include revenue from user fees and economic benefits to local and regional businesses. A small office facility would be included as part of the base case scenario for the project.

Ideally, all access to the site will be controlled through a single entry point. Most or all cells will be accessible by a trail network, although seasonal restrictions will likely apply depending on the cell type. Viewing towers will likely be constructed. Parking facilities will be constructed. Launch facilities for small (non-motorized) boats may be provided in some cells. Interpretive facilities could be incorporated into the project design.

4.2 Expected/Optional Uses

The restored wetland could provide opportunities for a variety of recreational, educational, and commercial uses by local residents, tourists, and others. It is also important that the use of the wetland generate revenues that can be used to support its ongoing maintenance and management. It will also be necessary to control public access in ways that will optimize people's enjoyment but not interfere with the purpose and value of the area as prime habitat; public use may be restricted in certain areas and during certain times of the year. Table 4.1 describes the list of likely uses for the restored wetland. This list was developed in close cooperation and detailed consultation with the LAC. Table 4.2 identifies expected uses and potential scheduling conflicts.

TABLE 4.1
PROPOSED USES/ACTIVITIES ST. CLAIR WETLAND PROJECT

Activity	Potential Capacity			Commercial Value		Use Intensity		Access	Potential Problems
	High	Low	Variable	Yes	No	High	Low		
Nature Appreciation (general birding, hikers, photography, etc.)	Habitat potential for shorebirds and related wildlife/ waterfowl Greater habitat diversity will increase appreciation opportunities			For offsite community, guiding/tour opportunities Need blinds to prevent flushing of all birds on the cell		Approx. 2,000 to 10,000 user days for shorebird viewing, depending on habitat unit and facilities General viewing nature clubs, etc.		Birders, specialized group use Level of use high if Rare/Threatened and Endangered Species (RTEs) present Control use if RTEs present Control use by: day/cell/ activity	May need to accommodate buses Site degradation with high level of use Too much traffic potential to disturb staging Potential user conflicts (e.g. hunters – birders)
Research			Proactive via networks Not impinge on wetland integrity and use (non-obtrusive)	Possibilities for commercial rice production			Spot to station research trailer Monitoring wildlife (fee to see it done (tour))		Facilities not extensive
Education 3 levels/types: - Self guided - Tours - Packaged programs	✓			Fee for access		Short-term use tours Host open houses, special events School programs (May, June) Targeted but not exclusive			Need facilities (e.g. signage, kiosk) Need to control access to avoid over use of site
Trapping Muskrat control			1 to 4 trappers, dependent on muskrat population Trapping Intensity: - Winter: 30 days - Spring: 2 weeks	✓			As needed	As needed; recreational mostly Winter/Spring	Benefit depends on prices and number of muskrat Pop'n muskrat: 5 muskrat/acre May need to pay trapper for the service

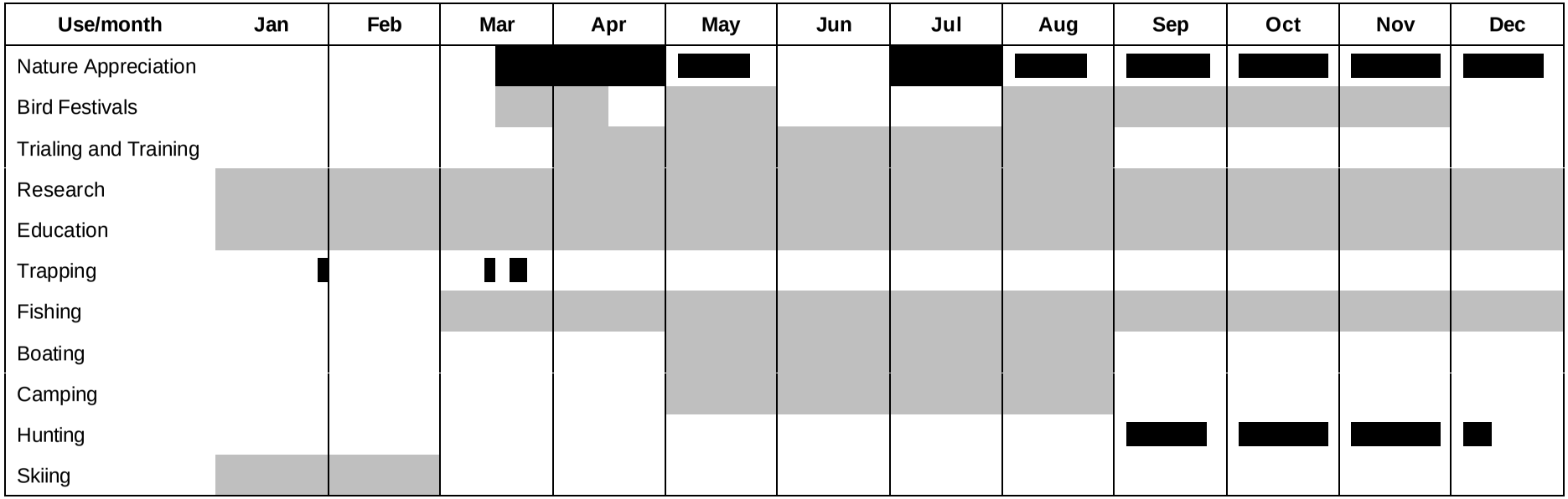
TABLE 4.1
PROPOSED USES/ACTIVITIES ST. CLAIR WETLAND PROJECT

Activity	Potential Capacity		Commercial Value		Use Intensity		Access	Potential Problems
High	Low	Variable	Yes	No	High	Low		
Fishing Several up to 100 days	Casual, low quality Species: Blue gill, crappie, and bass			✓		Not a priority use Management Implication costs	Degree of control Not allowed during staging and other times of the year No power boats	Winter kill Limited potential for development unless actively stocked and managed
Boating Not a primary activity Photography and viewing opportunities	✓		Canoe/punt boat tours/ rental Minor economic benefit for community			No motors but canoes and small boats allowed	Restricted to avoid staging disruptions Open August, early spring	Certain cells only Configuration dependent Liability issues
Camping Size: 1 to 2 ac. Site	Private/public? Target youth/ other groups		Potential fee	Some facilities required		Day use Day camps, scouts, and other groups Social/education benefit associated with special events	Closed after 9:00 p.m. Day access seasonal use	Control/insurance issues Standard waiver forms to compile by user groups to control access User group liability ensures covered
Skiing		Cross-country skiing Dependent on snow depth		Not likely due to quality of facilities		No groomed trails Occasional use by locals	No wheeled vehicles, ATVs, or snowmobiles	Surfacing on dykes governs activity types (i.e. grass vs. harder surfacing) Liability ice unpredictable which could restrict this use
Hunting **General Fee Access**		Depending on cell size/confi-guration Limited number of blinds but very high demand	Charge what the market will bear +$50 fee (per person, per half-day, per blind – 2 people per blind)		3 morning and evening hunts 500 hunter days/year		Designated Apprentice days? Designated times (i.e. 3 morning and evenings)	Competition with other marshes Efficiency/shell limits Priced to local competitors' prices Allocation for local residents

TABLE 4.1
PROPOSED USES/ACTIVITIES ST. CLAIR WETLAND PROJECT

Activity	Potential Capacity			Commercial Value		Use Intensity		Access	Potential Problems
	High	Low	Variable	Yes	No	High	Low		
Hunting High Fee Access			Unlikely unless something "above and beyond" general access blinds is available	✓			Guided hunts only in one or some cells? 500 ac. (202 ha)	Restricted if at all	Hard to charge more $ for same opportunity
Bait Fish Harvest		✓		Possible to allow commercial harvest to offset operating costs if bait fish are present in sufficient numbers			✓	Limited access No boats No access if bait fish number low	
Bird Dog Trial and Training	✓			Charge organization and portion of participants' fee goes to marsh			One weekend per year	Must be careful to control numbers to limit disturbance 60-75 ac.	Organizers will want the best piece of land/marsh to run this. Must be carefully regulated
Birding Festivals	✓			Charge a fee for parking and access			One or two weekends per year		
Bird Sanctuary			Set some areas off limits at all times Set some areas off limits according to need (i.e. nesting sites)		No		Research?		
Mineral Extraction			Check mineral rights during land acquisition phase	Possible revenue to help defer cost of operations			✓		Environmental, and aesthetic impacts must be zero
Fundraising Dinners			Limited numbers of attendees and functions	Funds to be used as operating capital					

TABLE 4.2
USES AND SCHEDULING



Use/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Nature Appreciation												
Bird Festivals												
Trialing and Training												
Research												
Education												
Trapping												
Fishing												
Boating												
Camping												
Hunting												
Skiing												

Black squares indicate more or less continuous activity.
Grey squares indicate ongoing activities, which may create conflicts.

4.3 Adjacent Land Use

An issue that must be addressed is the possibility that the placement of the wetland on the landscape could lead to new restrictions on development (over and above those that already exist) on lands that immediately surround the facility.

The wetland is expected to meet the requirements of provincial significance within a few years of construction. As such, the provisions of the wetland component of the Natural Heritage Policy of the Provincial Policy Statement would normally be expected to apply to new development proposals requiring Planning Act approvals, provided that such proposals fell within the adjacent lands as defined by the policy.

Recognizing that this project involves the creation of wetland rather than the protection of an existing wetland, and recognizing that public support is critical if the project is to proceed, the MNR, as the agency responsible for this policy, has indicated willingness to support reasonable flexibility in the application of the policy. Specifically, the MNR is willing to work with the municipality (in a manner consistent with the intent of the "have regard" provisions of Section 3 of the Planning Act) to ensure that potential constraints on development resulting from the wetland's eventual and probable status as provincially significant are minimized while ensuring adequate protection of the new habitat.

Except for those restrictions that already exist related to the application of the agricultural policies under the Provincial Policy Statement, it is unlikely that significant new restrictions will be placed on development of lands immediately surrounding the restored wetland.

4.4 Capital and Operating Budgets

Based on the general design concepts described above, an analysis was undertaken to estimate likely capital and operating budgets for the site.

Cost of Site Acquisition

Real-estate values for farmland were evaluated to assess the likely cost of acquiring 1,000 acres for the project. Data describing farm property sales in the study area from the beginning of 1998 to mid 1999 (18 months) were obtained from the Farm Credit Corporation (FCC); 26 sales were identified. Information provided for each sale included:

- Location (lot and concession)
- Date of sale
- Size of the land parcel (total land and arable land)
- Soil type (clay loam, sandy loam, muck)
- Description of structures (type, age, size, and estimated value)
- Purchase price of property ($ per acre)

These data were analyzed to determine the impact of various factors on the price of land. The most important factor, confirmed through discussion with area farmers, was the soil type; sandy loam and muck soils nearer the lake received a premium as vegetable production lands. The overall size of the property appeared to have a negative impact on the unit price. However, given the small number of observations, no significance is attached to this effect. Table 4.3 summarizes the price data for these purchases.

TABLE 4.3
SUMMARY OF PRICE DATA FOR LAND PURCHASES IN THE STUDY AREA

	All Sales		Sand and Muck Soil		Clay loam soil	
	Acres	**Hectares**	**Acres**	**Hectares**	**Acres**	**Hectares**
Total Per Acre Price	$4,320	$10,670	$4,780	$11,800	$3,980	$9,830
Per Acre Price Net of the Value of Buildings*	$4,050	$10,000	$4,510	$11,140	$3,710	$9,160

* Building values were estimated by FCC

This analysis indicates that there is, on average, a differential of $800 per acre between the price of land that will grow vegetable crops and land that is used for a typical corn/soybean rotation.

The cost of acquiring the restoration project site will depend on its potential use for crop production and on the presence of farm buildings. To estimate land costs, we assume that existing homes in the acquisition area are retained by the original owners along with an adjacent area of 1 acre (this assumes that existing buildings are located near roads around the site).

The cost of land is estimated at $4,500 per acre for vegetable land or $3,700 per acre for corn/soybean land. Therefore, the total cost of the site is expected to range from $3,700,000 to $4,500,000 and affect approximately five to eight farms.

In reviews of preliminary work with these estimates, Local Advisory Committee (LAC) members questioned the average land values described above, suggesting that these were low by $500 or more per acre, particularly for lands suitable for tomato production. There was also concern that some of the existing residential buildings would have to be demolished if located too far away from the road. A sensitivity analysis was conducted to address these concerns, and assess how the economic performance of the site would change with a higher land value. This analysis is discussed in Section 7.

The cost of land is estimated at $4,500 per acre for vegetable land or $3,700 per acre for corn/soybean land. Therefore, the total cost of the site is expected to range from $3,700,000 to $4,500,000 and affect approximately five to eight farms.

Capital Costs for Facility Development

Estimates of capital costs for facility development are presented separately for a) construction of wetland cells, b) onsite buildings and ancillary facilities, and c) additional complementary habitat.

Construction of Wetland Cells

For the purpose of determining capital costs, it is assumed that the restored wetland is located entirely on farmland. Capital costs for the development of a 1,000-acre wetland include:

- Blocking tile drains and surface drains
- Constructing dykes and land contouring
- Constructing water control structures
- Purchasing and installing pumps
- Removing fences and other small structures
- Removing unwanted buildings
- Constructing onsite facilities

Cost estimates provided by Ducks Unlimited Canada cover the first five items in the above list (West, 1999). Remaining estimates were obtained from local contractors. These costs, summarized in Table 4.4, imply a unit cost of construction between $700 and $1,700 per acre. As shown in Table 4.5, these costs fall within the mid-range of a sample of costs for the simple conversion of agricultural land into wetlands in the United States (converted to 1999 Canadian dollars). (King and Bohlen, 1995).

TABLE 4.4
WETLAND CONSTRUCTION COST ESTIMATES

Configuration	Construction Cost*		
	Low ($50/m of dyke)	Medium ($63/m of dyke)	High ($75/m of dyke)
One Cell	$667,000	$791,000	$915,000
Three Cell	$865,000	$1,039,000	$1,212,000
Four Cell	$989,000	$1,187,000	$1,385,000
Six Cell	$1,187,000	$1,435,000	$1,682,000

* Includes 15% contingency and 7% GST

TABLE 4.5
SAMPLE COSTS FOR CONVERSION OF AGRICULTURAL LAND TO WETLAND

Cost	Per Acre	Per Hectare
Average	$1,600	$3,950
Median	$800	$2,000
Minimum	$8	$20
Maximum	$34,300	$84,700

The high end of this range, in the tens of thousands of dollars per acre, may reflect the need for building removal, excessive land contouring, or other high-cost factors that are not anticipated in the Lake St Clair area. The cost estimates above are therefore considered reasonable for Lake St. Clair.

The base case design assumes a four-cell configuration; therefore, a base case wetland construction cost of $1.2-million is used for further analysis. Costs of $1.0- and $1.4-million were used in variations of the base case design, which featured fewer and more cells, respectively. The low and high cost estimates provide the basis for assigning a low–high range to each cost for purposes of the uncertainty analysis described in Section 8.

Onsite Buildings and Ancillary Facilities

Additional costs associated with the basic design include the cost of a building or buildings and the cost of additional dykes to go around residential properties that are retained. Additional dykes around residential properties are assumed to cost $23,000 (i.e. five properties, 200 m of dyke per property). The main onsite facility is assumed to be a central building to accommodate staff and provide space for volunteers. A basic 500-ft^2 facility would cost approximately $55,000 (at $110/ft^2), while a 3,000-ft^2 building with space for interpretive programs would cost approximately $330,000. An unheated 500-ft^2 workshed is included at $15,000 ($30/ft^2). Total building costs therefore range from $70,000 to $345,000, depending on the configuration.

Additional Complementary Habitat

One of the options under consideration features the addition of small areas of alternative compatible habitat types (i.e. mud flats, wooded swamp, and tall grass prairie). Mud flats differ from the "base" wetland system primarily in the management regime for water levels. No planting costs are anticipated, but there will be some additional construction costs for a dyke to isolate areas. The cost of constructing a mud flat area is assumed to include 600 m of dyke (priced at $75/m to account for additional land contouring in the vicinity of the dyke). A separate water control structure with pump at $40,000 is also assumed. The total cost, including contingencies, is $105,000. Maintenance and management costs will be higher due to more frequent pumping required on an annual basis.

Cost estimates for wooded swamp are highly variable, as shown in Table 4.6 in data from 19 projects in the United States (converted to 1999 Canadian dollars) (King and Bohlen, 1995). These costs reflect earlier experiences with this type of restoration using larger-calibre tree stock at relatively high planting densities. More recent experience indicates good results using 3-ft (1-m) saplings at planting densities that resemble final stand densities. The wooded swamp for this site is assumed to cost $7,000

per acre. This cost includes site preparation and planting and $50,000 for site contouring and dyking. The total cost for a 20-acre site is therefore estimated at $140,000 (Loftus, 2000).

TABLE 4.6
COST ESTIMATES FOR RESTORATION OF WOODED SWAMP

Cost	Per Acre	Per Hectare
Average	$128,000	$316,000
Median	$70,400	$173,900
Minimum	$1,480[1]	$3,700
Maximum	$409,000[2]	$1,000,000

Note: 1. Restoring hydrology only, no planting
2. Includes a research component

The cost of establishing tall grass prairie habitat will depend on the need for site preparation, planting method (seed or plug [seedlings]), and the type of plant mix. A cost of $4,000 per acre for plugs and $3,000 for seed can be expected for initial site preparation and planting a mixture of prairie habitat species, based on recent experience in southwestern Ontario using a mix of native plant species plugs (Ludolph, 1999, personal communication). Ducks Unlimited establishes stands of native grasses for as little as $200/acre using seed (West, 1999, personal communication). However, this program is not a true prairie restoration in that Ducks Unlimited uses a blend of warm season grasses to establish cost-effective upland wildlife habitat adjacent to wetlands. For purposes of costing in this study, a cost of $2,000/acre has been assumed, representing a compromise between the two approaches identified above. Total cost for a 20-acre site is therefore factored at $40,000. General upland habitat could be developed for much less.

Including all three ancillary habitat types in the project would add about $200,000 to site construction costs. Including only mud flats and tall grass prairie areas would add about $150,000.

Including all three ancillary habitat types in the project would add about $200,000 to site construction costs.

Cost Savings

Cost savings may occur if the site adjoins an existing wetland with a shared dyke. For instance, the opportunity to share approximately 600 m of existing dyke could reduce capital costs by about $45,000.

Capital Costs

Capital costs are expected to be contributed by EHJV project partners and will not be recovered from user fees. It is also expected that 65 percent of the capital costs will be contributed by project partners in the United States as part of ongoing commitments under the North American Waterfowl Management Plan (NAWMP).

Operating and Maintenance Costs

Operating and maintenance costs cover the following types of items and activities:

- Dyke maintenance and repair (weed and brush control, maintaining roads and pathways, trapping muskrats, repairing damage from muskrats)
- Water level monitoring and control
- Site patrols to control trespassing
- Biological monitoring (tagging, population, and species assessments)
- Managing public programs (promotions, interpretive services, publications)
- Overhead expenses (utilities, materials and supplies)
- Maintenance of grounds and buildings (lawn care, snow removal, weed control)

Information on operating and maintenance costs is summarized in Table 4.7.

TABLE 4.7
OPERATING AND MAINTENANCE COST DATA

Item	Description	Annual Amount	Source
Individual Cost Items			
Dyke maintenance	Weed control, repairs	$2,500	Ducks Unlimited*
Property tax	Property tax payments or payments in lieu of property taxes if site is tax exempt	$9,000	Calculated
	Program Budgets		
St. John's Marsh	1.5 FTE and 1 seasonal	$80,000	Chapter 5
Tiny Marsh	1 part-time and 1 seasonal	$30,000	Chapter 5
Hullett Marsh	No regular staff	$15,000	Chapter 5

* (West, 1999)

Total annual operating and maintenance costs for the site are assumed at between $40,000 and $80,000. The lower cost represents programming that focuses primarily on wetland habitat functions, whereas the higher cost includes additional funds to promote and support public use and benefits of the site.

Total annual operating and maintenance costs for the site are assumed at between $40,000 and $80,000.

4.5 Summary

The restored habitat will likely consist of a series of three to six wetland cells separated by dykes. Water levels within each cell will be controllable, thereby enabling independent management of each cell.

The design and management of the wetland will focus primarily on maximizing benefits to migrating waterfowl. It is also apparent that the incorporation of ancillary compatible habitats has the potential to increase biodiversity and socio-economic benefits of the project. Therefore, in the final design, consideration is being given to the compatible needs of other migratory and non-migratory species, including vulnerable, threatened and endangered plants and animals. Habitat types that have notionally been included in the general design concepts for detailed evaluation include the following; mudflats (approximately 50 ac.); tall grass prairie (approximately 20-100 ac.); swamp (approximately 20 ac.).

Public access to the site is deemed an important feature by the EHJV partners and the local citizens. Potential benefits to be realized from incorporating public access into the design include revenue generation from user and user fees as well as economic benefits to local and regional businesses.

Table 4.8 summarizes the capital and operating costs detailed in this chapter.

TABLE 4.8
PROJECTED CAPITAL AND OPERATING BUDGET

Site Acquisition	$3,700,000 to $4,500,000
Wetland conservation (4 cell base case)	$1,200,000
Other Costs	
Dykes around residential properties	$75,000
Buildings – enhanced program	$70,000
– basic design	$345,000
Alternative Habitats	
• Mud flat area	$105,000
• 20-acre wooded wetland	$140,000
• 20-acre tall grass prairie	$40,000
• Cost savings for adjoining existing wetland	($100,000)
Other costs for basic facilities	$0.07 to $0.3 million
Costs for other habitats	up to $0.2 million
Total Annual Operating and Maintenance	$40,000 to $80,000

5. Comparative Analysis of Wetland Restoration Projects

5.1 Comparative Sites Analysis

A key step in the methodology was a comparative analysis of other restored wetland sites. Given that there are few suitable empirical studies in the literature, in order to assess the potential effects of the project it was essential to collect and interpret data from professionals experienced in restoring and managing similar habitat from comparative sites within the Great Lakes basin.

This section analyzes wetland restoration and management experiences in several locations with a view to highlighting implications for the proposed project. The following seven sites were selected for analysis:

- St. John's Marsh Wildlife Area, Michigan
- Ottawa Wetland Complex, Ohio
- Pickerel Creek Wildlife Area, Ohio
- Montezuma Wetland Complex, New York
- Hullet Provincial Wildlife Area, Ontario
- Tiny Marsh Provincial Wildlife Area, Ontario
- Hilliardton Marsh Provincial Wildlife Area, Ontario

The locations of these sites are presented in Figure 5-1. Sites were selected based on their potential comparability to the Eastern Habitat Joint Venture (EHJV) project and their ability to provide a range of acquisition and management experiences. The St. Clair National Wildlife Area (NWA) was not selected as a comparative site as it does not provide a good comparison in terms of the uses and facilities envisioned for the restoration project.

Each wetland site is described briefly below, followed by a more detailed comparative analysis. A summary table of findings is provided at the end of the section.

5.2 St. John's Marsh Wildlife Area, Michigan

St. John's Marsh Wildlife Area (St. John's Marsh) is a 2,500-acre site located on the St. Clair River delta about 30 miles (48 km) south of Port Huron, Michigan, and less than 50 miles (80 km) northeast of downtown Detroit. The Michigan Department of Natural Resources started acquiring wetland and farmland on the site in 1976, and began dyking and restoring 200 acres of land to wetland in 1988. The restoration

Legend

- Comparative Wetland Locations

Project 118800.TT01	**Date** Jan. 2001
Scale NTS	**Drwn/Chkd** JPC / SND

N W E S

Figure 5-1

Comparative Wetland Locations

1962.01.figure11

CH2MHILL

EHJV•PCHE

project was completed several years ago. Surrounding land use includes a mix of agriculture and permanent and seasonal residences. The nearest town, Algonac, has a population of 4,500.

The site comprises 1,700 acres of natural coastal marsh, with 200 acres of dyked restored wetland (three cells ranging in size from 8 to 106 acres). Two of the cells are permanent marsh; one is seasonally flooded during the spring and fall waterfowl migrations. The remaining 600 acres is upland habitat, on which some prairie restoration is occurring.

As a state wildlife area, the site is managed to protect wildlife while providing a range of recreational opportunities including hunting, nature viewing, fishing, and education. More than 10,000 users visit the site annually.

5.3 Ottawa Wetland Complex, Ohio

The Ottawa Wetland Complex is an 8,250-acre site comprising the 5,600-acre Ottawa National Wildlife Refuge (Ottawa Refuge), the 650-acre Metzger Marsh Wildlife Area (Metzger Marsh), and the 2,000-acre Magee Marsh Wildlife Area (Magee Marsh). The Ottawa Refuge is federally owned and managed by the U.S. Fish and Wildlife Service; the two marshes are both owned and managed by the Ohio Division of Wildlife. This complex is located along the Lake Erie shore about 15 miles (24 km) east of Toledo, near Oak Harbor, Ohio. Land was acquired for the Ottawa Refuge in 1961, and dyking and wetland restoration started soon after. In total, more than 7,200 acres of wetland have been restored in an area where marshes historically covered 30,000 acres (known as the Black Swamp) until extensive agricultural land drainage occurred earlier this century (U.S. Fish and Wildlife Service, 1963). The surrounding land use is predominantly agricultural, with some seasonal residences and Crane Creek State Park nearby. The nearest town, Oak Harbor, has a population of 2,600.

The Ottawa Refuge, managed by the U.S. Fish and Wildlife Service, contains 200 acres of natural marsh, 4,860 acres of dyked restored marsh (25 cells of 60-500 acres), and about 540 acres of upland. The Metzger Marsh is a single 620-acre dyked restored marsh cell with 30 acres of adjoining upland, and the Magee Marsh is 1,800 acres of dyked restored marsh (10 cells) and 200 acres of upland.

As a federal wildlife refuge, the Ottawa site is managed for wetland-dependent species first, with recreational use as a secondary objective. Activities include nature viewing, hiking, education, and limited hunting. The state-owned Metzger and Magee marshes are managed for wildlife, especially waterfowl, and recreation. Activities include nature viewing, hunting, fishing, and hiking. Additionally, there is a nature centre, a 4,000-ft marsh boardwalk, and a 50-ft observation tower at

Magee Marsh, with swimming along the Lake Erie shore. Bird watching is especially popular at the Magee and Ottawa sites. Total annual visitation to the sites is 100,000 and 115,000, respectively. Many of the Magee visitors also visit the adjoining Ottawa site.

5.4 Pickerel Creek Wildlife Area, Ohio

The Pickerel Creek Wildlife Area (Pickerel Creek) is a 3,000-acre site on Sandusky Bay, about 15 miles (24 km) west of Sandusky and 50 miles (80 km) east of Toledo. The Ohio Division of Wildlife acquired farmland and began to dyke and restore 2,000 acres of farmland to wetland in 1992. The surrounding land use is agricultural and residential. The nearest town, Clyde, has a population of 5,800 and is about 10 miles (16 km) away.

The site comprises 2000 acres of dyked restored wetland (primarily marsh, with some wet forest, open water and wet meadow) in 30 cells ranging from 25 to 300 acres. The remaining 1,000 acres are predominantly upland.

This state wildlife area is managed for wetland-dependent wildlife and recreation. Activities at the site include waterfowl hunting, nature viewing, fishing, and hiking along Sandusky Bay. About 16,000 visitors use the site annually.

5.5 Montezuma Wetland Complex, New York

The Montezuma Wetland Complex (Montezuma Complex) includes more than 36,000 acres of wetland, farmland, small woodlots, grassland, and small rural communities located between Cayuga Lake and Lake Ontario, 30 miles (48 km) west of Syracuse and 40 miles (64 km) east of Rochester. It is a major commitment to the North American Waterfowl Management Plan, and the wetlands in the complex are a registered national natural landmark.

The complex includes the U.S. Fish and Wildlife Service's Montezuma National Wildlife Refuge (Montezuma Refuge) and the New York Department of Environmental Conservation's Northern Montezuma Wildlife Management Area (WMA). The remainder of the complex is mostly private land (predominantly farmland) that is subject to an ongoing public acquisition program by the U.S. Fish and Wildlife Service and New York Department of Environmental Conservation, supported by Ducks Unlimited Inc. and The Nature Conservancy. In the centre of the Northern Montezuma WMA is the community of Savannah, with a population of about 300. On the fringe of the WMA are the communities of Clyde (population 2,400), Port Bryon (population 1,300), and Seneca Falls (population 7,400).

In the nineteenth century, the 40,000-acre Montezuma Marsh extended 12 miles (19 km) northward from Cayuga Lake. By the early 1900s, most of this wetland was lost to agricultural drainage and construction of the New York Barge Canal. In 1932, the state purchased a small portion of the former marsh and established the Howland Island Wildlife Management Area. Between 1933 and 1941 about 300 acres were dyked and restored to wetland. In 1937, the federal government acquired more than 6,000 acres of farmland (former marsh) to establish the Montezuma Refuge. Dyking and wetland restoration started soon after. Currently, the refuge occupies 7,068 acres of land, including 3,600 acres of dyked restored marsh in nine cells ranging from 5 to 1,300 acres in size. Woodlands and grasslands make up the remainder of the refuge. The Northern Montezuma WMA, which incorporates Howland Island, totals 7,657 acres, including 5,360 acres of dyked restored wetland marsh in numerous cells from 5 to 80 acres in size. There are also some natural wet forests on the state-owned lands.

As a national wildlife refuge, the Montezuma site is managed primarily for waterfowl and other migratory birds, but also provides compatible wildlife-dependent recreational and educational opportunities. Facilities include a nature centre, observation towers, a 3.5-mile (5.5-km) self-guided automobile wildlife drive, and a 2-mile (3-km) walking trail. Limited hunting of waterfowl and deer is permitted. Annual visitation to the Montezuma Refuge is almost 140,000, while at least 2,500 visitors use the Northern Montezuma WMA.

5.6 Hullett Provincial Wildlife Area, Ontario

Hullett Provincial Wildlife Area (Hullett Marsh) is a 5,200-acre site located in Huron County, Ontario, near Clinton (population 3,000) and Goderich (population 7,500). Although the area is owned by the Ontario Ministry of Natural Resources, it is managed by Ducks Unlimited Canada in partnership with Friends of Hullett Inc., a not-for-profit group of volunteers.

The site consists of a variety of upland and wetland habitats. Most of the 1,680 acres of wetland have been dyked to create a diverse marsh/open water/flooded willow and timber complex. The area provides recreational opportunities including hunting (waterfowl, upland game, and deer), dog trials, hiking, canoeing, bird watching and nature viewing, and education. Active management in the area includes a focus on increasing opportunities for upland bird hunting, particularly for pheasant. The best estimates suggest that some 5,000 visitors use the area annually; the proportion drawn by or using the wetland area is not clear.

5.7 Tiny Marsh Provincial Wildlife Area, Ontario

Tiny Marsh Provincial Wildlife Area (Tiny Marsh) is located in Tiny Township in north Simcoe County, Ontario. The nearby towns of Elmvale and Wasaga Beach have populations of 1,200 and 5,000, respectively. Some 1,400 acres of marsh are included in the 2,300-acre site. The upland portion of the site contains both natural habitat and agricultural fields that are leased to local farmers for hay production.

The marsh was originally drained in the early 1900s for agriculture; in 1967, the province purchased the area, dammed ditches, and restored wetland. In 1980, with the involvement of Ducks Unlimited Canada, the marsh was divided into three cells for water level management. Tiny Marsh is managed as a multi-purpose recreational area, with the primary objective of diversifying habitat and enhancing waterfowl production.

The site attracts 10,000 to 12,000 visitors annually. The principal activities include general outdoor recreation, hunting, and education. Day-to-day management of the PWA is led by the voluntary charitable M.T.M. (Marl, Tiny, Machedash) Conservation Association.

5.8 Hilliardton Marsh Provincial Wildlife Area, Ontario

Hilliardton Marsh Provincial Wildlife Area (Hilliardton Marsh) is located in the Little Clay Belt in northeastern Ontario. The nearest town, Englehart, has a population of 1,800. The 1,790-acre site consists of 506 acres of marsh, shrub and forested swamp, fen and sphagnum bog complex, as well as adjacent forested and marginal agricultural lands. The marsh area has been divided into four dyked cells; these also include some other wetland types. A portion of the area (778 acres) consists of unalienated Crown lands, and the remainder consists largely of abandoned agricultural lands that reverted to public ownership.

The area was subject to the Class EA for Small Scale MNR Projects and approved for implementation in 1993. The official opening of the Hilliardton site took place in 1996.

The general management objectives provide for biodiversity and recreational benefits, but focus on increasing habitat for waterfowl breeding and rearing. There are no assessments of visitation, although estimates suggest that the number may be in the order of 1,000 annually.

5.9 Comparative Analysis

Restoration of wetland habitat was a key aim in the development of each of the seven sites. The comparative analysis highlights the following characteristics:

- Management objectives
- Activities, services, and facilities provided
- Waterfowl, other wildlife, and wetland management
- Visitation, promotion, and economic impacts
- Relationships with surrounding landowners
- Staffing and budgets

Management Objectives

In the United States, the management objectives for the federally-owned Ottawa and Montezuma Refuges differ somewhat from those for state-owned wildlife areas. As federal refuges, the Ottawa and Montezuma sites are managed primarily as resting, nesting, and feeding habitat for wetland-dependent wildlife, including waterfowl. Wildlife-compatible education and recreation are secondary objectives. On the other hand, the state-owned wetland sites in Michigan, Ohio, and New York give equal emphasis to wildlife and recreation objectives. To varying degrees across the four American wetland sites, attention is also given to managing grassland and forest habitats.

The three provincial wildlife areas differ in specific management objectives, principally reflecting their varying habitat conditions and opportunities for recreational and other activities. In addition to the marsh area, Hullett Marsh has a large area of upland habitat that attracts game and deer hunters and participants in dog trials. Tiny Marsh also contains areas that are attractive to upland game hunters. In the Ontario provincial wildlife areas the management focus is on enhancing waterfowl habitat; however, with a greater potential visitor base in its region, the management of Tiny and Hullett marshes extends more to managing those areas for multi-use recreation. Hilliardton Marsh was established recognizing that the limiting factor concerning waterfowl in the Little Clay Belt was the lack of brood rearing habitat, thus the priority to create and enhance marshes in the region.

Activities, Services, and Facilities

General Recreation

Several recreational activities are permitted at all of the wetland sites, while others are permitted at only one or two. Hiking, nature viewing, photography (including bird watching), and cross-country skiing are permitted at all sites, with no limitations on the number of users. These activities are facilitated by trails at all sites; observation towers at Tiny

Marsh, Hullett Marsh, Magee Marsh, Pickerel Creek and Montezuma Refuge; a 4,000-ft (1,200-m) boardwalk at Magee Marsh and a short boardwalk at Tiny Marsh; picnic sites at Hullett Marsh, Magee Marsh, Montezuma Refuge and Northern Montezuma WMA; and washrooms at Tiny Marsh, Hullett Marsh, Ottawa Refuge, Magee Marsh and Montezuma Refuge. There may be some restrictions to where hiking, nature viewing, and cross-country skiing can occur. For example, use may be confined to hiking trails, boardwalks, and observation areas (e.g. Montezuma Refuge), or specific marsh cells may be designated no-trespassing zones for periods of the year (e.g. Hullett Marsh during waterfowl brooding, Northern Montezuma WMA due to nesting bald eagles). These activities may also be prohibited on specific days when waterfowl, deer, or small game hunting occurs or when bird banding programs are underway. St. John's Marsh, for example, is closed to these activities on the first two days of waterfowl hunting, and hiking trails are closed at Ottawa and Montezuma Refuges during deer hunting. At Hullett Marsh and Tiny Marsh access is restricted in specified sanctuaries and baited areas.

Boardwalk for wetland viewing

Hunting, Trapping, and Fishing

Waterfowl hunting is permitted at all sites, though specific management of hunting and trapping differs from site to site. Blinds are provided at Magee Marsh only. Waterfowl hunting is limited through a lottery system at Ottawa and Montezuma Refuges, Pickerel Creek, and St. John's Marsh. For example, 20 hunting parties of two persons are drawn for each day of hunting. At Hullett Marsh there is a draw for opening day of the season, but the area operates on a first-come, first-serve basis thereafter. There are no limits placed on numbers of waterfowl hunters at the Northern Montezuma WMA. At Hilliardton Marsh, the number of hunters is restricted solely by the number of available parking spaces (10), and access is granted on a first-come, first-serve basis. In the past, when the number of hunters in Tiny Marsh was greater on opening day (up to 700) a limit of 300 free permits was introduced on a first-come, first-serve basis. More recently, as the number of hunters has dropped (typically to about 150 on opening day), no quota system has been used, although fees have been introduced.

Waterfowl hunting is permitted at all sites, though specific management of hunting and trapping differs from site to site.

Deer and small game hunting is permitted at most of the wetland sites, though it may be limited to a few days (e.g. seven days per year at Ottawa Refuge). Bow hunting for deer is permitted at Northern Montezuma WMA and Montezuma Refuge. At Hullett Marsh and Tiny Marsh, the upland area attracts a large number of upland game hunters. Approximately 2,000 pheasant are released annually at Hullett Marsh. Pheasant hunting at Tiny Marsh has been privatized: a single operator

provides the service for about 400 hunters annually at a cost of $25 per hunt (two-bird limit).

Trapping is permitted at all sites. Trapping rights at Ottawa and Montezuma Refuges are granted to the highest sealed bid, while trapping by permit or draw is permitted at the other wetland sites. Single individuals hold trapping rights in each of the Ontario provincial wildlife areas.

Fishing is not permitted in marsh cells, except at Tiny Marsh, St. John's Marsh, and Metzger Marsh. Fishing is permitted along the Lake Erie shore at Magee Marsh, along the Sandusky Bay shore at Pickerel Creek, and in canals adjacent to Montezuma Refuge. Only canoes and car-top boats are permitted in the Northern Montezuma WMA, no motors are allowed at Hullett Marsh, and boating is permitted in the coastal (undyked) area at St. John's Marsh.

Education

Nature interpretative tours and school programs are offered at each of the wetland sites except Pickerel Creek and Metzger Marsh. These services are available only by appointment at Hullett Marsh, Ottawa Refuge, St. John's Marsh, and Northern Montezuma WMA. In 1998, 17,400 people visited the nature centre at Montezuma Refuge, and onsite environmental education was provided to 3,000 students and 400 teachers. At Tiny Marsh, interpretation and school programs are operated through the privately operated Bluewater Interpreters. A single individual can have a significant impact: at Hilliardton Marsh the number of school visits (approximately 650 student-days in 1999) and other student activities (approximately 240 student-days) have been attributed to the leadership of one teacher. Interpretation is facilitated at Tiny Marsh, Magee Marsh, and Montezuma Refuge by nature or visitor centres. Such centres are planned for Hullett Marsh, Hilliardton Marsh, and Northern Montezuma WMA.

Students visiting wetland

Research occurs at most of the wetland sites, by staff stationed at the sites or by other researchers.

Site Access and Fees

Motorized vehicle access is not permitted at most of the wetland sites. All-terrain-vehicle use is prohibited at all sites, although snowmobile trails pass through portions of Tiny Marsh and Hullett Marsh. Bicycling is not permitted at the Montezuma Refuge, even along the automobile wildlife drive. Bicyclists and hikers are more disturbing to most wildlife than people in cars (the cars act as a blind), and therefore are not permitted on the wildlife drive. Of note, staff have prepared an information sheet explaining to visitors the necessity for some restrictions on recrea tional use.

With only a few exceptions, fees are not charged for activities, services, and facilities at the wetland sites. There are fees for trapping at Ottawa and Montezuma Refuges and Magee Marsh, and normal license fees for trapping at the Ontario sites. There is a modest fee for waterfowl hunting at the Ottawa and Montezuma Refuges. At Tiny Marsh, both waterfowl and pheasant hunters pay a daily fee (and, in the case of waterfowl hunters, can purchase an annual season pass). A season membership is collected for hunters at Hullett Marsh. Other users in some sites may pass by a donation box.

Waterfowl, Other Wildlife, and Wetland Management

The Montezuma Complex has historically been significant to waterfowl and other migratory birds using the Atlantic flyway. The other comparative wetland sites are important in the context of both the Mississippi and Atlantic flyways. Hilliardton Marsh is located in a key region for waterfowl for both spring and fall migration to and from the Hudson Bay Lowlands.

All of the sites contain a range of wetland and upland habitats, although emergent marsh is often dominant. Grasslands and wet forests are important habitats at the Northern Montezuma WMA; the wet forests or swamps are particularly critical to warblers and other neotropical migrants. The marshes and adjacent Lake Erie beaches at the Ottawa Complex and Pickerel Creek are important to migratory shorebirds. Upland areas, generally agricultural and former agricultural lands, comprise the greatest area of Hullett Marsh and a significant part of Tiny Marsh and Hilliardton Marsh. The diversity of wetland types is greatest at Hilliardton Marsh, where the area includes marsh, shrub and treed swamp, fen, and bog.

Waterfowl Population

Data on waterfowl numbers are available for six of the seven sites. Unfortunately, a variety of different measures are used as the basis of the counts (e.g. peak numbers during migration, average numbers, annual total usage, and waterfowl-days of use). As a result of this inconsistency, the data are not directly comparable and, given the variety of measures and census methods, any comparison would be suspect.

Staff at St. John's Marsh report 250 breeding ducks, 40 breeding geese, and 40 breeding swans in summer. The numbers indicate a total of 15 to 20 thousand duck-days, 300 goose-days, and more than 2,000 swan-days of use during migration.

At the Ottawa Refuge, staff calculate use numbers by waterfowl days (i.e. the total of the daily numbers during the migration period). These statistics indicate a usage of about 5,000 resident duck-days, 2,000 resident goose-days and 20 resident swan-days and migratory use of 45,000 duck-days, 15,000 goose-days, and 550 swan-days.

At the Montezuma Refuge, summer waterfowl residents total 2,000 ducks and 250 geese, with migration numbers peaking at 200,000 ducks, 150,000 geese, and 1,000 swans.

At Hullett Marsh, there are about 500 ducks and 500 geese resident in the area, with peak numbers reaching 5,000 ducks, 500 swans, and an unknown number of geese during fall migration.

Staff at Tiny Marsh report 1,500 resident ducks, 800 geese, and 2 swans. Migration numbers peak at 4,000 ducks, 1,000 geese, and 4 swans.

Some sense of the variety of ducks using the larger wetland sites can be gained from a November 17, 1998 duck count at Magee Marsh. Dabbling ducks observed included 925 gadwalls; 455 mallards; 325 green-winged teal; 95 wigeons; and 30 black ducks; other ducks observed included 30 ring-necks and 30 mergansers. On the same day, at Pickerel Creek, 75 green-winged teal, 70 mallards and 2 black ducks were observed. At the Northern Montezuma WMA, eight species of duck are known to breed. At Hilliardton Marsh, the 1998 duck banding results count 362 mallards, 40 wood ducks, 20 blue-winged teals, and five other species.

Other Species

While waterfowl are important target species in managing wetlands at all the sites, management considers all native wetland-dependent species and other wildlife and habitat.

While waterfowl are important target species in managing wetlands at all the sites, management considers all native wetland-dependent species and other wildlife and habitat. Neotropical migrants, including warblers, are of considerable interest at the Montezuma and Ottawa sites, shorebirds at the Ottawa and Pickerel Creek sites and osprey, and bluebirds and flying squirrels at Tiny Marsh. Grasslands are actively managed at the Montezuma and St. John's sites, and upland habitat at Tiny Marsh and Hullett Marsh. Seeds for prairie plant re-establishment at St. John's Marsh were obtained from Lambton County, Ontario.

Managers at each site were asked to list endangered, threatened, or unusual species or habitats at their sites. These responses are summarized in Table 5.1.

A wide range of habitat and species management practices are carried out at the wetland sites. Sites use water level manipulation of wetlands, trapping, chemical control, hand removal of exotic vegetation such as purple loosestrife, and nest boxes. Burning of vegetation is not undertaken at the Ontario sites, but is practised at all U.S. sites except the National Wildlife Refuge portion of the Ottawa Complex. Biological control of purple loosestrife is practised at the St. John's, Ottawa and Montezuma sites, though with limited success at the Ottawa Refuge. Loosestrife is not identified as a particular issue at the Ontario sites; control, if needed, is usually undertaken by hand pulling or localized spraying. Warm season grasses are planted for ground-nesting species at the Montezuma site and Hullet Marsh, and native prairie grasses are planted at St. John's Marsh. Mechanical control of vegetation is practised at the St. John's and Ottawa sites.

TABLE 5.1
ENDANGERED, THREATENED, OR UNUSUAL SPECIES AND HABITATS

Habitat	Species
Hullett Marsh	Least Bittern Black Tern
Tiny Marsh	Black Tern Least Bittern
Hilliardton Marsh	Yellow Rail Black Tern Peregrine Falcon
St. John's Marsh	King Rail Eastern Fox Snake
Ottawa Complex	Bald Eagle Common Tern Cerulean Warbler Deer's Tongue Arrowhead Wapoto Wild Rice Leafy Tussock Sedge
Pickerel Creek	Eastern Fringed Prairie Orchid Wet Meadow
Montezuma Complex	Bald Eagle Cerulean Warbler Black Tern Pied-Billed Grebe Peregrine Falcon Globally-Threatened Salt Marsh Floodplain Swamp

Visitation, Promotion, and Economic Impacts

Visitation

Table 5.2 shows annual visitation estimates, by type of activity, for each of the comparative sites. Reasonably detailed data are available only for the Montezuma Complex. With the exception of the St. John's Marsh, where fishing is very popular, wildlife observation is generally the dominant activity (with its long season of activity), with much smaller levels of waterfowl and other hunting. The proportion of hunters to total visitation is higher on the state-owned Pickerel Creek and St. John's Marsh and at Hullett Marsh.

There is some variation in the drawing power of the various wetland sites. Managers were asked to estimate the percentage of visitors from each of the following origins: local (within a half-hour drive), regional (within a half to two hour drive), and distant (more than a two hour drive). Table 5.3 shows these estimates. In the United States, not surprisingly, the smaller state-owned sites attract visitors from more local origins, while the federal refuges tend to draw visitors from more distant origins. Notable, however, is Magee Marsh adjacent to the Ottawa Refuge. The Magee Marsh appears to be well known to bird

TABLE 5.2
ANNUAL VISITATION BY ACTIVITY

Activity	Hullett Marsh	Tiny Marsh	St. John's Marsh	Ottawa Complex	Pickerel Creek	Montezuma Complex
Total visitation	≈5,000	≈10,000-12,000	10,000+	115,000 ONWR 100,000 Magee	≈16,000	139,500 MNWR 2,500 NMWMA
Wildlife observation	Unknown	≈8,000-8,500	≈1,000	Most of the total visitation	≈10,000	112,400 MNWR
Waterfowl hunting	The greatest proportion of visitation	≈500-800	≈500		≈6,000	400 MNWR
Other hunting	1200	≈500	≈400			1,300
Environmental education	≈500	≈1,000-2,000				3,400*
Trapping						400
Fishing		Few	≈8,000			2,900

* Offsite environmental education is 106,000 persons annually

TABLE 5.3
DISTANCE TRAVELLED (IN TIME ONE WAY) TO THE WETLAND SITES (PERCENT OF VISITORS)

Distance Travelled	Hullett Marsh	Tiny Marsh	Hilliardton Marsh	St. John's Marsh	Ottawa Complex	Pickerel Creek	Montezuma Complex
Local (less than 0.5 hour)	15%	50%	50%	80%	50% ONWR 40% Magee	70%	30% MNWR 70% NMWMA
Regional (0.5 to 2.0 hours)	80%	45%	45%	15%	25% ONWR 30% Magee	20%	35% MNWR 20% NMWMA
Distant (more than 2 hours)	5%	5%	5%	5%	25% ONWR 30% Magee	10%	35% MNWR 10% NMWMA

watchers (Kerlinger, N.D.) and has a nature centre, which the adjacent refuge does not. In Ontario, Hullett Marsh has a larger draw regionally than do the other two sites. Tiny Marsh and Hilliardton Marsh each draw half of their visitation locally. Hullett's attraction for hunting and hunting related activities (i.e. dog trials) appears to account for more of a regional draw than the other sites.

One measure of the attraction of a recreational site is the amount of repeat visitation. Data are available only for Magee Marsh and Montezuma Refuge. Almost 77 percent of visitors to Magee Marsh are repeat visitors (Kerlinger, N.D.). At Montezuma, 46 percent are repeat visitors who visit the refuge an average of 6.2 times a year (Montezuma NWR, N.D.). Repeat visitation is generally seen as representing a high proportion at the three provincial wildlife areas in Ontario.

Although the entire summer period is generally busy, many managers reported the largest number of visitors during October-November and April-May, corresponding with fall and spring migrations of waterfowl, songbirds, and other birds. August is also a busy month at Pickerel Creek because of shorebird migration. Dog trials during spring and summer attract many visitors to Hullett Marsh. Detailed monthly visitation data are available only for Montezuma Refuge as shown in Table 5.4.

TABLE 5.4
MONTHLY DISTRIBUTION OF VISITATION AT MONTEZUMA REFUGE, 1994-98 AVERAGE

Month	Average	% of Annual	Month	Average	% of Annual
January	320	0.2%	July	11,960	9.1%
February	706	0.5%	August	15,660	12.0%
March	7,240	5.5%	September	15,140	11.6%
April	16,840	12.9%	October	21,020	16.1%
May	17,320	13.2%	November	8,820	6.7%
June	12,380	9.5%	December	3,520	2.7%

This monthly distribution is likely typical of the other sites. October and May account for almost 30 percent of annual visitation to the Montezuma Refuge.

Promotion

All of the sites are marked by roadside signage, and all sites except St. John's Marsh and Hilliardton Marsh have their own brochures and descriptions in local tourism brochures. Only the Ottawa and Montezuma refuges and the Northern Montezuma WMA use direct mailings to past users or others and have promotional campaigns. For the Ottawa Refuge, a promotional campaign involves entering a float in local festivals and parades. The Ottawa Refuge and Northern Montezuma WMA have newsletters. Hullett and Tiny Marshes and the

Ottawa and Montezuma Refuges have web-sites for advertising and promotion. Paid advertisements in newspapers, magazines and radio/TV are not used to any extent. Some special events may be advertised, for example the auto tours offered by the Ottawa Refuge and the dog trials at Hullett Marsh. Magee Marsh has a low-power radio broadcasting system to provide visitors with information, and the Montezuma Refuge plans to install a similar system. The federal wildlife refuges tend to be more heavily promoted than the other wildlife areas.

Managers were asked to indicate the most effective method(s) of promoting their wetland site. Most managers noted the importance of word of mouth. Managers of the high-visitation Ottawa and Montezuma Refuges and Magee Marsh mentioned the value of newspaper and magazine articles about the sites.

Economic Impacts

All comparative wetland sites are located in rural areas, with at least one small community within a few miles and larger urban areas within an hour's drive. Managers were asked to note any nearby businesses that might be somewhat or entirely dependent economically on the wetland site. Restaurants are reported in the vicinity of all sites, and gas stations are near all but Pickerel Creek. There are two private campgrounds near the Ottawa Complex and one near Pickerel Creek. Tourist operators at Elk Lake benefit from Hilliardton Marsh. There are motels in the vicinity of the Ottawa and Montezuma Complexes, and local hotels offer accommodation to hunters and dog trial participants at Hullett Marsh. There are bait and tackle and sporting goods establishments near Hullett Marsh, St. John's Marsh and the Ottawa and Montezuma Complexes. A variety of other businesses are located in several small communities in the vicinity of the Montezuma Complex and other sites. A reconnaissance of the Montezuma Complex revealed that some nearby landowners charge hunters for access to their fields; however, it is not known how widespread this practice is at any of the sites.

Apart from a canoe rental establishment near St. John's Marsh and Bluewater Interpreters and a pheasant guiding business at Tiny Marsh, site managers were of the opinion that none of the local businesses are largely dependent on the wetland sites. Managers were unsure of the extent to which the wetland sites create local business development opportunities.

Data on visitor spending were available for only Magee Marsh, Ottawa Refuge and Montezuma Refuge. A 1993-94 survey of visitors to Magee Marsh (many of whom also visited Ottawa Refuge) was coordinated by the Black Swamp Bird Observatory (Kerlinger, N.D.). The aim of this survey was to estimate the local economic impact of birders. Responses were obtained from 455 bird watchers, 78 percent of whom reported staying in the area for more than one day (average of 2.5 days). Average

local expenditures on lodging, meals, gasoline and other items were estimated to be $29.00 per person, per day. The study applied this average to an estimated 193,500 birders visiting the Ottawa Complex between August 1993 and July 1994 to derive a total direct local impact of $5.6 million. Also of interest is the finding that 95 percent of visiting birders combined their trip to the Ottawa Complex with visits to other birding sites, including Pickerel Creek.

A 1995-96 survey of visitors to the Montezuma site was completed by refuge staff. The 658 respondents represented all activity types (56 percent were birders). Nineteen percent of respondents reported that they would be staying more than one day (average of 2.7 nights within 20 miles). All respondents were asked to estimate expenditures within 20 miles of the refuge; the average estimated expenditure for the 305 respondents was $122.36 per visit (Montezuma NWR, N.D.). For this proportion of visitors, this represents some $7.9 million in annual local spending. It is possible that some respondents included expenditures for other members of their party; conversely, many non-respondents to this question will have incurred some local expenditures not reported above.

Relationships with Surrounding Landowners

Site managers were asked to describe complaints received from landowners within the vicinity of their site. Managers for the federal wildlife refuges reported that they do not receive landowner complaints. However, apparently there is some lingering bitterness over expropriation of some of the land acquired for the Ottawa Refuge. Some complaints are received from landowners surrounding the St. John's and Pickerel Creek sites and the state-owned portion of the Montezuma Complex. Smoke from burning prescribed for wetland management at St. John's Marsh and Pickerel Creek generated several complaints from local residents, though apparently the complaints at Pickerel Creek were not justified. Residents occasionally complain about hunters at St. John's Marsh, and about trash that is sometimes left on dead-end roads in the area. Pickerel Creek receives one or two complaints a year from residents about a dog in their backyard. Problems regarding the traffic generated by Saturday morning duck hunts at Hullett Marsh have been addressed by providing temporary parking for hunters arriving before 5 a.m. The only complaints at Hilliardton Marsh have been related to enforcement of hunting activities.

Crop depredation does not appear to be a concern for surrounding landowners.

Crop depredation does not appear to be a concern for surrounding landowners. Part of the reason for this complacency is due to changes in harvesting machinery that reduce the potential for fall depredation. Only at the Northern Montezuma WMA and Tiny Marsh was the issue even identified by the managers. The issue was raised during the development of Hilliardton Marsh, but has never been identified as a problem since the area was re-flooded. At the Northern Montezuma

WMA there is a hint of concern over crop depredation, but this was the case even before land acquisition for the site was initiated in 1992. At Tiny Marsh farmers seem to simply accept some goose damage in spring, in part because they see an advantage to the marsh's presence providing a stable water table, especially in dry years.

Compensation to local governments for property tax revenue lost to public land acquisition is an issue with the Northern Montezuma WMA, particularly because of the scale of project (7,600 acres of state-owned land, and possibly growing to 20,000+ acres). New York State does not currently have any mechanism to compensate local governments for lost tax revenue (e.g. payments in lieu of taxation). In contrast, the federal government provides such compensation for the Montezuma and Ottawa Refuges, as do Michigan (for St. John's Marsh) and Ohio (for the Metzger Marsh, Magee Marsh and Pickerel Creek). The arrangement in Ohio is at the rate of 1 percent of the total assessed property value in the municipality, which is quite minimal. The Michigan arrangement also does not fully compensate for land lost to the tax base.

In Ontario, the province provides grants in lieu of taxes to local municipalities for provincial wildlife areas; these grants are equal to the municipal tax portion of property taxes. Although an equivalent of school taxes is not provided, the difference is made up in direct grants to school boards. This effectively makes the establishment of these areas revenue-neutral from the point of view of local taxation. In Hilliardton, a portion of the area is unpatented land; therefore, no taxes for this area would be assessed in any case.

In Ontario, the province provides grants in lieu of taxes to local municipalities for provincial wildlife areas.

Some additional insights regarding relationships with surrounding landowners relate to the Ottawa Refuge and Northern Montezuma WMA. The Ottawa site has managed a cooperative farming program for some time, through which 200 acres of the refuge remains in agricultural production. If corn is grown, one-third of the crop is left in the field for waterfowl. If soybeans are grown, the farmer gives the refuge one-third of the income from the crop. This program has been a link to the local farming community, and has probably helped to reduce crop depredation. However, in response to a number of complaints about corn being grown on a National Wildlife Refuge, presumably from refuge users, the cooperative farming program is being phased out.

A somewhat similar arrangement exists at Hullett Marsh. Approximately 750 acres of the area are leased out for agricultural production. The contract is tendered every five years and includes a provision that the farmer provide, from production, the feed used in the PWA bait stations. Baiting is seen as one means of retaining waterfowl within the site, thereby reducing potential crop depredation in nearby fields.

Perhaps the most valuable insights can be gained from the experiences surrounding the Montezuma wetlands initiative. As noted above, land

acquisition has been ongoing since 1992, with the prospect of acquiring an additional 20,000 acres of rural land. Acquisition has been on a "willing seller" basis. Initially, there was considerable local opposition to the project because of the loss of farms and loss of local tax revenue. Project managers spent a great deal of time talking to civic groups and landowners in an effort to explain the project and address concerns. Some of the actions taken by managers to address concerns and "sell" the project include the following:

- A private land wetland restoration program, which restores small areas of wetland (e.g. using ditch plugs) on private land at no cost to participating landowners
- Staging acquisition and restoring wetland soon after acquisition so that local residents can see some action occurring, rather than land sitting idle
- Permitting agriculture to continue on some 800 acres of acquired land, on a rental basis, because some farming practices benefit wildlife (idle land promotes purple loosestrife)

Apparently there is now a growing recognition within the local communities that wildlife-related recreation and tourism can be a basis for economic development. The Town of Savannah, in the middle of the Northern Montezuma WMA, now has a Chamber of Commerce and is developing a town plan based on eco-tourism.

Staffing and Budgets

Table 5.5 shows the staffing and annual operating budgets for the wetland sites. Minimal income is generated from users of these sites. Trapping generates $1,500 and hunting fees generate $2,000 at Ottawa Refuge; there are fees for trapping at the other sites as well. The state generates income from the sale of souvenirs at birding events on the Northern Montezuma WMA, and sales of books and other items at the nature centres at Montezuma Refuge and Magee Marsh also generate income.

5.10 Summary

The seven wetland sites studied in this comparative analysis represent a range of wetland restoration projects in terms of size, age, level of facilities, visitation, and other characteristics. Some of these characteristics are summarized in Appendix F.

All of the sites represent wetland restoration projects involving the reflooding of land, typically agricultural land. Dyked wetland cells range from 5 to 1,300 acres in size, with an average for all seven sites of about 300 acres. The oldest restoration project is at Montezuma, dating to the 1930s; the most recent is at Hilliardton, where dyking was undertaken in the mid-1990s.

TABLE 5.5
STAFFING AND ANNUAL OPERATING BUDGET

	Staff	Budget
Hullett Marsh	None (resources provided through MNR District Office)	Cdn $15,000
Tiny Marsh	1 part-time and 1 seasonal	Cdn $30,000
Hilliardton Marsh	2 part-time	Unknown
St. John's Marsh	1.5 FTE and 1 seasonal	US $80,000
Ottawa Complex	8.5 FTE and 9 seasonal at Ottawa Refuge	US $640,000 for Ottawa Refuge
	4.5 FTE and 1 seasonal at Magee WA	US $200,000 for Magee WA
Pickerel Creek	3.5 FTE and 3 seasonal	Not available
Montezuma Complex	8.2 FTE and 1 seasonal at Montezuma Refuge	US $600,000 for Montezuma Refuge
	1.5 FTE and 1 seasonal at Northern Montezuma WMA	US $100,000 for Northern Montezuma WMA

All of the sites are actively managed. Notably, some degree of water level manipulation is practiced at all sites. Burning is practiced at three of the U.S. sites, and chemical control of vegetation is generally undertaken at all sites, although purple loosestrife is not considered a particular issue at the Ontario sites. One of the managers suggested that opportunities for habitat management were greater in larger marsh cells.

Waterfowl are an important management focus at all of the sites. However, other wetland-dependent species of animals and plants are also important, including a number of rare, endangered, and unusual species mentioned by wetland managers at six of the seven sites. The focus of management appears to be broadening even beyond wetland species, for example, prairie grassland management and management of other upland habitats is important at several of the sites.

A varying number of tourist and recreation oriented businesses are found in the vicinity of each of the wetland sites. The greatest number of these is found near the largest site, the Montezuma Complex. The fewest are found near Pickerel Creek, St. John's Marsh, and Hilliardton Marsh. A number of businesses benefit from local spending by wetland users. In fact, economic impact studies of the Ottawa and Montezuma Complexes, which attract large numbers of users, show annual local spending of almost six million and eight million dollars US, respectively. However, managers identified only a handful of specific business establishments that were totally dependent, economically, on wetland users.

Crop depredation is not a significant concern at any of the wetland sites. At a couple of the U.S. sites, smoke from prescribed burning and hunters and/or their dogs have been the cause of minor complaints

from rural residents. A more serious concern at several of the U.S. sites is the impact of the site on the local property tax base. This is particularly a problem at the Montezuma Complex because New York State has no mechanism to compensate local governments for lost tax revenue due to the restoration project of Wildlife Management Areas. Compensation arrangements exist in Ohio and Michigan, but are not generous. In contrast, Ontario's mechanism for compensation makes the establishment of Provincial Wildlife Areas more or less revenue-neutral in terms of local taxation.

6. Biological Impacts and Values

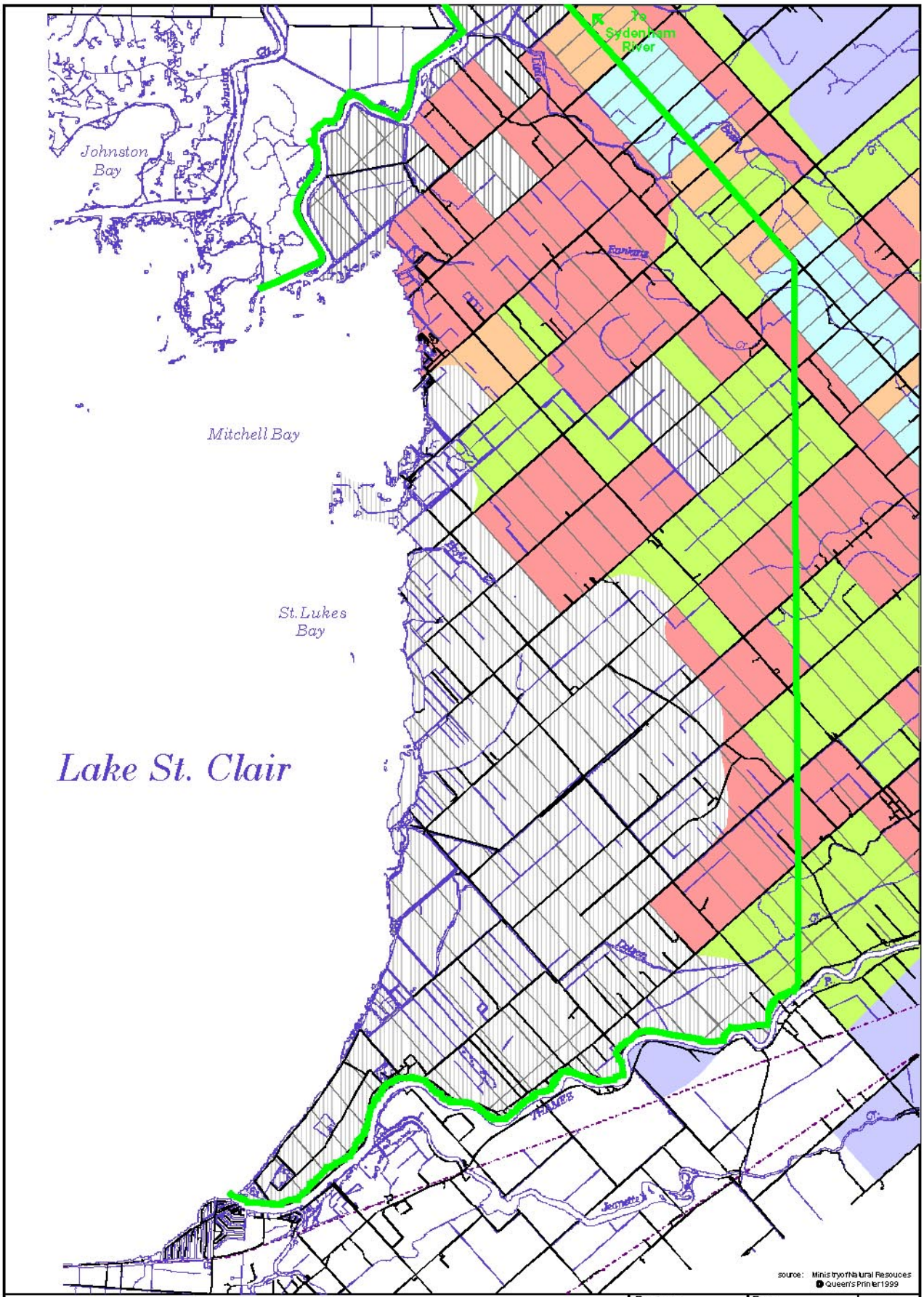
Tall grass prairie vegetation

6.1 Background

Land surveyor records from the late 18th to the early 19th century reveal that much of the Study Area was covered by "open meadow" vegetation (Figure 6-1). Although the term is ambiguous, "open meadow" likely refers to what is now called tall grass prairie as well as meadow marsh. These vegetation communities were subject to flooding events associated with the lake and the Thames River. Additional wetlands were no doubt present along Lake St. Clair itself and subject, as they are today, to lake level influences. Further inland, upland deciduous forests and deciduous swamps occurred in equal extent.

Edsall et al. (1988) report that along the Ontario shoreline of Lake St. Clair, 11,772 acres (4,764 ha) or 34 percent of coastal wetlands were lost in the delta and the lake areas between 1873 and 1968. Wetlands along the eastern shoreline of the lake were reduced dramatically between 1873 and 1968, from approximately 1.5 miles to 0.5 miles wide (2.5 km to 0.8 km). The conversion of wetlands to agriculture was the principal reason for this loss. Wetlands along the eastern shore of the lake, from the mouth of the Thames River to Chenal Ecarté, further decreased by 2,629 acres (1,064 ha) between 1965 and 1984 (McCullough, 1985). Agricultural drainage was the principal cause of this additional decline (89 percent) although some loss was due to marina and cottage development (11 percent). The wetlands on the Ontario side of the St. Clair Delta are intact in many places, but shoreline development, dredging, and placement of dredge spoils created impacts. Between 1965 and 1978, 1,255 acres (508 ha) or 4.5 percent of the wetlands on Walpole Island were lost (McCullough, 1982). Since 1978, wetland loss due to agricultural and urban development has continued in the lake and delta, albeit at a slower pace than in previous years (D. Hector, personal communication).

Current wetland mapping from the Ontario Ministry of Natural Resources (OMNR) shows the wetland area in the Study Area to be approximately 4,806 acres (1,945 ha). This figure varies considerably due to the fact that lake levels affect a large percentage of the coastal wetlands. High lake levels over the last decade resulted in a significant loss of coastal wetlands in St. Luke's Bay. However, low lake levels over the last two years have resulted in the re-establishment of some coastal wetlands. Continued low lake levels, which are predicted for the near future, will encourage the spread of wetland vegetation further into the lake.



Legend

- Road
- Streams, Creeks & Drains
- WaterBody
- Railway
- Township Lot

Vegetation Units:

- Hard Maple
- Black Ash Swamp
- Willow Swamp
- Oak
- Open Marsh
- Open Meadow

Project	Date
118800.TT.01	Jan. 2001
Scale	**Drwn/Chkd**
NTS	JPC/SND

N, W, E, S

Figure6-1

Historical Vegetation - circa l 8th century

1962.01.figure12

EH|V-PCHE

Although a substantial portion of the wetlands is still in existence, most of the remnant wetlands in the area are under a variety of stresses (Maynard and Wilcox, 1997; Reid and Holland, 1997; Chow-Fraser and Albert, 1999). Urban, recreational, and agricultural encroachment not only cause wetland loss but also stress remaining wetlands through fragmentation. Shoreline alteration, through bulkheading and dyking associated with urban areas and agriculture, severs the natural ecosystem processes between the wetlands and the lake and prevents the landward migration of the wetlands during periods of high water. Dyking can also prevent or impede the use of wetlands by fish for spawning, nursery or feeding. Bookhout et al. (1989) estimate that about half of the wetlands in Lake St. Clair and the St. Clair Delta have been dyked.

Although the Lake St. Clair area has been substantially altered from its original state, it retains remnant natural areas and ecological values of exceptional significance. For example, the Lake St. Clair shoreline (delta and eastern shoreline) was identified as a Biodiversity Investment Area at the State of the Lake Ecosystem Conference (SOLEC) in 1998 because of its aquatic ecosystems (Koonce et al., 1999), coastal wetland ecosystems (Chow-Fraser and Albert, 1999) and nearshore terrestrial ecosystems (Reid et al., 1999). Much of the significance attributed to the area is due to the considerable numbers of endangered, threatened, and vulnerable species present there.

The Lake St. Clair shoreline was identified as a Biodiversity Investment Area in 1998 because of its aquatic ecosystems, coastal wetland ecosystems, and nearshore terrestrial ecosystems.

The restoration of a 1,000 acre (405 ha) wetland would increase the area of wetlands in the Study Area by approximately 21 percent. This section will discuss the probable effects of the proposed wetland restoration on waterfowl and biodiversity.

6.2 Effects on Continental and Regional Waterfowl Populations

Background

In 1999, waterfowl in North America were estimated at 43.4 million birds, the largest estimated population since operational surveys began in 1955 (U.S. Fish and Wildlife Service 1999). Total waterfowl population estimates in 1999 were 32 percent higher than the 1955-98 average. In the Lake St. Clair area, mallards, which represent about half of all waterfowl during Fall migration (based on 1982 census of waterfowl-days (Dennis and North, 1984)) were estimated at 47 percent higher in 1999 than the 1955-98 average (U.S. Fish and Wildlife Service). Estimates in 1999 of gadwall, green-winged teal, blue-winged teal, northern shoveller, redhead, and canvasback were above their respective long-term averages; however, estimates of pintail, and scaup remained below their long-term averages.

Three to seven million waterfowl migrate annually through the Great Lakes region (Bookhout et al., 1989; EHJV, 1994; McCullough, 2000). Although substantial waterfowl production occurs in some areas, the main function of Great Lakes marshes is the replenishment of energy expended during waterfowl migration (Hoffman and Bookhout, 1985). Bookhout et al. (1989:143) state that "in the face of declining amounts of marsh, with concomitant concentration of waterfowl, the quality of the remaining Great Lake marshes is of critical importance to migrating waterfowl".

Lake St. Clair is the second most important staging area for waterfowl along the Canadian shoreline of the Great Lakes with more than 8.6 million annual waterfowl use days (Spring and Fall combined) (Dennis et al., 1984). Reid et al. (1999) state that over a million waterfowl use Lake St. Clair annually. Peak numbers of waterfowl using the Lake St. Clair marshes are estimated at 60,000 and 150,000 in Spring and Fall, respectively (Dennis and North, 1984). The marshes along the eastern shoreline of Lake St. Clair are the most important staging areas in southern Ontario for mallards, black ducks, Canada geese, and tundra swans. A large proportion of the North American population of canvas-backs and redheads also use the open water lake area for staging.

Although most of the waterfowl using Lake St. Clair for staging breed in western North America, waterfowl that breed in parts of southern Ontario also use Lake St. Clair as a staging area (McCullough, 1999). Prince et al. (1992) identified the marshes of Georgian Bay and Saginaw Bay as significant areas of waterfowl production in the Great Lakes with at least 2,100 and 4,400 nesting pairs of dabbling ducks, respectively. The Atlas of the Breeding Birds of Ontario (Cadman et al., 1987; Meredino, McCullough et al., 1995) also reveals large areas of southern Ontario with breeding records for Canada geese, wood ducks, green-winged teal, American black ducks, mallards, blue-winged teal, and mergansers.

Canada Geese

Two populations of Canada geese, the Southern James Bay Population (SJBP) and the Mississippi Flyway Giant Population (MFGP), regularly use Lake St. Clair during migration. There has been a significant increase in the size of the SJBP during the last ten years. The MFGP has only been monitored for the last 2 years and the preliminary 1999 estimate was 1,390,200 geese, which is 1.5 percent greater than the 1998 estimate (US Fish and Wildlife Service, 1999). Nelson and Oetting (1998) state that the rapid increase of giant Canada geese in the Mississippi Flyway during the past twenty years far exceeds that in any other flyway.

The eastern population of tundra swans was estimated at 109,000 individuals, which is 13 percent greater than the 1998 estimate (U.S. Fish

and Wildlife Service, 1999). However, no evidence was found to show a trend in the size of this population over the last ten years.

Although waterfowl populations in the Lake St. Clair area reflect the increase in North American waterfowl populations, it has not been determined how the use of Lake St. Clair by staging waterfowl is related to this overall increase.

Staging Waterfowl

Considerable work has been undertaken on postbreeding habitat use by waterfowl since Fredrickson and Drobney's (1979) landmark review revealed the scarcity of such information. Yet two decades later, despite increased research, the use and importance of habitats for waterfowl during migration remains a significant knowledge gap (Williams et al., 1999). Consequently, there is little research to support more than general statements about the effects of the proposed wetland restoration on migrating waterfowl.

The addition of 1,000 acres of wetland to the Lake St. Clair area should have a positive effect on the continental waterfowl population and on regional waterfowl populations.

The addition of 1,000 acres of wetland to the Lake St. Clair area should have a positive, albeit small, effect on the continental waterfowl population and on regional waterfowl populations. The principal benefit of the wetland to waterfowl will be the increase in available area for staging in the Spring and Fall. This additional staging area will primarily benefit dabbling ducks by maintaining or improving the birds fitness during migration.

The benefits provided by the restored wetland will be especially valuable during the Spring migration for several reasons:

- Spring migration is more rapid and as a result there is more crowding of available habitat at this time
- The managed drainage network in the area results in very few flooded fields (sheetwater) which restricts waterfowl to natural or managed wetlands
- Waterfowl generally have a greater demand for food (energy) in the Spring in preparation for egg laying
- Waterfowl feeding may be restricted to invertebrates since much of the vegetation has not initiated growth (BELSCWRW, 1999)

Using Canadian Wildlife Service aerial survey records for dyked wetlands along the eastern shore of Lake St. Clair, it is estimated that the restored wetland could provide 318,000 dabbling duck days during Spring and Fall migration (McCullough, 2000). Dabblers other than mallards or black ducks, such as gadwalls, wigeons, shovellers, wood ducks, green-winged teal, and blue-winged teal, would account for approximately 60 percent of wetland use during Spring migration.

Breeding Waterfowl

The principal aim of the restored wetland will be to serve as staging area for waterfowl. However, certain species of ducks will also breed in the new habitat. Therefore, the wetland will have a positive effect by adding to the North American population of waterfowl.

Based on breeding waterfowl surveys conducted by Ducks Unlimited Canada, waterfowl production could be as high as 0.85 ducks per acre, per year (Steele, 2000). If the restored wetland is highly managed, total waterfowl production from this site would be approximately 850 birds, representing about 142 broods. Most of the waterfowl produced would be mallards, with only a few from other dabbler species and diving duck species (i.e. redheads or canvasbacks).

Waterfowl nest

The above estimate assumes that all of the marsh cells will have:

- Similar waterfowl productivity
- Typical fledgling rates
- Adequate management to maintain habitat
- Similar available waterfowl pairs
- Adequate nesting sites/habitat

The first three assumptions will likely be met by the proposed wetland; however the two additional assumptions would require the use of numerous nesting cylinders along with other habitat initiatives and, therefore, are less likely to be met.

The incorporation of additional habitat types into the restoration project, specifically tall grass prairie and wooded swamp may, over time, increase the use of the site by other species (e.g. wood duck, black duck).

6.3 Local Waterfowl Population and Distribution

Background

Lake St. Clair is the second most important waterfowl staging area in Ontario. Between 1968 and 1982 there was a 37 percent increase in waterfowl numbers (from 4,973 to 6,811 individuals) during the Fall staging period along the eastern shore of Lake St. Clair (Dennis and North, 1984). However, not all waterfowl species experienced this increase; black ducks and other dabblers experienced significant decreases in numbers over the same period (36 percent and 73 percent respectively) in the Lake St. Clair marshes. Factors cited for the overall increase include expanding populations of mallards (99 percent increase) and Canada geese (190 percent

increase) and the increased use of baited sanctuaries. These baited sanctuaries are responsible for extending the duration of waterfowl use of Lake St. Clair during the southern migration period.

The distribution of staging ducks in the Study Area, as in most other areas, is influenced by three main factors:

- Available habitat and food
- Hunting and other disturbances
- Location of baited sanctuaries

Available Habitat and Food

The availability of natural foods does not assure that waterfowl will be attracted to an area. Wetland foods are only accessible if appropriate water depths are maintained during critical time periods, habitats are protected from disturbance, and habitats that provide protein and energy are close together (Fredrickson and Reid, 1988). Owen (1973 and 1976), for example, states that habitat and food availability are the most important factors influencing geese distribution, while disturbance is the most important factor controlling food and food habitat utilization.

The Study Area currently offers approximately 4,764 acres (1,945 ha) of wetlands. Local habitat and food sources for migrating waterfowl include natural and managed wetlands as well as agricultural fields.

The Lake St. Clair wetlands are particularly important for waterfowl during the Spring migration. As noted previously, the passage of waterfowl in the Spring is much more rapid and the availability of natural wetland foods may be limited. Some waterfowl (e.g. pintails) will feed on invertebrates associated with temporary surface water on agricultural fields (i.e. sheetwater), but, given the extensive drainage network in place, such areas are few in the Study Area.

In the Fall, migrating waterfowl use the wetlands and feed on available plant material. Agricultural lands are not as important for waterfowl as they once were due to the growing use of baited sanctuaries, improved efficiency of farm machinery for harvesting, and changing land use practices. Most of the wetlands managed by hunt clubs in the Study Area use baited sanctuaries to some extent to attract and retain waterfowl within their lands (BELSCWRW, 1999).

Waterfowl Responses to Hunting and Other Disturbances

Hunting can be a major disturbance to migrating and wintering waterfowl (Evenson et al., 1974; Henry, 1980; Jessen, 1981; Heitmeyer, 1985; Tamisier, 1985) and hunting from boats is particularly disturbing (Evenson and Hopkins, Jr., 1973; Joensen and Madsen, 1985). Hunting leads to great wariness in waterfowl, which increases their susceptibility

to disturbance from all human activities (Newton and Campbell, 1970; Meltofte, 1982).

Waterfowl tend to spend more time in flight during the hunting season and may change their habitat use, daily time budgets, and food habits in response to human-related disturbance (Heitmeyer, 1985). It is not uncommon for waterfowl to alter their daily activity patterns—feeding at night and spending the day in a refuge during the hunting season (Raveling et al., 1972; Thornburg, 1973; Evenson, 1974; Burton and Hudson, 1978; Owen and Williams, 1976; Maher, 1982; Madsen, 1988). In some instances, waterfowl will permanently or seasonally abandon a traditional migration or wintering area because of hunting pressure, even if food is still plentiful in the shooting zone (Berry, 1939; Owen, 1973; Newton et al., 1973; Madsen, 1988).

Baited Sanctuaries

Baited sanctuaries, which often use corn and other grains, are highly attractive to some waterfowl species during migration. For example, mallards may prefer feeding in baited sanctuaries, versus entirely foraging in natural wetlands, because the sanctuaries minimize overall feeding time and other costs (e.g. exposure to predators and extra energy for flight) (Baldassarre and Bolen, 1994). Baiting can hold birds for longer periods of time in a given area during migration and can attract some waterfowl species to use areas subject to hunting disturbance. Some landowners intentionally flood standing corn crops as a means to attract waterfowl for hunting. Within the Study Area, baited sanctuaries have been established at several locations under the authority of the Migratory Birds Conservation Act. Hunting is prohibited within 400 m of these baited sites, resulting in a 125 acre (51 ha) sanctuary.

However, despite its great attraction for some waterfowl species, baiting has a number of limitations. First, agricultural foods provide waterfowl with a nutritionally incomplete food source (Baldassarre et al., 1983). For example, although corn provides adequate energy (ca. 4.70 kcal/g dry matter), it lacks some essential nutrients that can only be acquired from natural foods in wetlands (Fredrickson and Taylor in Bookhout et al., 1989). Second, baiting is not attractive to many waterfowl species, including gadwall, wigeon, blue-winged teal, ringneck, and wood duck, as they depend almost entirely on natural wetland foods. Third, even for those species attracted by baiting, the degree to which these species will feed on agricultural grains is affected by the abundance and availability of food in natural habitats (Baldassarre and Bolen, 1994).

The use of baited sanctuaries is a valid management tool for the restored habitat but is not seen as a priority. Future use of baited sanctuaries should be coordinated with other marshes and clubs in the area.

Cooperation with other clubs should result in minimal alteration of the local distribution of waterfowl during the hunting season.

Summary

The abundance and distribution of waterfowl in the Study Area are affected by three main factors; the available habitat and food, hunting and other disturbances, and, for some species (e.g. mallards), the location of baited sanctuaries.

Waterfowl present in the Study Area have undoubtedly been affected by the large reduction in wetland area that has occurred around Lake St. Clair; as this reduction resulted in fewer opportunities for waterfowl feeding and resting. The use of baited sanctuaries may compensate somewhat for loss of waterfowl feeding opportunities, but these sanctuaries are limited in terms of the waterfowl species they attract and the nutrition they provide (compared to natural sources).

Further compounding the loss of wetlands for waterfowl in Lake St. Clair has been the continued local hunting pressure and increase in other human disturbances such as boat traffic. These disturbances are important influences affecting the local abundance and distribution of waterfowl in Lake St. Clair. For example, human disturbance is believed to have reduced Fall waterfowl numbers in Lake St. Clair. Jaworski and Raphael (1978) reported that hunting pressure and disturbance by boaters and fishermen force most diving ducks to leave the U.S. waters of Lake St. Clair before food supplies are consumed. Dennis and North (1984) predicted that as hunting pressure increased in the Lake St. Clair area, use by waterfowl would decrease during Fall migration. Also, a shift in daily activity patterns from day feeding to night feeding in response to hunting pressure has been observed in the Study Area (BELSCWRW, 1999).

The restoration project of wetlands in the Study Area would increase opportunities for attracting and retaining additional waterfowl in the Fall, even under existing disturbance pressures.

The restoration of wetlands in the Study Area would increase opportunities for attracting and retaining additional waterfowl in the Fall, even under existing disturbance pressures. Hunting opportunities would not necessarily be compromised since the likely result would be an overall increase in waterfowl using the Study Area. Larger extents of wetland would also benefit waterfowl during Spring migration and provide additional nesting areas.

6.4 Effects of Wetland Restoration

A 1,000 acre restored wetland represents approximately 21 percent of the total wetland area in the Study Area. As previously discussed, this additional wetland area will benefit migrating and, to some extent, breeding waterfowl that use the area by increasing available habitat. It is not known with certainty whether the wetland would simply redistribute waterfowl currently using the area or if it would generate additional waterfowl stopovers. Given the increase in waterfowl numbers in

recent years, it is anticipated that additional wetland habitat will increase the number of migrating waterfowl using Lake St. Clair area as a stopover. McCullough (2000) predicts that in the short-term (i.e. 1 to 5 years) the wetland could redistribute birds within the Study Area; however, after five years an increase in dabbler use over the entire Study Area is expected as the wetland becomes established.

It is not anticipated that the proposed wetland will affect the local distribution of waterfowl.

The proposed wetland may influence the local distribution of migrating waterfowl. However, waterfowl distribution and use is more likely to be influenced by wetland management policies than by actual location of the restored acres (BELSCWRW, 1999). Hunting will be permitted in some parts of the restored wetland; therefore, hunting pressure in the restored area should have the same effect on waterfowl distribution as local hunt clubs. In addition, since baiting is not anticipated in the proposed wetland, it is unlikely that the waterfowl will shift their distribution from existing hunt club locations.

Implications of Wetland Location

Large sites afford greater security from disturbance for waterfowl than smaller sites (Newton et al., 1973; Owen and Williams, 1976). This finding suggests that waterfowl may experience increased benefit if the proposed wetland is consolidated with other existing wetlands, rather than being located in isolation. Consolidating blocks of wetlands would also benefit many other organisms, especially those that are not able to travel great distances (see Section 6.5 on biodiversity).

The proposed wetland should not be located in an area with incompatible adjacent land uses (i.e. areas with levels of human activity, such as urban areas). Locating the wetland close to areas of high human disturbance would likely interfere with the function of attracting migrating waterfowl.

Locating the wetland as close to the lake as possible may increase the advantage to migrating waterfowl due to shortened travel distance to and from the lake. Hunting within the wetland may cause waterfowl to seek refuge during the day and then return to feed in the wetland at night when hunting is prohibited. In this case, the lake may function as a diurnal refuge for the waterfowl and its proximity to the wetland would lessen the energy expended by the waterfowl.

Finally, the wetland should be located in an area that ensures adequate quantities of high quality water. Pollution sources, such as runoff from intensively managed agricultural fields, could interfere with the ecological functions within the wetland by increasing turbidity and nutrients. An increase in the latter could lead to eutrophication of the wetland cells and a subsequent decline in some waterfowl plant food and invertebrates.

Implication for Wetland Design

Ducks Unlimited has considerable experience in the design and management of wetlands to serve as waterfowl staging areas (see Mansell et al., 1998). Managed as a waterfowl staging area, the proposed wetland will consist of a number of wetland cells separated by dykes. Water level in each cell can be controlled depending on required habitat conditions. Typically, wetland habitat for staging waterfowl would be composed of about fifty percent emergent marsh and fifty percent open water with floating-leaved emergent or submergent vegetation.

Wetland management includes the raising and lowering of water levels to:

- Ensure the persistence of the wetland conditions
- Control the spread of emergent vegetation (i.e. cattails)
- Control the spread of undesirable plant species (e.g. purple loosestrife)
- Ensure use by waterfowl at the appropriate time in the season
- Maximize wetland productivity
- Maximize benefits to other wetland dependent wildlife

Additional wetland management issues in this particular case include allowing hunting and limiting the use of baited sanctuaries in portions of the wetland.

6.5 Biodiversity

Biodiversity, short for "biological diversity," is a multidimensional and multiscalar concept that can be simply defined as the diversity of life and its processes.

Biodiversity, short for "biological diversity," is a multidimensional and multiscalar concept that can be simply defined as the diversity of life and its processes. Biodiversity includes genes, species, populations, communities, ecosystems, and ecological processes. For the purposes of this report, biodiversity will focus on species, habitat types, and ecological processes.

When attempting to increase biodiversity as an ecosystem management goal, the somewhat conflicting requirements of "generalist" and "specialist" species must be considered. Simply augmenting the number of habitat types present in a certain area can increase biological diversity. If habitat patches are fairly small, this management action will tend to favour generalists at the expense of specialists. Specialists have specific requirements for the size of habitat type, proximity among different habitat types, or special habitat features, whereas generalists are less specific in their needs. Devoting a large area to one particular habitat type will favour specialists of that habitat type but will tend to decrease overall species diversity in that area by eliminating species with other habitat requirements. Therefore, at a site-specific level, augmenting the number of habitat types at the site can increase species diversity. On a landscape scale, biodiversity can be increased by ensuring that some habitat types are large enough to support the specialists or area-dependent species.

Factors to be considered in setting management objectives for biodiversity include:

- Number of habitat types
- Size of the habitat types
- Interspersion between habitat types
- Isolation of habitat types

Each of these factors has been shown to have an influence on the assemblage of organisms that will use the area. For example, the size of individual, contiguous patches of a particular habitat type has a great effect on whether certain birds will use a habitat patch or not. This effect has been shown for forests (e.g. Freemark and Collins, 1992), grasslands (e.g. Samson, 1980), shrublands (e.g. Confer and Knapp, 1981), non-forested wetlands (e.g. Brown and Dinsmore, 1986), and both forested and non-forested wetlands (Mansell et al., 1998). Some species require a shifting mosaic of suitable habitat types. Henslow's sparrows, for example, have very exacting habitat requirements and they will shift from patch to patch of suitable grassland as certain other areas become unsuitable (Askins, 1993). Moreover, it has been shown that these sparrows will not inhabit grasslands smaller than 75 acres (30 ha) (Herkert in Askins, 1993).

The following sections identify the importance of the Lake St. Clair shoreline as an area of biodiversity and discuss the possible effects of the proposed wetland on biodiversity and the implications of wetland location, design, and management on biodiversity.

Background

As previously stated, the Lake St. Clair shoreline has been identified as a Biodiversity Investment Area (BIA), largely due to the large number of rare species found there (Reid and Holland, 1997). The Study Area, including Lake St. Clair, provides habitat for species of plants, amphibians and reptiles, birds, and mammals (see Appendix G). Several of these species, such as the King Rail, Least Bittern, Spotted Turtle and Spiny Softshell Turtle, are rare in Canada and are listed as endangered, threatened, or vulnerable by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

The area also supports a number of vegetation communities, such as cattail marshes, swamps, remnant tall grass prairie, etc. Hundreds of plant species occur in the area; several of which are considered rare in Ontario and/or Canada (e.g. Swamp Rose-mallow-Hibiscus mosheutos, Green Arrow-arum-Peltandra virginica, American Lotus-Nelumbo Iutea) (see Appendix G).

Most of the species of fauna and flora as well as the vegetation communities present in the Lake St. Clair area are highly dependent on

the direct effect of lake dynamic processes for their continued existence. Similar dynamic water level processes are present within dyked wetlands and, under typical water level management regimes, contribute to wetland biodiversity.

Effects of Wetland Restoration

Although the primary purpose of the restored wetland will be as a feeding and resting area for migrating waterfowl, wetland restoration will also support numerous other plant and animal species. In addition, the incorporation of alternate habitat types in the overall design of the restored wetland project has the potential to significantly augment local biodiversity.

The incorporation of alternate habitat types in the overall design of the restored wetland project has the potential to significantly augment local biodiversity.

The St. Clair NWA serves as an example of species that could be expected at the proposed wetland. Over 200 species of plants and birds have been recorded in the area. Of the birds observed, 50 are confirmed to be breeding onsite. Some of the organisms at the site are considered rare and have been listed by COSEWIC as either endangered, threatened, or vulnerable. Therefore, the proposed wetland restoration project has the potential of increasing the available habitat for species deemed significant because of their rarity in Ontario and Canada – a critical step towards reducing their "at risk" status.

Biodiversity can be further enhanced if additional vegetation types can be restored or combined with the staging area wetlands. Each vegetation type carries its own suite of plants, ecological features and functions, and dependent wildlife species. Forested areas, such as provided by swamps for example, are exceedingly sparse in the Study Area. Provision of a forest stand in the site plan design would benefit a host of organisms that are uncommon in the area simply because of the sparseness of forests locally. Simply planting a few trees will create feeding opportunities for migrating songbirds that otherwise might not use the site.

Figures 6-2 through 6-15 illustrate the total and cumulative number of species of plants, butterflies, amphibians and reptiles, birds, and mammals that could inhabit the existing and possible habitat types proposed for the project. For the purposes of this study, bird species numbers include migrant waterbirds, such as ducks, geese, and shorebirds. The first figure of each pair for the organism groups shows the total number of species that could colonize and inhabit each habitat type. The second figure shows the cumulative species number, i.e. the number of species for each successive habitat type that are not associated with any of the previous habitat types listed. These figures were derived from lists of species developed by members of the Study Team, the Lake St. Clair Technical Committee, the Natural Heritage Information Centre (NHIC), and others (see Appendix G).

The figures show that, although existing agricultural lands and drains provide habitat for a certain suite of species, restoring additional habitat types successively contributes to the species diversity of the area as a whole. The species already associated with the existing agricultural lands and drains in the study area are used as the base case against which to examine potential biodiversity effects of restoring additional habitat types. As a general rule, the greater the number of habitat types the greater the number of species that will be attracted. The restoration of the principal habitat type, shallow marsh, will attract a host of species in addition to migrating waterfowl. Some of the habitat types, although not attractive to migrating waterfowl, will serve to attract large numbers of species, some of which are rare.

The species already associated with the existing agricultural lands and drains in the study area are used as the base case against which to examine potential biodiversity effects of restoring additional habitat types.

Existing agricultural lands and drains in the Study Area have the potential of supporting 270 species of plants, butterflies, amphibians and reptiles, birds, and mammals taken as a group (termed 'total biota' in this report) (Figure 6-2). Although this is a large number of species, many of these species are common throughout southern Ontario. Total biota of existing agricultural fields and drains include 8 rare species (Figure 6-3 and Figure 6-4). Rare species include those that have been given status of threatened, vulnerable, or endangered by COSEWIC, and/or have been given the rank of S1, S2, or S3 by the NHIC.

FIGURE 6-2
NUMBER OF SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES

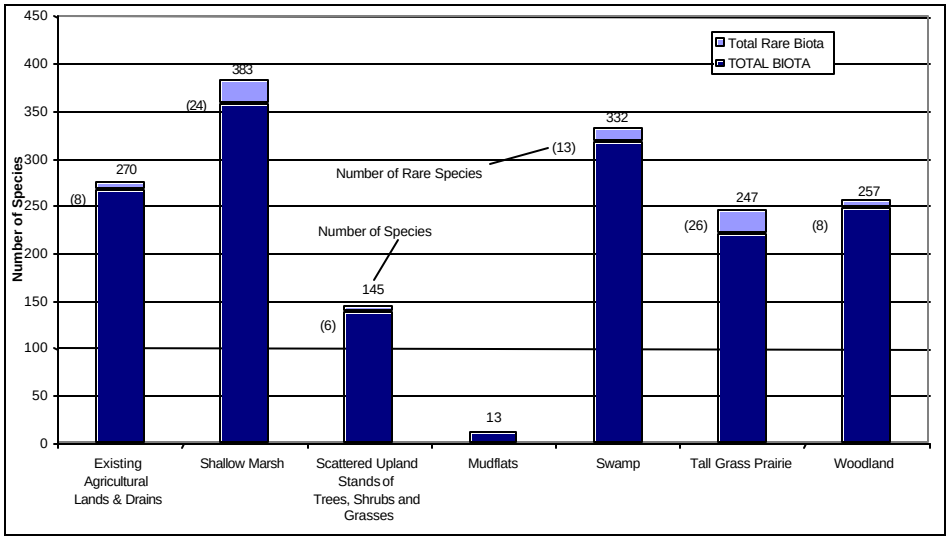


FIGURE 6-3
TOTAL SPECIES OF ANIMALS LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES

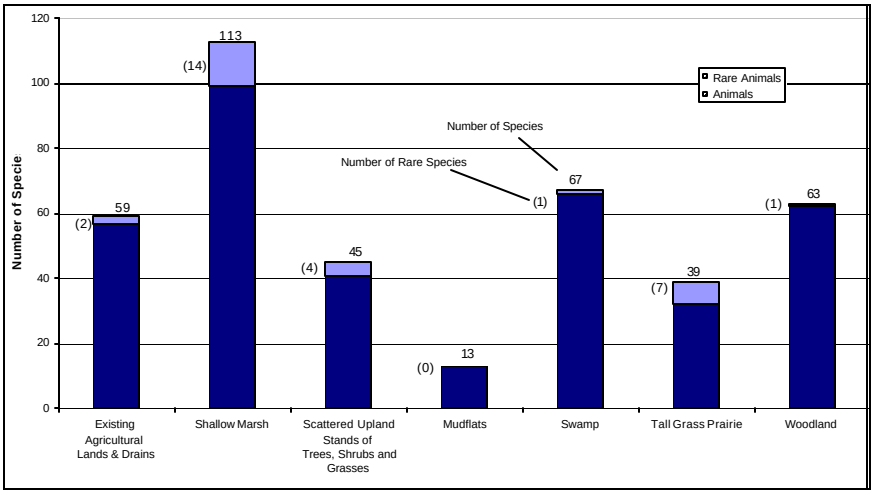
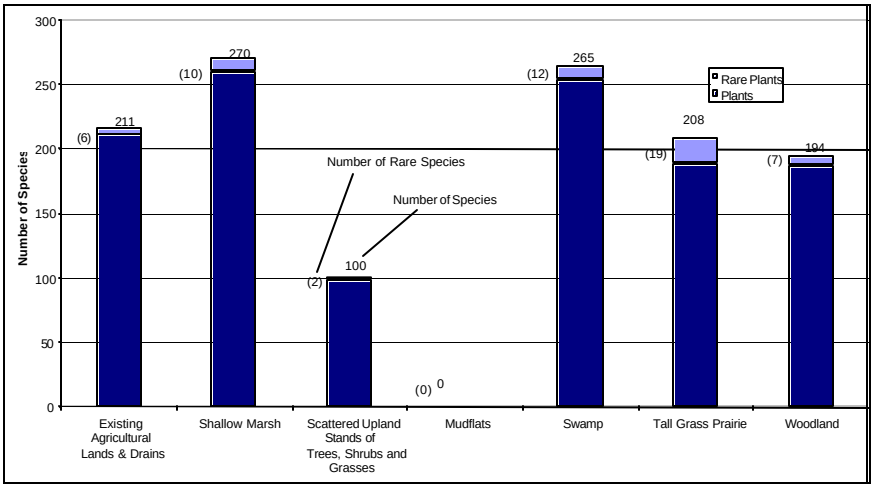


FIGURE 6-4
TOTAL SPECIES OF NATIVE PLANTS LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES



Of the proposed habitat types to be restored, the greatest number of species is associated with shallow marsh, followed by swamp, woodland, tall grass prairie, upland on the dykes, and mudflats (Figure 6-2). Shallow marsh also accounts for the greatest number of rare species, followed by tall grass prairie, swamp, and uplands on dykes. Shallow marsh contains by far the most species of animals (113), followed by swamp (67), woodland (63), existing agricultural lands and drains (59), the uplands of the dykes (45), tall grass prairie (39), and mudflats (13) (Figure 6-3). Shallow marsh is also expected to contain the most native plant species (270), but the differences between some habitat types are less marked for plants than for animals. For example, existing agricultural lands and drains (211) and swamp (265) have almost the same number of plant species as shallow marsh. Tall grass prairie and uplands have noticeably fewer plant species (108 and 100 species, respectively).

Restoration of all of the proposed habitat types could more than double the total biota in the area to 804 species (Figure 6-5). Of the 534 additional species provided for by the restored habitat types, 135 are animals and 399 are plants (Figure 6-6 and Figure 6-7). Twenty of the additional animal species and 39 of the plant species are considered rare. Of course, each of the various habitat types is associated with a group of species not found in any other habitat type. The shallow marsh and associated upland dykes, which will cover most of the restored area, will account for half (269 or 50 percent) of the new species. Swamps could add 91 (17 percent) additional species to the area and tall grass prairie could add 72 (14 percent). The remaining 102 species (19 percent) could be contributed through upland woodland habitat.

FIGURE 6-5
CUMULATIVE NUMBER OF SPECIES LIKELY TO INHABIT PROPOSED HABITAT TYPES

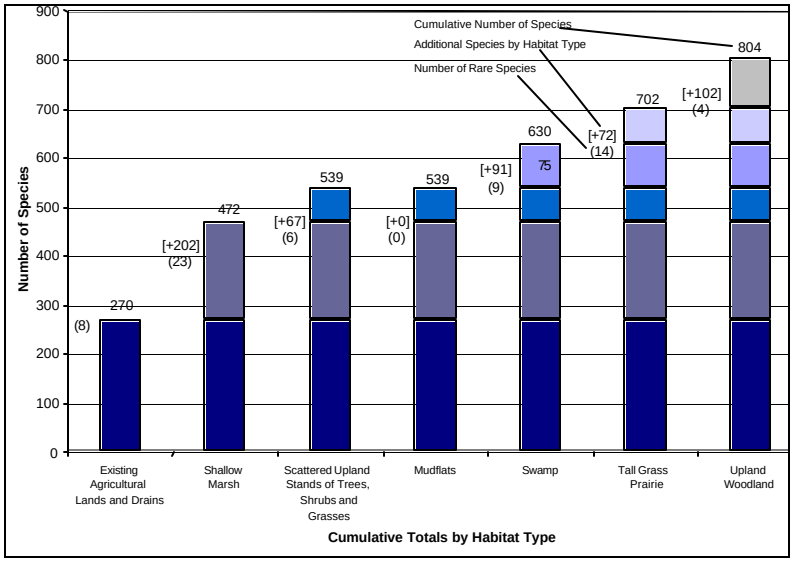


FIGURE 6-6
CUMULATIVE NUMBER OF ANIMAL SPECIES LIKELY TO INHABIT PROPOSED HABITAT TYPES

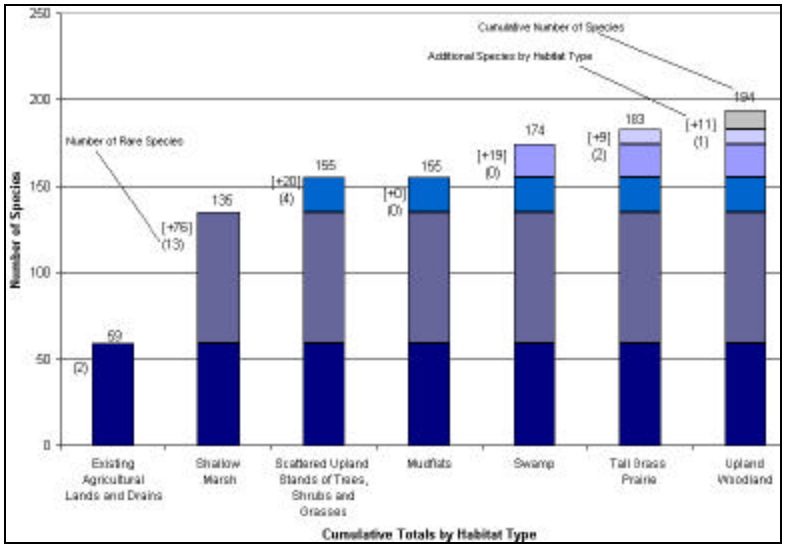
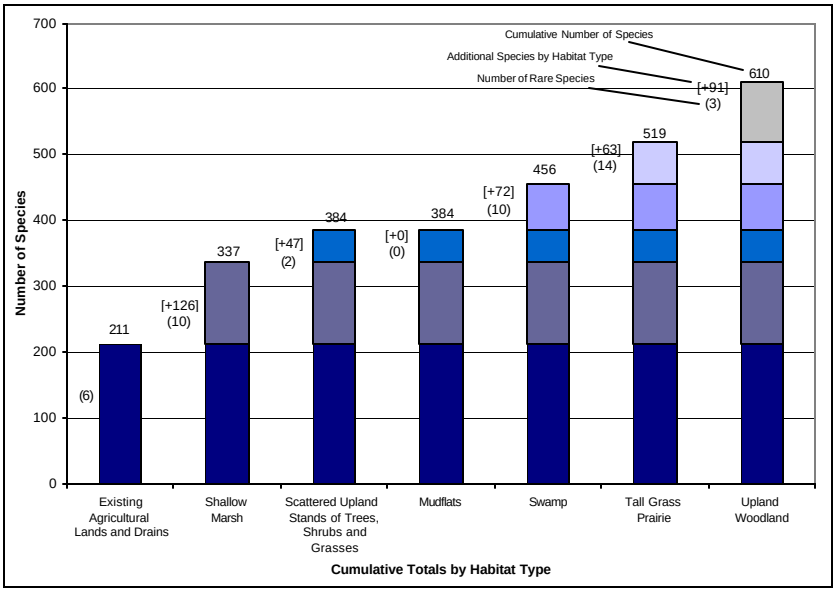


FIGURE 6-7
CUMULATIVE NUMBER OF PLANT SPECIES LIKELY TO INHABIT PROPOSED HABITAT TYPES



Monarch butterfly

The greatest number of butterfly species are anticipated in shallow marsh, followed by the swamps, tall grass prairie, woodland, and existing agricultural lands and drains (scattered upland sites associated with the dykes) (Figure 6-8). The restoration of shallow marsh and the associated dykes will more than double the number of butterfly species in the area, from 11 species to 32 (Figure 6-9). Forested swamps are expected to add only seven new species, while tall grass prairie could provide habitat for three additional species.

FIGURE 6-8
BUTTERFLY SPECIES LIKELY TO INHABIT PROPOSED HABITAT TYPES

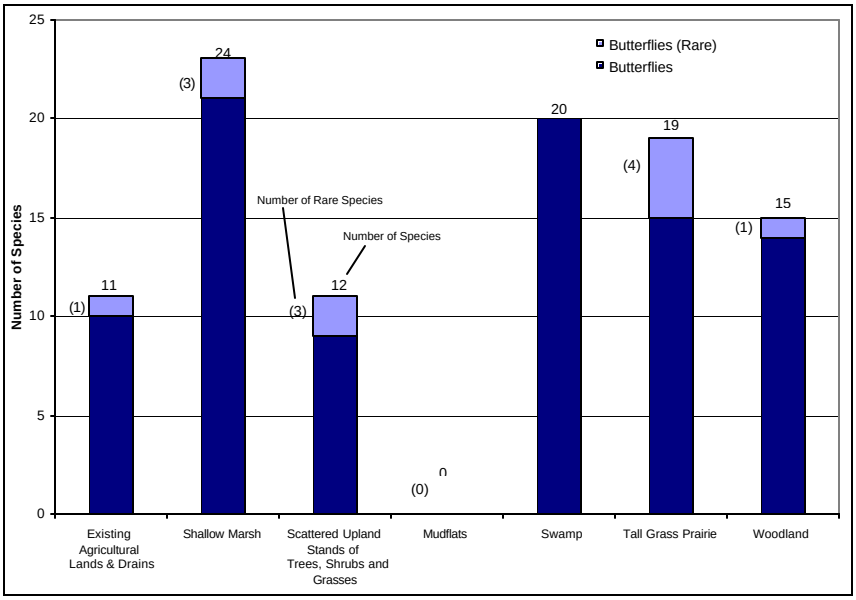
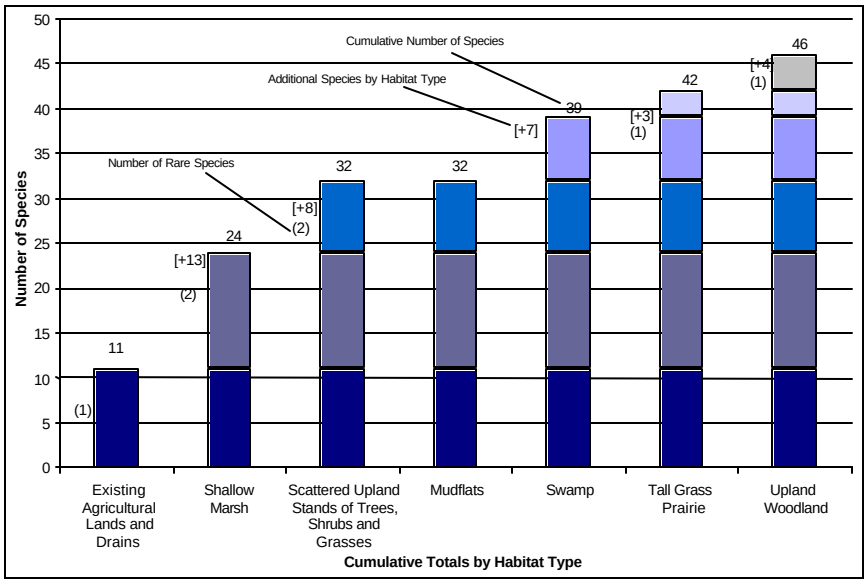


FIGURE 6-9
CUMULATIVE NUMBER OF BUTTERFLY SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES



The greatest number of amphibian and reptile species is anticipated in shallow marsh (15), followed by swamp (11), existing agricultural lands and drains (6), tall grass prairie (5) and upland woodland (5) (Figure 6-10). The restoration of shallow marsh will more than double the number of amphibian and reptile species in the area (Figure 6-11); two of the additional species are considered rare. The addition of further habitat types will add only two new reptile species associated with tall grass prairie, one of which is rare.

Frog

FIGURE 6-10
AMPHIBIANS AND REPTILES LIKELY TO INHABIT THE EXISTING AND PROPOSED HABITAT TYPES

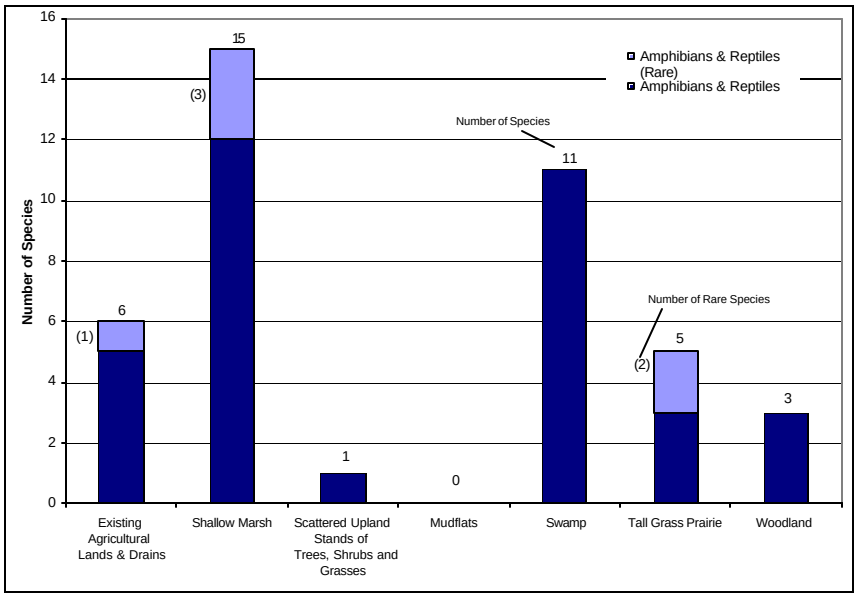
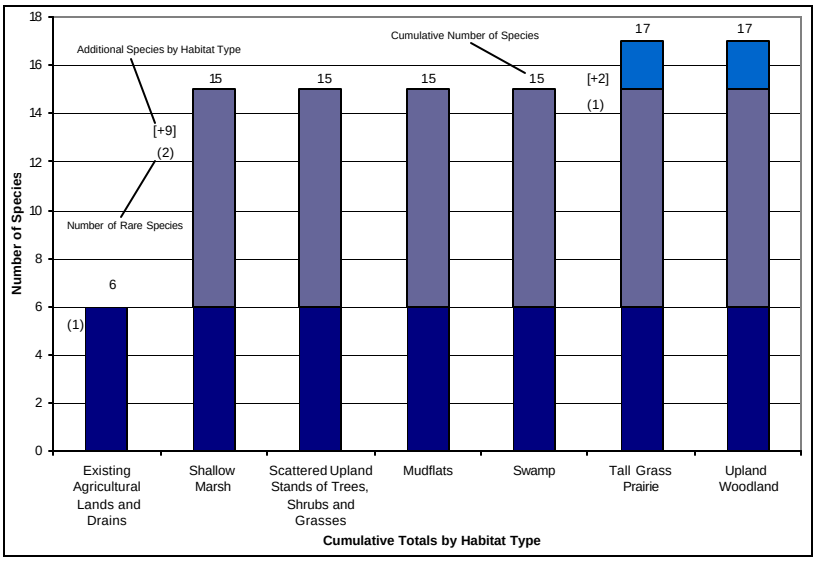


FIGURE 6-11
CUMULATIVE NUMBER OF AMPHIBIAN AND REPTILE SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES



Blue heron

The greatest number of breeding bird species is anticipated in shallow marsh (66), followed by existing agricultural lands and drains (35), woodland (34), uplands associated with the dykes (32), swamp (28) and tall grass prairie (11) (Figure 6-12). Migrant waterfowl species are most numerous in shallow marsh, followed by mudflats and existing agricultural lands and drains. The restoration of shallow marsh and the associated dykes could nearly triple the number of species of breeding birds in the area (Figure 6-13); nine of the additional species are considered rare. The restoration project of additional habitat types will add only a few new species of breeding birds to the area.

FIGURE 6-12
BIRD SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES

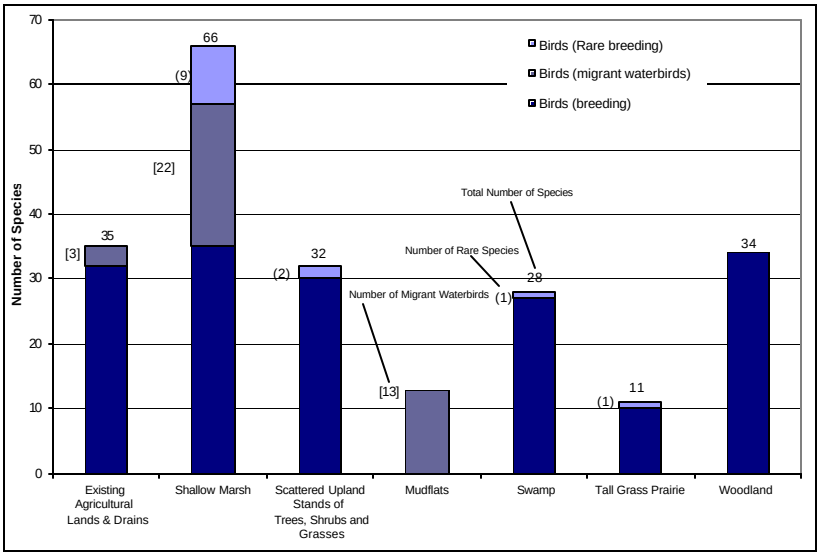
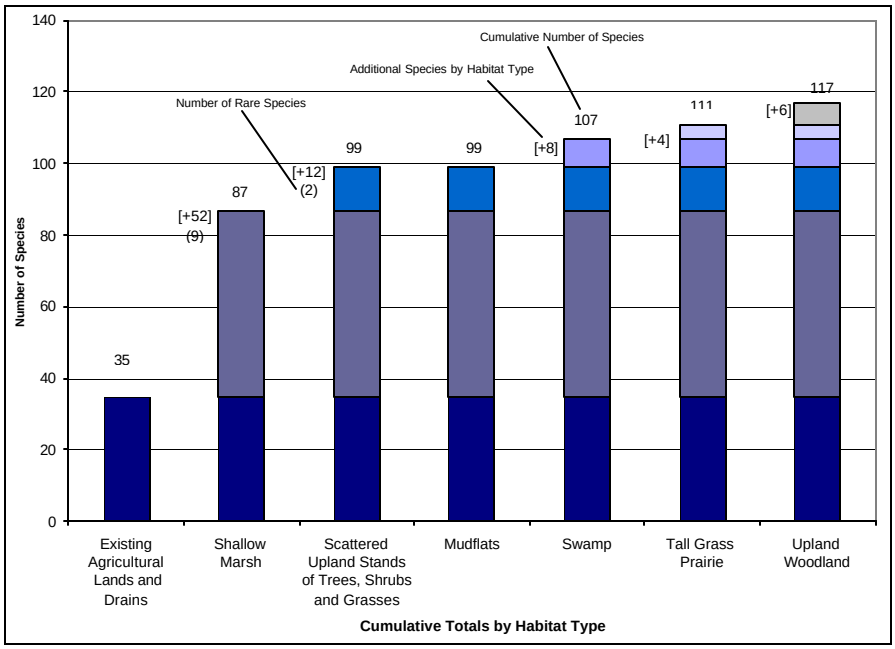


FIGURE 6-13
CUMULATIVE NUMBER OF BIRD SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES



The restoration of shallow marsh and associated dykes is not expected to have a great influence on the number of mammal species that currently inhabit the area (Figure 6-14 and 6-15) and would result in the addition of only two additional mammal species. The restoration of swamp, however, would provide an additional four new mammal species.

FIGURE 6-14
MAMMAL SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES

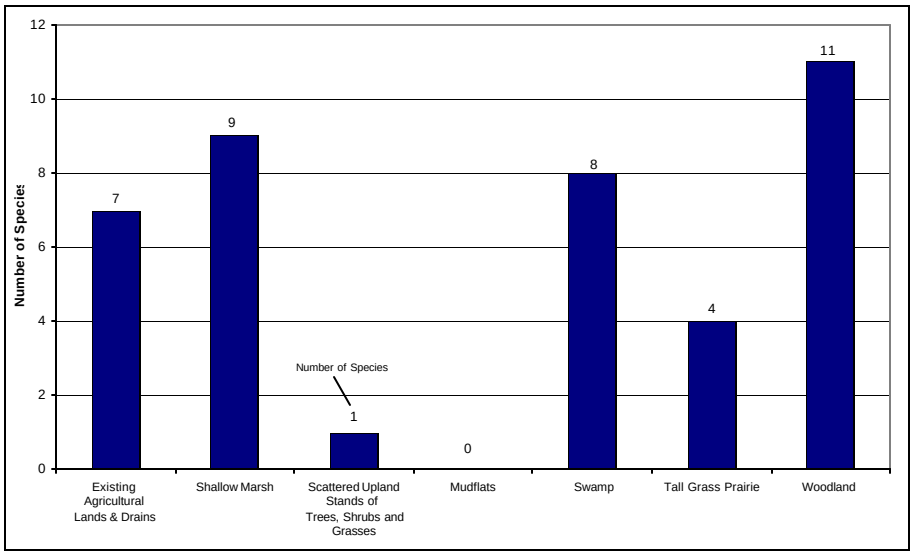
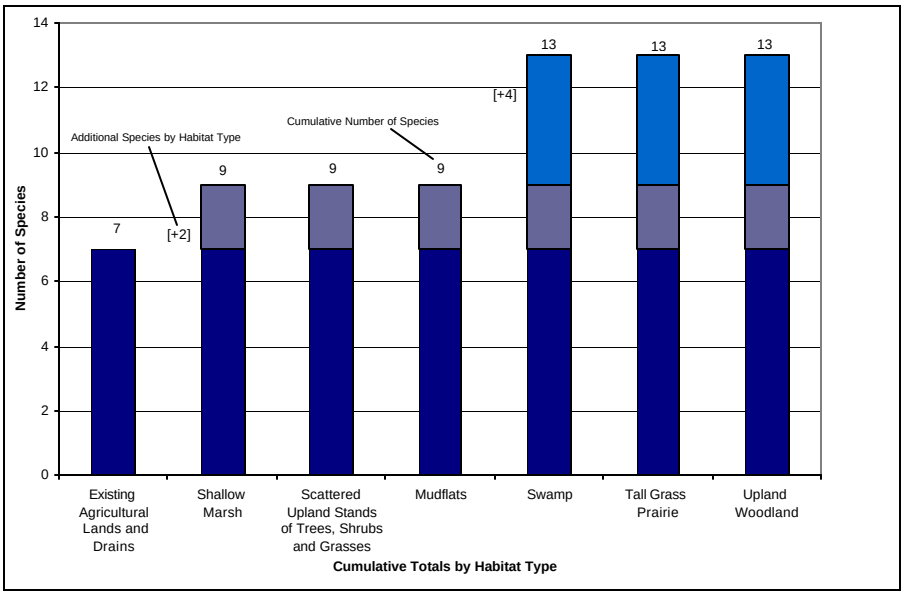


FIGURE 6-15
CUMULATIVE NUMBER OF MAMMAL SPECIES LIKELY TO INHABIT EXISTING AND PROPOSED HABITAT TYPES



In summary, the base case restored wetland (i.e. shallow marsh habitat) has the potential to significantly increase biodiversity in the area; this is a net positive biological effect. The incorporation of ancillary habitat types in the method design has the potential to increase the magnitude of this positive effect by contributing additional species.

The following sections discuss some general implications of wetland location, design and management on biodiversity in general and rare species in particular.

Implications of Wetland Location

The proposed wetland should be located as close as possible to other wetlands if the greatest number of species is to benefit.

The most important factor in wetland location that affects biodiversity is proximity to other existing habitat types. Colonization of the restored wetland by plants and animals depends largely on the proximity of neighbouring populations. While most birds, wind-disseminated plants, and bird-disseminated plants will disperse over considerable distances, many other organisms will be highly dependent on the proximity of the new habitats for colonization. The maintenance of wetland complexes that provide the most heterogeneous array of habitats possible, in terms of both size and types of communities, is likely the best strategy for protecting an array of plants and animals (Baldassarre and Bolen, 1994).

As a general guiding principle, the proposed wetland should be located as close as possible to other wetlands, as well as to other habitat types, if the greatest number of species is to benefit. Factors to be considered include:

- Differences in vagility (i.e. dispersal capability) among species

- Existing barriers to dispersal for certain species (e.g. roadways, intensively cultivated agricultural lands)
- Species requirements for several different habitat types

Locating the proposed wetland close to other habitat types will also take advantage of existing species distribution in those habitat types.

Implications for Wetland Design

Mudflat management for shorebirds adds a potentially significant biodiversity benefit.

Since water management will be a feature of the restored wetland, the greatest influence on biodiversity will likely be the topography of the cells. Bottom contour determines which areas will be covered by water and water depths. In general, two broad habitat types generally associated with the management of a wetland to serve as a staging area for waterfowl are shallow marsh and deep marsh. Mudflat management for shorebirds adds a potentially significant biodiversity benefit. The biodiversity implications for habitat design are discussed below.

Shallow Marsh

In the Great Lakes region, a shallow marsh is best represented by a typical cattail marsh, in which emergent perennials such as cattails and bulrush are dominant. Other common species include submergents such as pondweeds, water milfoil, coontail, and bladderwort. Together these species provide a substantial component of the food resource in foliage, tuber and seeds, as well as harboring macroinvertebrates.

Cattail marsh

In a shallow marsh, emergent vegetation is interspersed with open water. The ratio of vegetation and water can be managed by water level control as well as by control of muskrat populations. Water level control is used to promote growth of specific aquatic plant species, enhance plant community diversity, and improve general plant robustness and vigour. Depending on specific management objectives and site conditions, water levels for shallow marsh areas should remain at less than 60 cm throughout the growing season. A partial Spring drawdown will encourage regrowth of perennials from rootstocks, whereas increased water levels due to Winter and Spring precipitation can be left unchanged to suppress plant community expansion.

Shallow marshes provide the maximum benefit to the greatest number of wetland wildlife species (Weller and Spatcher in Bookhout et al., 1989; Gibbs et al., 1991). Although waterfowl use during fall migration is substantial, Bookhout et al. (1989) report that, as food source, submergent and perennial emergent plants are seldom preferred over seeds of mudflat plants. However, waterfowl requirements for both food and refuge are best provided by shallow marshes. Shallow marshes tend to distribute migratory waterfowl use more effectively than mudflats.

Shallow marshes are an important source of macroinvertebrate food, which is consumed by waterfowl. The greatest numbers of macroinvertebrates occur in areas where open-water habitats of submergent vegetation are interspersed with emergent vegetation (i.e. hemi-marsh) (e.g. Voights, 1976). The large population and diversity of macroinvertebrates found in hemi-marsh wetlands are likely related to the diversity of habitat types rather than to the interspersion of cover and water per se (Murkin et al., 1992). A variety of habitat types will ensure that macroinvertebrates are always abundant somewhere in the wetland throughout the Summer.

Depending on the contour of the bottom of the wetland a margin of "meadow marsh" composed of various forbs and graminoids will also be created between the tall emergent vegetation and the upland vegetation. This margin of meadow marsh can vary in width depending on the bottom contouring, but typically it would be relatively narrow.

Contouring of the wetland bottom in conjunction with water level manipulations can also allow for some areas of the wetland to be above the mean water level, thereby creating pockets of moist upland. Various forbs, shrubs, and trees will colonize these moist upland areas and dykes resulting in linear strips of upland vegetation across the wetland.

Deep marsh

Deep Marsh

Deep marshes are typically composed of open water with a depth greater than 60 cm and scattered clumps of perennial, emergent vegetation. Various species of floating-leaved plants are also common. Compared to mudflats and shallow marshes, deep marshes are generally the least attractive to most waterfowl. A deep marsh with dense growths of such submergent species as wild celery and water milfoil is, however, the most desirable habitat for migrating diving ducks (i.e. canvasbacks and redheads) and some dabbling ducks such as American wigeons, gadwalls, and northern shovellers. Although deep marshes are not specifically planned for the proposed wetland, deep water pockets could contain similar components of deep marshes (i.e. submergent vegetation and floating-leaved emergents).

Mudflat

Mudflats

Mudflats can be managed for either migrating waterfowl or migrating shorebirds. Managed mudflats for waterfowl are characterized by dense stands of annual emergents and high abundance of seed. Managing a portion of a dyked wetland complex for migrating shorebird habitat could be an important goal given the recent decline in the population of these birds (Morrison et al., 1994). However, mudflat or moist-soil management intended to provide

waterfowl feeding opportunities will conflict with the goal of providing mudflats for migrating shorebirds due to the timing of drawdowns and partial refillings (Rundle and Fredrickson (1981). Also, Ducks Unlimited Canada has found it impractical to undertake moist-soil management for waterfowl due to the rapid colonization of the managed impoundments by undesirable vegetation (e.g. purple loosestrife) (Steele, personal communication).

Managed shorebird habitat may alleviate the decreasing quality and quantity of natural shorebird habitat (Weber and Haig, 1996). In Ontario, the standard practice by Ducks Unlimited is to manage mudflats for shorebirds by flooding wetland impoundments during the late Fall, Winter, Spring, and early Summer with at least three feet of water and gradually reduce the water level to expose a shallowly sloped shoreline. The initial drawdown is timed to coincide with the arrival of the first wave of migrating shorebirds in mid-Summer. Further incremental drawdowns progressively expose additional shoreline area throughout the shorebird migration period. Incremental drawdowns are important since shorebird predation can cause a significant decline in invertebrate biomass (Weber and Haig, 1996). Management by deep flooding and incremental drawdowns has proven to be the most effective technique to eliminate all vegetation and provide the most suitable feeding habitat for migrating shorebirds. Weber and Haig (1996) report greater use of managed wetlands by migrating shorebirds than natural wetlands.

Other Habitat Types

In general, the greater the diversity of habitat types and habitat features (e.g. snags) the greater the number of species that will utilize the area, to feed, breed, or seek refuge. Two additional habitat types are discussed below—tall grass prairie and thicket/treed swamp. These habitat types are representative of those that were common historically in the Study Area. Swamps are somewhat complementary to the primary purpose of the proposed wetland as a waterfowl staging area since some species will use these habitat types for feeding or breeding. Tall grass prairie is more likely to be used by breeding waterfowl; however, in order to ensure nesting success, the prairie would need to be large enough to disperse predators sufficiently.

In addition to these two habitat types, certain specific habitat features would also help in diversifying the species that use the area. A stand of upland trees, even a single row, will provide habitat for migrating songbirds in Spring and Fall. Woodland is especially rare in the Study Area, which makes any forest stand particularly valuable biologically. Plantings of specific fruit-bearing shrubs and coniferous cover, even simply around the parking area, would provide additional food and cover for migratory species.

Tall grass prairie

Tall Grass Prairie. Tall grass prairie was a dominant vegetation type in the Study Area prior to European colonization. The absence of trees allowed these areas to be rapidly converted to agricultural uses.

Since migrating waterfowl require places to rest and replenish energy and fat, restored prairie is not a wetland management objective for staging waterfowl, as these requirements are met primarily by foods found in wetlands, agricultural fields and/or baited sanctuaries. However, restored tall grass prairie is compatible with waterfowl production and will provide nesting habitat for a number of dabbling duck species.

Depending on the detailed ecosystem management objectives for the proposed area, the size of the prairie is an important factor in determining the species that will inhabit it. If the primary objective is to establish prairie plant species and attract a few generalist grassland birds and invertebrates, then a relatively small area is sufficient (i.e. 10 to 50 ac.). If, however, the objective is to attract specialist grassland birds (e.g. grasshopper sparrow, Henslow's sparrow, upland sandpiper), then larger areas are required (i.e. >75 to 100 ac.) (Herkert and Vickery in Askins, 1993). Finally, if the objective is to provide for more than one or a few breeding pairs of grassland specialist birds and to ensure successful reproduction or to allow for the dynamics of a shifting mosaic of grassland patches, then a very large area is required (i.e. >1,000 ac.) (Askins, 1993; Zimmerman, 1988).

Thicket and/or Treed Swamp. Thicket swamp and treed swamp (composed of deciduous species in this case) are two distinct habitat types but are discussed together here since the former may be replaced by the latter over time. Willows, red-osier dogwood and perhaps other species, such as buttonbush, would be expected to naturally colonize portions of the wetland over time creating thicket swamps. Generally, wetland management favours aquatic plants rather than these shrub colonizers; however, a relatively small area of thicket swamp, can provide habitat for additional bird species, both in migration and during the breeding season. For example, these habitat types are favoured by green herons, alder and willow flycatchers, eastern phoebes, yellow warblers, and common yellowthroats.

Treed swamps may replace thicket swamps if suitable seed sources are available nearby. Silver maples and/or red/green ashes would likely be the dominant tree species expected. A drawback to the establishment of treed swamps is the several decades necessary for maturation. Planting of these species would ensure the development of the treed swamp (assuming the hydrological conditions are met) and would somewhat hasten the development of the swamp.

Treed swamps are used by a number of breeding bird species in Ontario, but a substantial area (i.e. >500 ac.) would be required to attract the very area-sensitive species (e.g. hooded merganser, prothonotary warbler) that breed in swamps. A smaller swamp (e.g. 50 to 100 ac.) would be expected to attract fewer and less area-demanding species (e.g. green heron, wood ducks, northern waterthrush). A forested area of any size, whether upland or lowland, would likely attract large numbers of migrant songbirds since much of the Study Area is currently devoid of trees. Therefore, ecosystem management objectives should not only consider requirements of breeding species but also those of migrants that could be attracted to the site.

A forested area of any size would likely attract large numbers of migrant songbirds.

6.6 Implications for Wetland Management

Water control is the most important wetland management option affecting biodiversity. Proper water level control is essential for maintaining desired vegetation communities within the wetland. While some wetland plant species tolerate prolonged periods of water-saturated soils (i.e. the submergents and floating-leaved emergents), most require a period when soil oxygenation can occur. Water level control is especially important for the management of mudflats to ensure proper timing for mudflat exposure and use by shorebirds, shoreline animals, etc. Too little water for too long will cause upland vegetation to colonize and will disrupt populations of benthic organisms.

Water sampling

Synthesis

Biodiversity will be enhanced at a site-specific scale by simply increasing the number of habitat types present. An increase in habitat types will result in an increase the number of breeding species, and those using the site during migration. The Lake St. Clair shoreline has been cited for the number of rare species present (Reid and Holland, 1997), so consideration of these species in setting objectives for the proposed wetland should be given. Setting ecosystem management objectives to increase the number of "rare" species, however, requires consideration of species requirements for minimum habitat areas, interspersion of different habitat types, and presence of special habitat features.

Based on the brief overview above, the following general guidelines should be considered in setting ecosystem management objectives for increasing biodiversity:

- Objectives for increasing biodiversity need to be compatible with the primary purpose of the wetland restoration project.
- If all of the habitat types are relatively small, habitat generalists will be favoured at the expense of habitat specialists.

- Long-term management for certain habitat specialists must consider the suitability of habitat patches as a shifting mosaic over time. Therefore, area requirements to accommodate the shifting mosaic dynamics must be considerably larger than the area requirements for a certain species to be present there at any given time.
- Proximity of habitat types will tend to increase species diversity since some species (e.g. some raptors) have requirements for more than one habitat type.
- Specific configurations for the interspersion between habitat types is an important requirement for some species (e.g. several duck species).
- Ecological processes responsible for maintaining certain habitat types must be considered and accommodated (e.g. water level dynamics for mudflats, fire for maintenance of prairie, etc.).

The following features should be considered in the planning, design and management of the proposed wetland:

- **Shallow Marsh**
  - Shallow marsh is the primary habitat type for creating staging areas for migrating waterfowl.
  - Large extents of shallow marsh will be beneficial to typical marsh birds as well as rarer species, such as king rail and least bittern.
  - Interspersion of water and emergent vegetation at a ratio of 50:50 should provide habitat for the largest number of species.
  - Meadow marsh components should be expanded to allow the establishment of wide bands of sedges, manna grasses, etc.
  - Components of deep marshes should be included by leaving pools with water between 0.5 to 1 m deep; this will foster the establishment of submergent and floating-leaved emergent vegetation.
- **Dykes**
  - Some trees and shrubs should be permitted to establish to provide habitat for some songbirds.
  - Dykes should be used for nesting by some waterfowl and turtles.
  - If possible, dyke alignment and width should be diversified.
- **Mudflats**
  - A wetland cell or a portion thereof could be managed to provide mudflats for migrating shorebirds; this would require ensuring that mudflats are exposed in late Summer to early Fall as well as in Spring.

- **Thicket Swamp**
  - The swamp could be allowed to naturally develop at the edge of some of the wetland cells.
  - A thicket swamp should attract certain bird species, such as green heron, common snipe, American woodcock, yellow warbler, alder and willow flycatchers and eastern phoebe.
  - Development of thicket swamp should be adjacent to open meadow areas for some species, such as American woodcock.
- **Treed Swamp**
  - The swamp should be of a shape that minimizes edge.
  - Some areas should be planted to hasten the development of a treed swamp. Ideally, the proposed wetland should be located adjacent to existing swamp.
- **Tall Grass Prairie**
  - The area of tall grass prairie could be in the order of 75 to 150 acres (30 to 61 ha) to attract some breeding birds that are grassland specialists as well as maintain a suite of prairie invertebrates.
  - Management interventions, such as burning, should be rotated in 20 to 40 acre (8 to 16 ha) parcels.

6.7 Summary

The proposed wetland will benefit continental and regional waterfowl populations primarily by providing high quality Spring staging habitat for resting and feeding, which will improve the health and increase the chance of survival of migrating waterfowl. The improved health status of birds passing through the St. Clair area will contribute to improved reproductive fitness and will increase the size and stability of continental and regional waterfowl populations. The proposed wetland will also provide some breeding habitat for waterfowl. Since it is managed, the proposed wetland will not be as susceptible to drought conditions as natural wetlands and therefore will increase the reliable supply of good quality wetland habitat.

The abundance and distribution of waterfowl in the Study Area are affected by three main factors; the available habitat and food, hunting and other disturbances, and, for some species (e.g. mallards), the location of baited sanctuaries.

The restoration project of wetlands in the Study Area would increase opportunities for attracting and retaining additional waterfowl in the Fall, even under existing disturbance pressures. Hunting opportunities would not necessarily be compromised since the likely result would be an overall increase in waterfowl using the Study Area. Larger extents of

wetland would also benefit waterfowl during Spring migration and provide additional nesting areas.

Large sites also afford greater security from disturbance for waterfowl than smaller sites. This finding suggests that waterfowl may experience increased benefit if the proposed wetland is consolidated with other existing wetlands, rather than being located in isolation. Consolidating blocks of wetlands would also benefit many other organisms, especially those that are not able to travel great distances.

Although the primary purpose of the restored wetland will be as a feeding and resting area for migrating waterfowl, wetland restoration will also support numerous species of plants and animals as well. In addition, the incorporation of alternate habitat types in the overall design of the restored wetland project has the potential to significantly augment local biodiversity. Restoration of all of the proposed habitat types could more than double the total biota in the area to 801 species.

In summary, the restored wetland provides clear biological benefits contributing positively to local waterfowl populations and increasing local biodiversity.