Conserving Lake Champlain's Biological Diversity




The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

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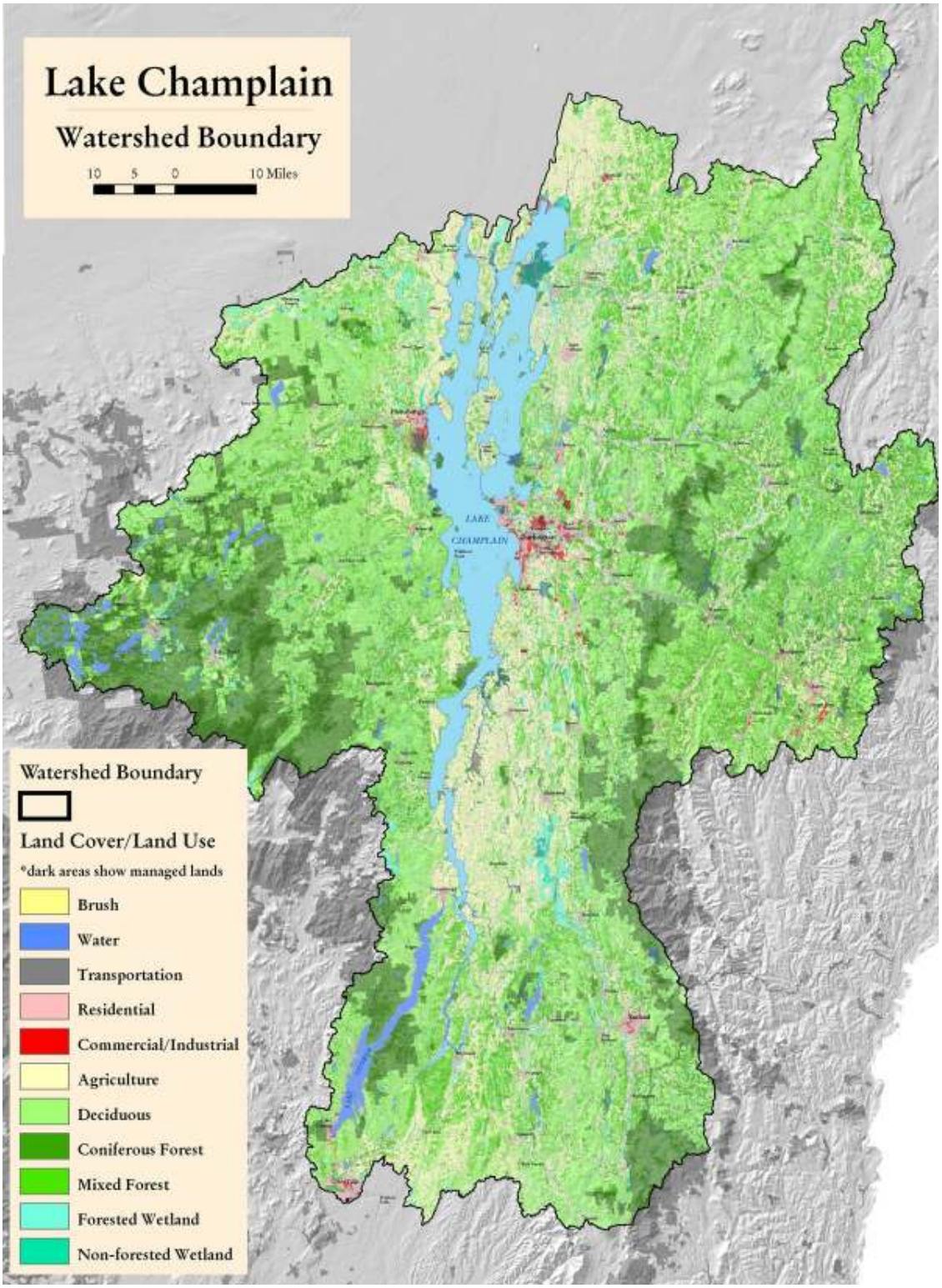

Lake Champlain's watershed encompasses 8,234 square miles: 56% is located in Vermont, 37% in New York, and 7% in Quebec. A high percentage of the watershed – 78% -- is comprised of natural cover including forests, wetlands, and open water. Agricultural land accounts for 16% of the watershed. Only 6% is developed land.

I. Introduction

The Nature Conservancy's mission is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. The Conservancy has been active in conserving biodiversity in the Lake Champlain region for many decades, protecting lands and waters throughout the basin in both Vermont and New York, including Lake Champlain's shorelines, wetlands, and tributaries. Now, as part of an organization-wide focus on freshwater conservation, The Nature Conservancy is adopting conservation strategies to protect Lake Champlain itself – the lake's diverse aquatic ecosystems and incredible diversity of native plants, fish, birds, and wildlife.

Lake Champlain benefits from the collective conservation efforts of dozens of state, federal, and local government agencies, non-profit environmental groups and land trusts, watershed associations, academic institutions, and interested citizens. The task facing The Nature Conservancy is to identify opportunities for us to "add value" to the efforts of the many organizations active in the basin. Along with a long history of land protection activities around the lake, the Conservancy brings conservation science, invasive species control, and habitat restoration expertise, along with government relations capacity, to this effort. These are important strengths to consider in evaluating the Conservancy's niche in covering Lake Champlain's ecological health and diversity.

The Nature Conservancy has completed a year-long biodiversity conservation planning exercise for Lake Champlain, led by a team of 9 TNC staff and 5 representatives of partner organizations. This report summarizes the output the planning effort, setting forth a description of the lake's major biodiversity components, an identification of the major threats to these resources, and the selection of key strategies for conserving biological diversity.

This plan cannot catalogue the universe of existing environmental initiatives aimed at protecting Lake Champlain. Instead, it focuses specifically on the protection of Lake Champlain's biodiversity, setting forth a series of key strategies needed to abate threats to the lake's biodiversity – strategies that need to be implemented by the Conservancy and partner organizations over the next several years. The Plan concludes with a Workplan, identifying specific actions that The Nature Conservancy will pursue over the coming year.

The Nature Conservancy utilizes an iterative approach to conservation planning. This document will be periodically updated in the future – to refine and improve our conservation strategies as we learn more about Lake Champlain wildlife, natural communities, and ecosystems.

II. Lake Champlain's Biodiversity

Lake Champlain is a very large, complex, and diverse system. Through extensive consultations with scientists and experts on the lake's ecology, the Conservancy has identified eight ecological systems and species assemblages that capture the biodiversity of Lake Champlain. The premise is that, if we are able to develop strategies to address key threats to these systems, we will conserve Lake Champlain's full diversity of native plants, animals and natural communities.

The eight ecological systems and species assemblages are:

- **Deep Lake Pelagic Zone**. The deep, open water area of Lake Champlain where sunlight does not penetrate to the lake bottom (defined for planning purposes as areas where depths exceed 50 feet), the deep lake pelagic zone is an oligotrophic system featuring clear cold water and low levels of phosphorus and other nutrients. This deep water zone is the dominant ecological feature of Lake Champlain, encompassing slightly less than half of the lake's surface area (125,000 acres) but accounting for 80% of total water volume. Critical living components of the pelagic zone include cold water fish species (including Atlantic salmon, lake trout, burbot, smelt, lake whitefish, and cisco) along with open water plankton communities.

- **Deep Water Benthos**. Located in deep water where sunlight does not penetrate (defined as areas where depths exceed 50 feet), the deep water benthos consists of the lake bottom substrate, accumulated sediments, and decaying organic matter. It provides habitat for macro- and micro-invertebrates such as crustaceans, insect larvae, and burrowing worms. Smelt spawn in the deep water benthos, which is unusual compared to other lakes. Native zooplankton overwinter on the lake floor

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- **Littoral Zone**. The shallow zone of the lake where sunlight reaches the bottom (defined for planning purposes as areas less than 50 feet in depth), the littoral zone encompasses 150,000 acres of lake surface area, and includes both the water column and the lake bottom benthos. This system includes vegetated submergent beds, rocky beds, and river deltas. Characterized by warm summer water temperatures and higher nutrient levels, this highly productive ecosystem provides vital spawning, nursery, refuge, and feeding habitats for a remarkable variety of fish and wildlife. The littoral zone supports the most abundant and diverse plant, plankton, and macroinvertebrate communities in Lake Champlain.

- **Lake Influenced Wetlands**. Lake Champlain hosts diverse wetlands, including deep and shallow emergent marshes, silver maple / ash swamps, shrub swamps, and floodplain forests, that are influenced by natural fluctuations in the lake's water level (fluctuations average 5 feet per year in the lake). Wetlands are among the most productive ecosystems in the world. They perform many important

ecosystem functions, and provide critical habitat for a variety of plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. There are 166 wetlands greater than 50 acres in size with direct hydrologic connection to Lake Champlain.

- **Tributary Systems**. Stretching from their headwaters to the deltas formed where they flow into the lake, "tributary systems" encompass not only in-stream habitats, but also their associated wetlands, floodplains, and adjacent uplands communities. These rivers serve as a source of water, nutrients, sediment, and biota to the lake, and provide breeding, nursery, and feeding habitats for fish and other species that move back and forth from lake and stream habitats. Major rivers include: the Great Chaz, Saranac, Bouquet, and Ausable Rivers in NY; the Lamoille, Otter, Lewis Creek, Missisquoi, and Winooski Rivers in VT; and the Poultney River (both states).

- **Native Fish Assemblages**. The Lake Champlain basin is home to at least 87 species of fish, including several globally rare species. The lake supports the highest diversity of fish species in all of Vermont, and among the highest in the entire Northeast (only the Great Lakes have higher fish diversity). Due to its unique glacial history, Lake Champlain's fish represent a mix of boreal, Atlantic coastal, and Mississippi watershed species. The Nature Conservancy's goal is to conserve naturally reproducing populations of the entire native fish assemblage, by conserving or restoring the ecological processes they depend upon.

- **Native Mussel Assemblages**. Freshwater mussels are one of the most imperiled group of species in the world. They are an important component of freshwater species diversity. Their high sensitivity to human-caused impacts, such as pollution, sedimentation, and alteration of water regimes, make them an excellent indicator of ecosystem health. Lake Champlain and its tributaries are home to 14 freshwater mussel species. The explosion of zebra mussels since 1993 has decimated native mussel species in the lake. However, important mussel populations persist in the lake's tributaries and, to some extent, on river deltas.

- **Colonial Nesting Birds**. The Lake Champlain basin is home to 318 species of birds, sixteen of which are listed by New York, Vermont and/or the federal government as endangered or threatened. Initially, The Nature Conservancy is focusing on colonial nesting species – birds that nest in colonies, usually on islands or in wetlands, including herons, egrets, gulls, and cormorants.

In consultation with partners and experts, The Nature Conservancy has evaluated the current health, or "viability", of the eight biodiversity systems. Each was graded for its landscape context (status of the larger landscape within which the system is embedded), current condition (the health of the system itself), and its size (the acreage size of systems, or the population diversity and sizes for species assemblages). As summarized in the table below, the current ecological health of the Deep Lake Pelagic Zone was rated "Good", and the Deep Lake Benthic Zone was rated "Very Good." All other systems were rated "Fair" or "Poor". The viability rating for the Native Fish

Assemblage has not yet been rated. The combined Viability Rank for all of Lake Champlain was rated "Fair", meaning that significant conservation efforts are needed to improve the lake's ecological health.

Current Health of Lake Champlain's Major Ecological Systems

Ecological Systems	**Landscape Context**	**Condition**	**Size**		**Combined Viability Rank**
	Grade	*Grade*	*Grade*		
Deep Lake Pelagic Zone	Good	Good	Very Good		Good
Deep Lake Benthic Zone	-	Very Good	Very Good		Very Good
Littoral Zone	Good	Poor	Very Good		Fair
Wetlands & Shorelines	Fair	Fair	Good		Fair
Tributary Systems	Fair	Fair	-		Fair
Native Fish Species	-	-	-		-
Native Mussels	Fair	Fair	Fair		Fair
Colonial Nesting Birds	Fair	Poor	Fair		Fair
Overall Biodiversity Rank					**Fair**

III. Biodiversity Threats

Through a collaborative process drawing upon partner organizations and experts, The Nature Conservancy identified the major sources of threat to Lake Champlain's biodiversity, identifying more than 30 threats. Some threats reflect historical activities (such as filling of wetlands); others are ongoing (such as invasive species introductions); and yet others lie in the future (potential impacts of climate change). All threats were carefully evaluated and ranked. This process identified ten key threats to Lake Champlain's biodiversity (all are considered a high priority; they are not listed in priority order):

1. **Incompatible Agricultural Practices**. Crop and livestock production, if not property managed, can result in nutrient, sediment, and toxics loading to streams and the lake, as well as result in direct impairments to riparian habitats.

2. **Invasive Species**. Introduced species – plants, fish, mussels, plankton, pathogens, and disease – can crowd out native species and severely disrupt ecosystem processes. Some invasives have already arrived; many others are knocking at the door.

3. **Poorly Planned Residential & Commercial Development**. Poorly planned development destroys and fragments wildlife habitats, and causes non-point runoff into streams and directly into the lake. The overall level of basin-wide development is also a concern.

4. **Existing Impacts to Riparian Zones**. Virtually all of Lake Champlain's tributaries have been altered by activities such as land conversion, channelization of streambeds, and filling of wetlands. These historic activities, although halted decades ago, continue to impair ecosystem health.

5. **Loss of Wetland Buffers**. Wetlands require vegetated buffers (100+ feet) to protect water quality, along with much larger adjacent natural habitats (1,000+ feet) that are used by wetland-dependent reptiles, amphibians, birds, and mammals.

6. **Road Construction and Maintenance**. Poorly sited or maintained roads can isolate wetlands, impair hydrological connectivity, and cause non-point water pollution.

7. **Dams, Culverts and Other Barriers**. Dams prevent up- and down-stream movement of species and isolate fish from their spawning habitats. Even small road culverts, if improperly installed or maintained, disrupt aquatic connectivity. Hydroelectric dam operations can substantially impair natural water flow regimes.

8. **Overabundance of Sea Lamprey**. Recent research indicates that sea lamprey are native to Lake Champlain. For reasons not currently understood, however, it appears that lamprey populations are much higher than normal, resulting in significant impacts on Atlantic salmon, lake trout, and other fish.

9. **Expansion of Cormorant Populations**. Double-crested cormorants first nested on Lake Champlain in 1982. Since then, their populations have grown exponentially, to 3,900 nesting pairs in 2004, potentially threatening other native colonial birds including herons and egrets (the total number of cormorants using the lake, including juveniles and migrants, exceeds 20,000).

10. **Climate Change**. The Northeast's climate has been warming over the past century. The average date that Lake Champlain freezes over is now 8 days later than the average freeze date in the 1800s. Over the last 186 years, almost half of the winters in which the lake never froze have occurred since 1970. No specific ecological impacts resulting from climate change have been documented for Lake Champlain. However, the potential for further reduction in ice cover, coupled with future changes in the amount and timing of precipitation, could cause major impacts to the lake's ecosystem and native species.

Some of these threats impact only one of the 8 biodiversity systems; others impair many resources. The table on the following page identifies our best understanding of how the major threats impact ecosystems and species assemblages. Several observations:

- Lake Champlain's littoral zone, native fish and mussel assemblages, and tributary systems face a "high" overall threat rank. The deep lake pelagic zone, wetlands & shoreline communities, and colonial nesting birds face an overall "medium" threat level. The deep lake benthos threat rank is ranked low, although this may simply reflect our relatively poor understanding of this difficult to study habitat.

- The Lake Champlain Basin Program has identified nutrient loading as one of the leading threats to the lake. Although nutrient loading is not listed as a specific threat in this report, The Nature Conservancy agrees with the high priority importance of this issue and fully supports continued public investments at reducing nutrient inputs to the lake. Many of our strategies are aimed at addressing major sources of nutrient loading, including improper agricultural practices, roads, and residential and commercial development (these activities also result in other impacts, such as habitat destruction and hydrological impairment). Focusing on the specific activities that generate elevated nutrients (rather than considering "eutrophication" a single threat) allows us to create and track targeted conservation strategies designed to address the multi-faceted sources of nutrient loading to Lake Champlain.

- TNC's goal is to develop conservation strategies to address all "high" ranked threats – which are identified by the "red boxes" on the Threats Table or strategies which simultaneously remove some mix of red and medium ranked threats.

Sources of Threats to Lake Champlain's Biodiversity Health

Biodiversity Threats: Lake Champlain	**Deep Lake Pelagic Zone**	**Deep Lake Benthic Zone**	**Littoral Zone**	**Wetlands & Shoreline**	**Tributary Systems**	**Native Fish Species**	**Native Mussels**	**Colonial Nesting Birds**	**Overall Threat Rank**
Invasives: Non-Native Fish	High		High	Medium	Low	High		Low	High
Invasives: Zebra Mussels	Medium		High			High	Medium	Low	High
Invasives: Non-Native Plants			High	High		Medium		Medium	High
Residential & Com Development	Low	Low	Medium	Medium	High	Medium	Medium	Medium	High
Overabundance of Sea Lamprey	High					High			High
Improper Agricultural Practices	Low	Low	Medium	Medium	Medium	Medium	High	Low	Medium
Road Construction & Maintenance			Low	Medium	High		Medium		Medium
Barriers (Dams, Culverts, Structures)		Low	Medium		High	Medium			Medium
Altered Hydrological Regime & Erosion							High		Medium
Loss of Wetland Buffers			Medium	High	Medium				Medium
Overabundance of Cormorants & Gulls								High	Medium
Toxins (e.g. PCBs & Mercury)	Medium	Low	Medium						Medium
Nutrient Loading (point)				Low	Medium				Low
Climate Change – Temp & Precipitation	Low	Low	Low	Low					Low
Impacts to Riparian Zones					Medium				Low
Invasives: Non-Native Zooplankton	Medium								Low
Overall Rank By Target	Medium	Low	High	Medium	High	High	High	Medium	**High**

Through consultation with experts, The Nature Conservancy identified and ranked more than 30 threats to Lake Champlain's biodiversity. Pictured above are the threats that emerged as most significant through this analysis. The goal of this analysis is to inform strategies – implemented by the Conservancy and public and private entities active in the basin – to address all "high" sources of threat (each "red" box above).

IV. Conservation Strategies

In the final step in the planning process, The Nature Conservancy has identified a set of strategies designed to address the critical threats listed above, thereby protecting and restoring the health of Lake Champlain's biodiversity. The Conservancy will directly engage in some of these strategies. For others, TNC will play a support role to other public and private organizations that are best positioned to advance them. The biodiversity conservation strategies are organized under four broad themes:

- Enhanced Fish, Wildlife and Ecosystem Viability
- Tributary Restoration & Water Quality
- Land/Water Protection & Sustainable Development
- Invasive Species Prevention and Control

A. Enhanced Fish, Wildlife and Ecosystem Viability

The threats to Lake Champlain's native plants, fish, wildlife, and ecosystems are varied and many. This section sets forth specific strategies aimed at addressing the highest priority threats.

Fish / Biodiversity Monitoring

The states of Vermont and New York, the federal government, and the Lake Champlain Basin Program maintain sophisticated and extensive water quality monitoring programs to track phosphorus levels and other water quality parameters throughout the Champlain basin.

However, a parallel effort to monitor biological resources – the status of fish populations, wildlife, and the plankton and invertebrate species that support the lake's food chain – does not exist. Alarming trends are apparent for several high visibility species: lake trout are not naturally reproducing; sea lamprey and double-crested cormorant populations are high; and zebra mussels are displacing native mussel species. However, remarkably little is known in terms of basic population numbers or trend levels for the hundreds of fish, wildlife, and plankton species that reside in the lake. The lack of comprehensive biological monitoring information is a major impediment to the success of efforts to conserve Lake Champlain's biodiversity.

Moreover, while ecological models have been developed for some species, a comprehensive model describing the entire Lake Champlain ecosystem – including the relationships between different trophic levels and groups of species – does not exist. The lack of a whole-lake ecosystem model greatly hampers efforts to predict the impacts of potential changes (such as the introduction of invasive species) to the lake's biodiversity.

1. **Lake Champlain Ecosystem Model**. Public and private funding is needed to support a collaborative effort, involving research institutions and academic experts around the lake, to develop a whole-lake model describing the ecological interactions and relationships that drive the health of Lake Champlain's biodiversity. The modeling effort will help refine management goals for Lake Champlain, such as desired population sizes for priority species, water quality targets, etc.

2. **Fish / Biodiversity Research & Monitoring Initiative**. A major new Lake Champlain biodiversity research and monitoring program should be established, to evaluate and track the health of fish populations, zooplankton and phytoplankton, key wildlife species, and other critical ecological indicators. Monitoring is needed for both native and introduced species. The technical expertise to administer this program already exists – in state and federal agencies and academic institutions. A substantial increase in public funding is needed to launch this initiative.

Sea Lamprey

Recent research suggests that sea lamprey are native to Lake Champlain, dating to the period some 11,000 years ago when the lake was directly connected to the Atlantic Ocean via the St. Lawrence (not all experts agree with this conclusion). Native or not, it appears that lamprey populations today are high, resulting in significant impacts on Atlantic salmon, lake trout, and other fish species, and disrupting the lake's ecology. There has been much study and public debate surrounding the use of lampricides to control sea lamprey populations. This debate needs to be expanded in two areas:

3. **Sea Lamprey Research**. Scientific research is needed to determine the factors causing high sea lamprey populations. For control efforts to be effective in the long-term, we need to know why sea lamprey populations can rebound to high levels when control programs are stopped.

4. **Lamprey Control Alternatives**. The Lake Champlain Fish & Wildlife Management Cooperative has created a Sea Lamprey Control Alternatives Workgroup. Expanded resources are needed for this Workgroup to undertake research and field studies to develop innovative sea lamprey control strategies. Current efforts to control lamprey populations rely primarily on chemical treatment of tributaries and river deltas with lampricides, powerful chemicals that can be toxic to some amphibians, a wide spectrum of native fish and insects, and probably other animals as well. The development of comprehensive and effective alternatives, which could include barriers, trapping, nest eradication, predator reintroduction, and pheromone attractants, is needed to build a sustainable approach to sea lamprey control.

Native Fish Diversity

Lake Champlain is home to at least 87 fish species, ranking it among the most diverse lakes in all of New York and New England (only the Great Lakes support more species). However, little is known about the overall health of many species and several fish species are experiencing severe viability problems. For example, lake trout – a key top predator in the lake's deepwater ecosystem – are not successfully reproducing, requiring annual stocking to maintain their presence in the lake.

5. **Native Fish Conservation Efforts.** *NOTE: The Nature Conservancy has not yet completed its analysis of Lake Champlain's native fish assemblage, nor has TNC identified specific conservation strategies aimed at conserving native fish diversity. This section will be developed, in consultation with experts about the lake's fish communities. Highlighted species could include lake trout, lake sturgeon, landlocked Atlantic salmon, and many others. TNC is interested in pursuing a 'native fish community' approach that nests species-specific approaches in a holistic understanding of native fish population dynamics.*

Cormorants

Double-crested cormorant populations are growing exponentially throughout the eastern United States. The factors causing cormorant population growth are not fully understood, although the banning of DDT and other toxic chemicals, coupled with abundant winter food sources associated with catfish aquaculture in the southern U.S., are thought to be key influences.

Cormorants first nested on Lake Champlain in 1982 on Young Island when one nest was found. Over the past two decades, cormorant populations have grown dramatically. In 2004 there were approximately 3,900 nesting pairs on Lake Champlain, with major colonies on Young Island and Four Brothers Islands. TNC owns the Four Brothers Islands.

The total number of cormorants annually found on Lake Champlain, including nesting adults plus juvenile and migrating birds, is estimated to exceed 20,000. Cormorants, which nest in dense colonies, have the capacity to transform island habitats and displace other colonial nesting birds, such as herons and egrets. The most dramatic impacts have occurred on Young Island, which has been largely denuded of vegetation. As a result of cormorants and ring-billed gulls, tree nesting bird species such as black-crowned night herons no longer use the island. The Vermont and New York State Departments of Environmental Conservation have developed aggressive cormorant management strategies designed to reduce breeding pairs by 80% below their current numbers. The strategies include nest removal and oiling of cormorant eggs, and beginning in 2004, the shooting of some adult birds.

6. **Cormorant Research & Management.** TNC has concluded that additional research is needed to better understand cormorant population dynamics and to evaluate the effectiveness of cormorant management strategies. Therefore, we are not prepared to approve nest removal and egg oiling on the Four Brothers at this time. Instead, we have identified a series of questions that should be addressed over the next two years, and TNC has committed to participating in research efforts to answer these questions. They include: a) Development of a comprehensive regional cormorant management plan which addresses not only breeding populations where there is regular interchange of birds (e.g. the Great Lakes) but also wintering populations in the south; b) Setting science-based Champlain-wide cormorant population control targets which address regional management plan objectives; c) Evidence that Four Brothers cormorant populations are not, in fact, stabilizing (nest count data for 2004 show a slight decline in cormorant nests from the previous year); and d) Further documentation (including monitoring data) which confirm that night oiling of eggs does not result in cormorants displacing to other areas (for example, to interior Adirondack lakes). TNC has committed to revisiting its cormorant management policy for the Four Brothers in two years, once these research issues are addressed.

B. Tributary Restoration & Water Quality

Lake Champlain's tributaries are a critical driver of the lake's ecological health: they provide important habitat for many species that travel between tributaries and the lake itself, and they play a pivotal role in the lake's nutrient and sediment balances. For many years, public agencies and private organizations have advanced successful programs to reduce nutrient and sediment loading to Lake Champlain's tributaries, with a particular emphasis on reducing phosphorus loading. These efforts are essential to maintaining the ecological health of the lake – it is vitally important that they be continued. However, while much has been done to reduce point and non-point water pollution, much more remains to be done.

Riparian Zone Habitat Conservation Initiative

The focus of current tributary protection programs should be expanded. In addition to continuing efforts to reduce water pollution inputs, efforts to reduce sedimentation need to be greatly increased, and work to restore and improve aquatic and riparian habitats and the processes that shape them need to be added as a priority focus to all tributary management programs. Specifically, TNC proposes a new "Riparian Zone Conservation Initiative." Under this approach, TNC would help create some of the missing tools and partnerships to help develop a framework to organize and focus implementation of a wide range of existing state, federal, and private conservation programs. The initiative's goal would be to create a more comprehensive ecosystem approach that protects both water quality and natural habitats so that elements of biodiversity protection gradually become incorporated into much of the conservation

work that occurs within the Lake Champlain Basin. Specific action steps to advance this strategy could include:

7. **Riparian Protection Standards and Protocols**. TNC will work with the Vermont Department of Environmental Conservation's (VT DEC) River Management Program, and the University of Vermont's Spatial Analysis Lab, to develop a set of standards and protocols that can be used to incorporate biodiversity and habitat protection into riparian zone conservation work. Given the large number of public and private players, and their differing perspectives, TNC will not convene a planning process to seek an agreement among the partners. Rather, TNC and VT DEC will synthesize the state of current knowledge and provide easy public access to that knowledge so that others can gradually and voluntarily incorporate this information into their work. This will enlarge the current focus of the VT DEC to protect the meander-belt width zone of streams and rivers to reduce flood damage. Our intention is that these tools will enhance understanding of biodiversity issues among landowners, elected officials, and the public, helping create a common biodiversity language so that riparian conservation approaches are more unified across the basin, as well as other watersheds in New England and New York.

8. **"Riparian Zone Conservation Packages."** Currently landowners, and even conservation practitioners, are faced with a bewildering array of programs focused on tributary restoration and water quality. There is not an organized menu of conservation choices, nor is there a description of how these programs optimally interact. The result is a loss of landowner acceptance and assistance from programs, and a loss of leverage between programs that would increase riparian conservation project success – making it less likely that biodiversity values will be protected in a given project. Consideration should be given to creating a "Riparian Zone Conservation Package", which would describe in one document the universe of available programs, possibly through TNC leadership in a strategic partnership with state and federal agencies. In addition, public and private funding needs to be increased for riparian conservation work in the Lake Champlain Basin. Where possible, funding criteria for riparian conservation should be developed that encourage leverage among different funding sources and programs.

9. **Focused Conservation & Restoration Efforts**. Based on a lake-wide prioritization, several key watersheds should be selected as initial pilot sites to develop and implement comprehensive tributary management plans. Potential candidates include the Hubbardton, Lamoille, and Missisquoi Rivers in Vermont, and perhaps the Chazy and Boquet Rivers in New York. Within priority river reaches on one or more of these rivers, TNC would develop model riparian zone conservation projects, to demonstrate how biodiversity protection can be incorporated into ongoing water quality, erosion control, and habitat management programs. In addition, TNC would provide technical advice and landowner outreach for other riparian portfolio sites to increase the rate with which partners

incorporate biodiversity protection into their existing goals. Strategic partnerships should be created that leverage small scale demonstration projects into conservation at the Basin-wide scale.

Dam, Roads, and Fish Passage

Dams and other barriers on Lake Champlain's tributaries have a significant impact on the lake's ecological health. Structures that block fish passage prevent fish species from reaching suitable spawning habitat – this is particularly an issue for landlocked Atlantic salmon, which spawn in a limited number of Champlain tributaries. Dams also prevent the upstream movement of freshwater mussels, which are transported in their juvenile stage by attaching to the gills of specific host fish species. Moreover, the operation of dams to generate electricity or maintain water levels in human-created reservoirs can negatively impact downstream flows and hydrology, to the detriment of riverine species and ecosystems. On smaller streams, culverts and road crossings can have a big impact. The following strategies should be pursued in conjunction with the tributaries initiative outlined above:

10. **Dams & Barriers**. A focused effort is needed to identify key dams and other structures that present major barriers to fish migration within the Champlain basin that could be addressed through the removal of dams and/or installation of fish passage structures. State and federal natural resource agencies have already analyzed some dams. We need to clarify the amount of effort needed to complete a comprehensive analysis of major dam and barriers affecting the lake. Equally important, funding and organizational focus is needed to implement high priority dam removal and modification projects. Also, further study is also needed to understand the ecological impacts of current water release regimes for dams on Lake Champlain's tributaries.

11. **Bridges & Culverts**. Bridges and culverts need to be designed, installed, and maintained to allow for up- and down-stream movement of fish and other species. Ecologically-friendly design and maintenance standards have recently been developed for Northeast rivers and streams. An outreach program is needed to educate state and local highway departments about the importance of this issue. In addition, the feasibility of identifying priority restoration projects should be considered.

12. **Impacts of Roads**. Existing roads can have significant impacts on stream ecosystems. Non-point run-off of soil, sand and gravel, road salt, and pollutants can harm water quality. Roads and berms can disrupt vital hydrological connections between streams and adjacent wetlands. A program is needed to evaluate opportunities to modify existing roads, to enhance the connectivity of streams, wetlands, and other riparian habitats. Initial efforts should be focused on seasonally-maintained roads that run adjacent to river corridors.

C. Land/Water Protection & Sustainable Development

Land protection is a key strategy for conserving the biodiversity of Lake Champlain. While the lake's bottom and waters are publicly owned, the biodiversity of the lake is greatly influenced by the health of its shorelines, wetlands, and riparian habitats. An ongoing land acquisition program is needed to protect the lake's remaining undeveloped shorelines and natural areas:

13. **State Open Space Funding**. Enhanced state funding is needed to enable the states of Vermont and New York to accelerate their land protection programs, to expand state parks and wildlife management areas that harbor important wildlife habitats and ecological communities. In addition, funding, tax incentives, and other mechanisms are needed to increase the pace of private land conservation efforts undertaken by non-profit land trusts.

14. **Federal Land Protection Funding Initiative**. An effort should be launched to create a major new source of annual federal funding for land protection efforts (fee purchases and conservation easements) in the Lake Champlain Basin, linked to the federal Lake Champlain Special Designation Act. Federal appropriations would be available to federal agencies, state governments, and non-profits working to acquire critical open space parcels in the basin.

15. **Farmland Protection**. Farmland protection efforts – drawing upon conservation easements and other tools – should be accelerated. Habitat protection objectives and standards should be incorporated into agricultural easements, to meld farmland and biodiversity conservation goals, particularly at the land/water interface.

While land acquisition is an extremely important strategy, it alone is not enough. The vast majority of the 8,234 square mile Lake Champlain watershed will always remain in private ownership. What happens on this land – decisions about the types, density, and configuration of future residential and commercial development – will exert a tremendous influence of Lake Champlain's ecological health.

Much of the Champlain basin remains in rural landscapes (78% of the watershed is comprised of natural cover including forests, wetlands, and open water). However, population growth and sprawl is occurring around major cities, fragmenting land areas and causing increased non-point pollution to the lake. Looking long-term, the health of Lake Champlain's biodiversity is dependent on the adoption of sustainable economic development and land use patterns throughout the basin:

16. **Building a Conservation Ethic**. A public education effort is needed to make the basin's residents aware of the direct connections between land use and development decisions, and the health of Lake Champlain. Looking long-term, we need to build a strong public conservation ethic that values the protection of the lake's ecosystems.

17. **Smart Growth: Moving from Concept to Reality**. Efforts are needed to advance "smart growth" initiatives in Vermont and New York, with particular focus on rapidly expanding areas such as Burlington and Plattsburgh. Smart growth techniques, such as regional planning, comprehensive land use and zoning ordinances, best management practices for home and road construction, thoughtful transportation enhancements, and brownfields redevelopment, are well known. Riparian Protection Standards and Protocols (described above) might serve as an important tool in addressing biodiversity concerns in local land use planning efforts. Leadership is needed on the part of elected officials and community leaders to adopt these principles in rapidly-growing areas around Lake Champlain.

D. Invasive Species Prevention and Control

Invasive species – non-native plants and animals that outcompete native species and transform and simplify ecosystems – pose daunting threats to Lake Champlain. Introduced species such as zebra mussels, Eurasion milfoil, water chestnut, and white perch have already placed major stresses on the lake's ecosystems, to the detriment of native species. Other recent arrivals, such as alewife, will almost certainly cause further harm.

However, in comparison to the Great Lakes, Lake Champlain has not been overwhelmed by invasive species. At least, not yet. Time is still available to stem the introduction of harmful non-native species to Lake Champlain.

The Lake Champlain Basin Program and the Vermont and New York Departments of Environmental Conservation have developed an impressive, comprehensive plan to address invasive species threats. The Lake Champlain Basin Aquatic Nuisance Species (ANS) Management Plan, written in 2000 and updated in 2004, sets forth a wide spectrum of prevention, early detection, rapid response, control, and research strategies. The Plan identifies 71 specific actions to combat invasives issues, at a total annual cost of $4.3 million. What is now needed is a sustained commitment, dedicated funding, and new laws and policies to implement these strategies throughout the Lake Champlain basin.

18. **Program Management / Strategy Prioritization.** The Lake Champlain Basin Program is well positioned to coordinate overall implementation of the ANS Plan. In recognition of the complexity of the program, the need to coordinate and prioritize among the large universe of potential strategies, and the large number of involved entities, the Basin Program has recently created the LCBP Aquatic Nuisance Species Advisory Subcommittee. This body is charged with the advising the Lake Champlain Basin Program and partner organizations on effective implementation of the ANS Management Plan. The subcommittee should aggressively move to prioritize, recommend, and conduct specific actions

set forth in the ANS Plan, and provide specialized professional advice to the Basin Program regarding emerging issues, budget priorities, and technical review.

19. **Increased Federal and State Funding**. The Aquatic Nuisance Species Management Plan identifies $4.3 million in detailed annual funding priorities. Current federal and state funding commitments meet only about one-quarter of these needs. A comprehensive outreach and lobbying strategy is needed to significantly increase funding from the federal government and the states of New York and Vermont.

20. **Water Chestnut Initiative**. The states of Vermont and New York should adopt a goal of eliminating water chestnut mats from Lake Champlain by 2012. After that date, water chestnut would be limited to individual plants, controlled by annual maintenance efforts (dense mats would be eliminated). To implement this goal, $1.5 million in state and federal funds will be needed annually for water chestnut control. The "success story" of eliminating water chestnut mats will serve as a platform for securing increased public funding for invasive species issues basin-wide.

21. **Rapid Response Mechanism**. The relevant state and federal agencies need to create a "rapid response" mechanism to swiftly act to contain and eradicate invasions by new exotic species. This mechanism could include: enhanced agency regulatory powers, paid "SWAT" teams, use of youth conservation corps, training of volunteers, etc. Key steps include: creating the institutional relationships needed for a rapid response program to function effectively, including protocols for assessment, risk management, and rapid response decision trees; and alleviating potential agency permitting roadblocks to implementing rapid response strategies.

22. **Stronger Regulations, Enforcement, and Education**. Stronger state regulations and enhanced enforcement capabilities are needed to combat invasive species. An assessment of New York's and Vermont's existing regulatory systems should be undertaken (there are significant differences between the two states), and an effort should be made to adopt a consistent regulatory approach drawing upon best practices in both states. Potential examples include mandatory boat washing regulations, stronger bait bucket laws, livewell cleaning programs, strong prohibitions against introduction of non-native species, etc. Increased funding for public education efforts and facilities is needed.

23. **Invasive Species Barrier Technologies**. Preliminary proposals have been advanced to construct barriers to prevent invasive species passage through the Champlain and Chambly canals, into Lake Champlain (these could be electronic barriers, or physical barriers with lift and carry mechanisms for recreational boats). Federal and state funding is needed to undertake additional studies to determine the technical and economic feasibility of such barriers.

Future Threats

The strategies set forth above respond to the most pressing threats facing Lake Champlain's biological diversity. Looking long-term, two additional issues require consideration:

- **Climate Change**. Climate change is a major threat to Lake Champlain. Global warming has already resulted in measurable reductions in the length and frequency of ice coverage for the lake. Potential changes to the region's precipitation regime – the amount and seasonal timing of rainfall, and the size of the snowpack and annual spring run-off, are fundamental drivers of Lake Champlain's ecosystem. Changes to these regimes, occurring as a result of global warming and climate change, pose significant threats to Lake Champlain. Regional, national, and international strategies are needed to slow the pace of carbon emissions and to sequester carbon in the world's forests.

- **Altered Lake Hydrology**. One of Lake Champlain's most remarkable features is its intact hydrological regime. Inflows and outflows to the lake are unregulated, resulting in an average annual lake level fluctuation of five feet. Today, there are no proposals to regulate the lake's level, nor to withdraw water from the basin. However, if any such proposals were to emerge in the future, they would instantly jump to the top of threats to Lake Champlain's ecological diversity. As an interim step, a more complete map of Lake Champlain's hydrology should be created.

Conclusion

The Nature Conservancy is actively seeking input, comments, and suggested changes to the draft conservation strategies proposed in this document. We welcome input from all parties, and we look forward to working collaboratively with state and federal agencies, local governments, other environmental groups, community leaders, lake constituency groups, and interested citizens to advance efforts to conserve Lake Champlain's biodiversity.