Final Research Priorities
Introduction

Al McIntosh, University of Vermont

A two-day workshop to review the status of recent research and monitoring on the Lake Champlain ecosystem and to develop priorities for future efforts was held on October 31 and November 1, 1997 at the Bishop Booth Conference Center in Burlington, Vermont. The event was co-sponsored by the Lake Champlain Basin Program and the Vermont Water Resources and Lake Studies Center.

On the first day of the program, researchers and state federal regulators presented brief summaries of relevant research and monitoring activities undertaken since the passage of the Lake Champlain Special Designation Act. The areas of endeavor discussed and the speakers were the following:

Topic	**Speakers**
Atmospherics	Tim Scherbatskoy/Rich Poirot
Cultural/Social Issues	Art Cohn/Ann Cousins
Economics/Land Use	Art Woolf/John Banta
Ecosystem Health	Mary Watzin/Dave Tilton
Fisheries	Donna Parrish/Larry Nashett
Hydrodynamics/Sediments	Tom Manley/Jamie Shanley
Nutrients	Suzanne Levine/Eric Smeltzer
Toxic Substances	Alan McIntosh/Fred Dunlap

On the second day of the workshop, participants discussed priorities developed by Friday's speakers. The following pages contain a listing and brief description of priority research needs identified for each area. In addition to those areas listed above, we have included an additional set of priorities related to biodiversity issues. Listed priorities represent the best current thinking of experts in each area and are intended to serve as a basis for decisions regarding the allocation of future research funding within the basin.

Readers of this document should note the following: (a) there has not been an attempt to rank priorities in any area; and (b) there is substantial overlap between priorities in many areas. For example, research in the areas of toxic contamination and nutrient enrichment would benefit from additional data generated by research describing the flow patterns in the lake. Similarly, information about the impact of zebra mussels on the lake's ecosystem would benefit both investigations of the lake's fish communities and the problem of nutrient enrichment. It is important for researchers in the various areas to communicate to insure that research results can be useful in all relevant areas of endeavor. Hopefully, the Lake Champlain Research Consortium can facilitate such coordination.

A final point relates to information management. Over the past six years, we have made substantial progress using technologies like GIS and remote sensing to display data on a variety of aspects of the Lake Champlain ecosystem. We have included a list of data management priorities developed by Bruce Westcott of the VT Center for Geographic Information, Inc., John Banta of the Adirondack Park Agency and Lenore Budd of ARD, Inc. in our list of research priorities. All investigators are encouraged to take advantage of these resources as they plan research projects or interpret data from on-going work. Contact the Vermont Center for Geographic Information, Inc. at 802-656-4277 or visit their web site at http://geo-vt.uvm.edu for more information.

Atmospheric Research Priorities

Tim Scherbatskoy, University of Vermont

1. *What are the atmospheric processes that are important to Lake Champlain?*

Atmospheric processes are important in the Lake Champlain basin because the atmosphere is a constant source of nutrients, pollutants and energy. The Lake Champlain basin is in a substantially polluted airshed, and the lake itself is in a relatively large watershed (19:1 watershed:lake area) which is affected by the atmosphere. Within the basin there are multiple ecosystem functions and human uses that are directly and indirectly affected by atmospheric processes.

Atmospheric deposition of acidifying substances, toxics and nutrients continues to affect the basin. The main pathways for deposition include wet deposition (precipitation, cloud water) and dry deposition (gasses and particles). The fate of these atmospheric substances is affected by a number of ecosystem properties, including landscape structure, complex atmosphere-surface interactions, biogeochemistry, energy flow and cycling, and food web processes. Finally, climate change is probably having significant direct and indirect effects on the ecosystems of the basin and their responses to atmospheric and other factors. These include changes in the physical (precipitation, temperature, radiation) and chemical climate (nutrients, pollutants).

2. *What are currently the most pressing atmospheric issues in the Lake Champlain basin?*

Toxic contaminants (including Hg, PCBs, PAHs, and fine particulate trace metals) pose the greatest threats to the organisms and ecosystems in the basin, and processes affecting their transport and accumulation are not well understood. Nutrients are an emerging atmospheric problem, as nitrogen deposition continues to be high and calcium deposition (important to upland forested watersheds) may be declining. Climate change, although still difficult to quantify, can alter ecosystem processes and affect atmospheric loadings to the basin by changing hydrologic patterns, chemical fluxes, and UV-B flux.

Two important issues needing attention are the transport of contaminants within the basin and source-receptor relationships. Other factors that could modify the impacts of atmospheric contaminants in the basin include pollution control/prevention, remediation, and climate change. Although controlling interstate pollution affecting the basin is difficult, efforts to address this are making headway. Pollution control and prevention at the local level should also be addressed, as perhaps 30-50% of atmospheric Hg deposition is thought to be of local (<100 km) origin. Remediation of air pollution impacts is extremely difficult, although we do know that forests in the Lake Champlain basin seem to help reduce the movement of Hg to the lake, and healthy ecosystems generally ameliorate stresses better than degraded ones. Climate change is likely to complicate both our understanding and management of atmospheric influences in the basin. For example, we can readily speculate that increased precipitation will stimulate mixing and transport processes, and climatic warming will exacerbate Hg transport through forested watersheds.

3. *What research is needed to address these atmospheric issues in the Lake Champlain basin?*

Two broad areas are outlined below for additional research which is needed to better understand the behavior and risks of atmospheric contaminants in the Lake Champlain basin, as well as indicate appropriate pollution control and management strategies. Specific research tasks are prioritized according to urgency.

In addition, several strategic recommendations were identified to facilitate this research, including : (a) seek the assistance of a visiting atmospheric scientist to conduct air transport and deposition modeling in the basin and region; (b) increase the attention on these issues in the basin, including financial assistance, under the clean air regulations of the state and the Clean Air Act (section 112m); (c) increase spending on assessment of research data; and (d) address shorter-term, more feasible issues first.

I. Understand the transport mechanisms for hazardous air pollutants within the basin.

(a) Measure concentrations and loadings of Hg and other trace metals in representative sub-basins, land uses, and surface waters of the basin. This task should be coordinated with research on toxics.

(b) Identify mechanisms affecting Hg transport and accumulation, particularly the role of dissolved organic carbon, sediment transport, hydrology, and entry into food webs.

(c) Characterize the behavior of other important hazardous air pollutants in the basin, including measuring surface-atmosphere exchange rates of PCBs in the lake, and screening for other contaminants in the basin. This task should be coordinated with research on toxics.

(d) Identify physical and chemical impacts of climate change on transport processes and loadings of pollutants in the basin, including changes in : hydrologic and sediment transport to the lake, acid rain pollutants, seasonal temperature regimes, and UV-B exposures. This task should be coordinated with research on lake hydrodynamics and ecosystem health.

II. Clarify source-receptor relationships for atmospheric contaminants in the basin.

(a) Calculate direct and indirect loadings of Hg, nutrients, and other hazardous air pollutants to the lake and basin, including deposition fluxes and pools in representative land use types and streams, better dry deposition estimates, comparison with existing data on contaminants in sediment cores, and mass-balance calculations for Hg and possibly other hazardous air pollutants. This task should be coordinated with research on toxics and nutrients.

(b) Identify sources of atmospheric contaminants in the basin, including characterizing air trajectories and air mass chemical signatures, distinguishing local and distant sources, adding additional weather monitoring in the northern and southern lake to support transport modeling, measuring water chemical signatures to link with the air data, and screening for as-yet unrecognized problem contaminants. This task should be coordinated with research on lake hydrodynamics.

(c) Determine risk factors from the combined effects of exposure to multiple sources of contaminants in the basin (e.g., food+water+air), including identifying and quantifying exposure pathways, and coordinating research with state air toxics and health initiatives. This task should be coordinated with research on toxics and ecosystem health.

(d) Assess possible strategies for pollution control and remediation in light of source-target linkages and ecosystem pollutant retention/release processes, including quantifying effectiveness of various strategies, conducting uncertainty analysis, and identifying effects of climate change on strategies. This task should be coordinated with research on nutrients and ecosystem health.

Cultural/Social Research Priorities

Art Cohn, Lake Champlain Maritime Museum
Ann Cousins, Lake Champlain Basin Program

1. *Museums and historic places (including historic districts, villages and agricultural properties) have recently been the focus of cultural heritage tourism initiatives, yet anecdotal feedback suggests that while cultural heritage tourism is the leading niche tourism interest in the Basin, historic sites are not enjoying the direct economic benefit initially hoped for. What is the economic value of cultural heritage places to the region? How can that value be translated into public private investment?*

The value of cultural heritage places to the tourism industry can be assessed by querying existing tourism data. Additional research could identify 1) examples of museums, galleries and historic districts that have translated increased visitation and tourism exposure into revenue; and 2) models of public investment and private patronage resulting from an appreciation of that value.

2. *Given the increased technological and biological pressures, how can we protect underwater cultural resources?*

To supplement the Impact of Zebra Mussels on Shipwrecks archival study completed in 1995 by the Lake Champlain Maritime Museum, researchers can field test predictions through a monitoring program. Simultaneously, researchers should continue the systematic lake bottom survey to complete the inventory of Lake Champlain shipwrecks. Based on the combined information gleaned from the inventory and impact study, a task force can develop management options and implementation criteria, ranging from doing nothing to raising and conserving the resource.

3. *Vermont and New York have balanced protection vs. public access to historic shipwrecks through the Underwater Historic Preserves and educational programs. What is the value of these programs? How can they be enhanced to better address public interest and State responsibility?*

Using existing diver registration forms, researchers can survey the diving community to assess the economic, recreational, and historic preservation value of the Lake Champlain and Lake George preserves. Simultaneously, researchers can identify and extrapolate economic and value data from comparable underwater preserve models to predict the potential of an enhanced Lake Champlain-Lake George underwater preserve system.

4. *What is the impact of marinas on Lake Champlain water quality?*

Researchers can identify pollutants likely associated with marinas and monitor water quality to determine the impact of marinas on Lake Champlain water quality.

5. *What is the impact of zebra mussels on recreational uses, resources, and places?*

Municipal and state beach managers can be queried to determine the impact of zebra mussels on swimming areas. Using boat registration information, researchers can survey boaters to determine the economic impact of zebra mussels on boaters. Geographic data will provide a tool to predict economic and recreational impact in areas of Lake Champlain not yet saturated.

6. *With increasing recreational pressure on areas of the lake, how can planners assure a balance between access and protection, particularly related to ecologically sensitive and congested areas?*

To follow up the Malletts Bay Recreation Planning Project, researchers can build a computerized model to predict the impact of changes in land and recreation uses on the lake. This predictive model will be key in developing management plans, which could consider criteria and standards for recreational uses in areas of the lake.

Data Management Research Priorities

Bruce Westcott, VT Center for Geographic Information, Inc.
John Banta, Adirondack Park Agency
Lenore Budd, ARD, Inc.

1. *How can Lake Champlain Basin Program managers assure that all public digital data developed for or used by LCBP projects -- whether that data is in geographic, tabular, image, or other forms -- be included in a logically-centralized indexing system?*

Researchers, public officials, and the public are entitled to access this wealth of information[1], and the potential cost-savings and improved decisions that can result from its use will only be realized if users can learn that it exists.

2. *For each data base developed or used by LCBP projects, what is the essential information about each data base which should be recorded and maintained by the data developer, and should be accessible to query and indexing systems?*

3. *Can LCBP researchers and managers identify data bases which are not currently available but which -- if developed -- could be shared and used by a variety of researchers and agencies?*

4. *How can LCBP researchers and managers assure that data developed through LCBP efforts are better understood and more often used by commercial entities and public agencies operating within the Basin in order to improve the quality of their plans and decisions?*

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[1] Standardized "metadata" records relating to each GIS data base are becoming more ubiquitous, thanks to the efforts of the Federal Geographic Data Committee (http://www.fgdc.gov). The National Institute of Standards and Technology (http://www.nist.gov/) and the International Standards Organization (http://www.iso.ch/) also champion activities related to standardized documentation of many forms of data resources.

Economics and Land Use Research Priorities

Art Woolf, University of Vermont

1. *Can we design market-based incentives to more effectively reduce the overall level of phosphorus loading at the lowest possible cost? How can these incentives be used to economically allocate the reductions among the point, non point agricultural, and other non point sources?*

We need better data on point and non point control costs and the impacts of reducing phosphorus loading from each. This means better technical and cost data on specific treatment plants, a better understanding of the level of loadings from non-agricultural non point sources and better data on agricultural loading. The agricultural loading data could include information on different land and soil types, distances of farms from major and minor watercourses, and similar technical data. This would allow us to better analyze the costs and effectiveness of different control strategies and therefore advise us on where control techniques can best be placed and resources best be directed.

2. *Can we further refine the economic benefits that result from a cleaner lake?*

Economic benefit studies are important because the costs of pollution control strategies need to be balanced against the benefits. The costs are specific to treatment plants, farms, and other sources of pollutants. The benefits are much more diffuse across industry groupings, economic activities, and sectors of the economy. Benefit studies have focused on fishing and boating and other activities. These can be expanded and other benefits such as swimming and beach values can be quantified. Other benefits should also be identified and explored.

3. *Can we get a better breakdown of benefits to visitors (tourists) and benefits to local residents from a cleaner lake (or the costs of not having tourists and the costs to residents from a dirtier lake)?*

As tourism becomes more important to the economy and the lake becomes a central focus of that tourism economy in the basin, better information on the economic impacts of tourists will help target resources and enhance the value of the lake. Benefits to local residents will allow for a better understanding of the direct local impacts.

4. *Given a fixed amount of resources available to implement basin strategies, where should they be used to correspond to the values, risks, and priorities of area residents?*

The costs to the public and private sectors of pollution control strategies should be based on the best use of the resources to control pollution. A mechanism should be put in place to help determine the optimal use of resources used to mitigate and reduce pollution of different types.

5. *How can we maintain an ongoing database with current socioeconomic data relevant to the basin?*

The 2000 Census will provide us with much new information on the basin, but the Census data are not easily transformed from the two states to a basin wide area, not to mention the lack of information for Quebec. Other data are collected by state and federal agencies, but it is time consuming to transform those into basin wide information. The Census data should be used to give us year 2000 baseline data and, if possible, it should be enhanced and updated.

Ecosystem Health Research Priorities

Mary Watzin, University of Vermont
Dave Tilton, US Fish and Wildlife Service

1. *How can the Lake Champlain Basin Program's management goals be translated into a reference condition for Lake Champlain? Is there agreement among the people of the Lake Champlain Basin as to what they want their lake to look like?*

These questions could be answered through a combination of sociological research into human values in Basin communities and scientific research and interpretation of what ecological conditions are necessary to provide these values.

2. *What are appropriate measures of the ecological quality or integrity of Lake Champlain? Are there ecosystem measures that can be used to tell us whether Lake Champlain is healthy or not?*

Research is needed to identify appropriate indicators of ecosystem health. There are a variety of approaches that have been taken to develop indicators in the Great Lakes and other water bodies. Basic information on reference community composition and the tolerances of organisms to anthropogenic stresses is needed.

3. *How can ecological indicators be linked to management actions in order to evaluate the success of the Lake Champlain Basin Program?*

Ecological indicators must be linked to management actions in order to evaluate whether our management plan is achieving its goals. A hierarchy of indicators could be developed to accomplish this goal.

4. *How are phosphorus and nitrogen concentrations linked to the composition of the aquatic community in Lake Champlain? Are the in-lake phosphorus criteria appropriate for the biological community we want in Lake Champlain?*

Additional research on trophic transfer and trophic dynamics in Lake Champlain are needed to answer these questions. A model that links all the trophic levels in the lake could be used to explore the implications of various phosphorus and nitrogen concentrations for upper levels of the food web would be a valuable management tool. Additional research is also needed on the effects of zebra mussels on phosphorus dynamics.

5. *Data on biological, chemical, and physical anthropogenic changes are scattered and patchy. What techniques can best evaluate the degree of impairment of the Lake Champlain ecosystem?*

Managers and researchers in the Great Lakes have explored a variety of habitat assessment approaches to quantify impairment. Some are based on long term data sets and some are based on "best professional judgment" and other more qualitative approaches. Research is needed to explore the best options for the Lake Champlain Basin.

Fisheries Research Priorities

The Lake Champlain Fish and Wildlife Management Cooperative
Fisheries Technical Committee

1. *What contribution does walleye stocking make to the adult population?*

Researchers need to establish an effective long-term mark to apply to fry and fingerling walleye to evaluate stocking effectiveness and assess recruitment to the adult population. Through bioenergetics modeling they should establish the A yearling equivalency of stocked walleye (similar to that for stocked salmonids) and establish stocking caps to protect the forage base.

2. *How should we sample walleye?*

Researchers need to determine gear, locations and sampling methodology required to collect adequate samples of juvenile and non-spawning adult walleye for establishing population estimates within 25% of actual value with 95% confidence. These abundance estimates and associated biological data will allow managers to better regulate the fishery harvest and refine bioenergetics models.

3. *Are smelt populations different among basins?*

There is a need for research to determine, possibly via genetic techniques, if the Lake Champlain smelt population is a homogeneous mix or if various basins support discrete populations. If populations are discrete, the salmonid and walleye fisheries must be managed basin-by-basin to optimize populations of both smelt and predators.

4. *What level of predation can smelt sustain in Lake Champlain?*

Research, using a combination of modeling techniques and literature review, is needed to establish a mortality rate threshold beyond which the smelt population is in jeopardy of collapse. Managers could reduce predation on smelt, if necessary, by reducing stocking levels of salmonids and walleye.

5. *Are lake trout naturally reproducing, and if not, why not?*

There is a need to determine if viable spawning products are deposited in appropriate spawning habitat, and, if so, why they are not contributing to recruitment into the adult population. To date, nearly all lake trout collected during sampling activities have been fin-clipped, indicating they were stocked.

Hydrodynamics Research Priorities

Tom Manley, Middlebury College
Jamie Shanley, USGS

1. *What is the circulation within Lake Champlain and how does it change over space and time? What are the forces that create/modify these circulation patterns?*

In this context, circulation implies not only the observations of water flow, but also that of exchange between the various 'closed bays' and the central lake. Observations of temperature and currents should be continuos (~1 hr) and long term (>1 year) in order to better understand seasonal and inter-annual variations. Aside from our ability to observe currents at a specific location (utilizing free drifters). Since wind is the most dominant forcing function in lake circulation, correlation between observed winds and currents must always be examined. Satellite imagery should also be utilized whenever possible.

2. *The long-term goal of the hydrodynamic program is to develop the capability of predictive modeling so that management issues could be investigated and potential solutions discussed. Examples could be the impact of an accidental toxic release into the lake, or the optimization of effluent and drinking water intake pipes within close proximity of each other.*

The development of hydrodynamic models that are capable of reproducing all of the relevant circulation patterns observed in the lake is essential. This includes linear and nonlinear aspects of the internal seiche as well as sluggish flow during winter time. Interactions between the south lake and the main lake as well as the main lake and the restricted bays should also be defined. Changing stratification within the lake as a function of atmospheric forcing should also be considered important. With regards to modeling input and verification, strong interaction between observational programs must be maintained. Additionally, new in-lake meteorological stations as well as lake level gauges at both the northern and southern extremities of the lake should be installed.

3. *As more detailed morphology of the lake bottom is being gathered, so is our knowledge that specific regions (in some cases at depths greater than 200 ft) have long term histories (10-1,000 years) of bottom erosion / resuspension. It is just as clear that potentially toxic laden sediment can be redistributed within the lake. While new regions of erosion are being documented each year, very little is known about how much time this sediment remains in water column, distance traveled, or if there are preferred depositional sites.*

Research needs to be focused on further documentation of these erosional sites, as well as the net depositional trends within the lake. Additional efforts should also be spent in areas of shallow water, and river inlets. Of particular importance is that of the inflow of sediment laden water from the south lake. Recent evidence shows that this sediment is not evenly distributed within the southern part of the main lake (Port Henry to Thompson's Point), but concentrated on the eastern Lake Champlain.

4. *What are the sources of sediment to Lake Champlain? What are the dominant forms of the sediment? What are the principal sediment transport processes?*

Much of the phosphorus and mercury entering Lake Champlain is in particulate form. Our current understanding of sediment sources and transport processes in the basin is inadequate. It may be easiest to reduce loading of some pollutants and toxins through better management practices of sediment loads.

5. *What are the key factors that lead to high lake levels? Can we develop a predictive model for lake level forecasting? What are the gaps in current data collection?*

Recent high water events on Lake Champlain caught authorities and lake shore residents of guard and caused extensive property damage. Flow data from the several new stream gauges installed on lake inlets in 1989-90 need to be synthesized into numeric models to predict lake level changes.

Nutrients Research Priorities

Suzanne Levine, University of Vermont
Eric Smeltzer, Vermont Department of Environmental Conservation

1. *Is the trophic status of Lake Champlain changing?*

Continue existing long term monitoring programs on the lake and tributaries. Develop and apply statistical trend analysis methods to the data gathered, and incorporate the data into existing phosphorus (P) models for the lake.

2. *How do in-lake processes affect lake ecosystem response to phosphorus loading?*

Analyze in-lake processes that affect phytoplankton use of P, including growth limitation by other nutrients or light, bioavailability of dissolved organic phosphorus (DOP), and recycling via decomposition and animal excretion. As part of this analysis, determine optimal P levels for achieving the algal levels and grazing relationships desired for the lake (those promoting a productive salmonid fishery, diverse planktonic and benthic communities, and water clarity). Use the results to inform future revisions or refinements to in-lake water quality criteria.*

3. *What nonpoint source phosphorus control practices are most effective?*

Research and demonstrate the effectiveness of nonpoint source best management practices (BMPs) in reducing the loads of phosphorus and other pollutants delivered to streams. Select agricultural and urban BMPs most in need of demonstration of their effectiveness. Identify sites where implementation of BMPs is planned and water quality monitoring is feasible. Design and implement multi-year monitoring studies at selected sites using sound experimental design, including adequate pre-implementation data, paired watershed or upstream-downstream sampling design, and provision for continuous flow measurement.

4. *How are nutrients recycled within the lake?*

Better quantify P and nitrogen (N) return from sediments and from the metalimnion, and controls on flux rates. The role of benthic invertebrates and macrophytes is in special need of quantification.*

5. *Are blue green blooms associated with N limitation as the N-fixing abilities of the algae involved suggest? Could we avoid these blooms by managing N:P supply ratios?*

Examine the relationship between blue-green algal blooms and N dynamics.*

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* Make fuller use of existing water quality databases and recently developed modeling tools for Lake Champlain (e.g. long term water quality and biological monitoring program, hydrodynamic and water quality model, benthic phosphorus cycling model) to support research on these processes. Provide support for local investigators to work with these data sets and models.

Toxic Substances Research Priorities

Alan McIntosh, University of Vermont

1. *What is the importance of various sources of toxic substances?*

We need to understand more about the comparative importance of the different sources of such toxic substances as mercury and PCBs within the Lake Champlain Basin. For example, we have yet to demonstrate the role of atmospheric inputs of PCBs, nor do we fully understand how historic sources like contaminated sediments contribute to the overall budget of major contaminants.

2. *What processes control the fate of toxic substances in the basin?*

The size and diversity of the Lake Champlain basin and the complex physical environment of the lake itself significantly influence the fate and ultimate effects of toxic substances present within the basin. For example, we could better understand contaminant behavior if we could identify key transformations of trace elements like mercury and arsenic that occur within the watershed and determine how in-lake processes such as the internal seiche and sediment conversions affect such substances as PCBs. We should also assess how the presence of zebra mussels in the lake will affect contaminant cycling.

3. *How important are existing sites in the lake where contamination has already been documented?*

The recently completed lake-wide assessment of toxic substances identified several sites with elevated levels of sediment-associated contaminants. These locations merit continued attention. For example, we need to understand what effect the remediation of Cumberland Bay will have on the dynamics of PCBs in the lake and whether or not the sharply elevated levels of arsenic, manganese and nickel pose a long-term threat to Outer Malletts Bay. The potential for contaminant movement off-site from areas like Inner Burlington is also an important issue.

4. *What are the long-term impacts of toxic substances on the Lake Champlain ecosystem?*

There still are comparatively few data on the chronic effects of toxic substances on the lake's ecosystem. It would be useful to identify indicators or biomarkers to detect unacceptable exposures of lake biota to toxic substances. We should also determine if levels of mercury and PCBs carried by walleye and lake trout are sufficiently high to cause sublethal effects, particularly on sensitive life stages. More intensive assessments of the chronic effects from existing point source discharges should be undertaken as well.

5. *What are the future issues?*

There may well be concerns in this area that have not yet surfaced. Some capability to do proactive research to identify emerging issues would seem a wise investment.

Wildlife/Biodiversity Research Priorities

The Lake Champlain Fish and Wildlife Management Cooperative
Wildlife Technical Committee

1. *How do we (does society) make better informed decisions about management of our living natural resources?*

Development of methodology to monitor ecological change in selected natural community types, e.g. development of terrestrial Index of Biological Integrity (IBI) or methodologies to select indicator species.

2. *How do we increase our ability to locate rare natural communities?*

Develop and test model for locating and characterizing rare natural community types, e.g. vernal woodland pools, lakeshore grasslands, calcareous fens, using remote sensing and ground-based field work.

3. *What exotic terrestrial plant species are having the greatest impact on the native vegetation and animals of the Lake Champlain watershed?*

Assess the relative threats to natural communities of alien invasive species, e.g. glossy buckthorn, common buckthorn, Morrow's honeysuckle, Tartanian honeysuckle, Japanese knotweed, and goutweed, in the Lake Champlain Basin through literature review and comparative habitat studies.

4. *Have PCBs entered the food chain in the Cumberland Bay area of Lake Champlain?*

Monitor and assess PCB contamination within the food chain in Cumberland Bay, NY, especially as it relates to levels found in higher order predators, e.g. mink and river otter.

5. *What are the effects of the expanding cormorant population on Lake Champlain?*

Continued research on cormorant ecology on Lake Champlain

- i. Effects of control measures on cormorant breeding ecology and movements
- ii. Development of nonlethal control measures
- iii. Continued assessment of feeding ecology on Lake Champlain, e.g. food habits during pre nesting (Apr.-May), food habits during post nesting (Aug.-Sep.), food habits of non-breeding subadults (Apr.-Sep.), assessment of impacts of cormorant feeding on local fish populations.
- iv. Assessment of impact of cormorant nesting on Lake Champlain island vegetation.

6. *What can we do to assist ongoing exotic vegetation control efforts in the Lake Champlain watershed?*

- i. Assessment of purple loosestrife biocontrol program (release of exotic insects) on native wetland flora and fauna (invertebrates).

- ii. Development of new methodologies to control water chestnut.