Designing a Geography of Hope Update: Reflections of Current Thinking & Conversations

Update #6: Including Aquatic Targets in Ecoregional Portfolios: Guidance for Ecoregional Planning Teams

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Contents

Designing a Geography of Hope *Updates share lessons learned and best practices generated by the most recent experiences of ecoregional planning teams throughout The Nature Conservancy. These up-to-date guidelines will eventually be incorporated into the next edition of* ***Designing a Geography of Hope****. To comment on, to suggest future topics, or to receive earlier Updates, contact Sara Kaplaniak at 703/247-3679 or sara_kaplaniak@tnc.org.*

Purpose

This document provides general guidelines and options for ecoregional planning teams to incorporate aquatic species and community targets into their portfolios. Our goal is to provide sufficient information for ecoregional teams to understand their options, assess their resources, design and carry out a strategy to identify aquatic targets, and assemble a portfolio that conserves these targets. Future updates will supplement this document and keep ecoregional planning teams apprised of new tools and approaches to meet these aquatic ecoregional planning goals. [1]

The Conservancy's Freshwater Initiative (FWI) aquatic ecologists will provide support to ecoregional planning teams through regional workshops, documentation of ongoing aquatic ecoregional planning efforts, distribution of planning tools such as custom ArcView tools, and direct individual consultations. We hope to learn as much as we can about all aquatic planning efforts so that we can share lessons and promote successful approaches that create products comparable across ecoregions.

This document includes four sections:

1. The *Introduction* explains the importance of aquatic site conservation and the context for this work within The Nature Conservancy.
2. *How the Freshwater Initiative Can Help* mentions services the Freshwater Initiative can provide to ecoregional teams.
3. The *General Approach* presents a five step process for integrating aquatic targets into ecoregional planning at two levels of assessment.
4. The *List of Assessment Steps* provides a logical sequence of steps which ecoregional teams may use to assess how best to incorporate aquatic biodiversity information into their ecoregional plans.

Introduction

Aquatic ecosystems in the United States contain a diverse and unique fauna, but our rich aquatic heritage is imperiled. While many people think of the tropics as the center for biodiversity, the United States has the greatest variety of many freshwater organisms in the world. The United States contains more than half the world's crayfish species, and has a greater variety of species of mussels, snails, stoneflies, mayflies, and caddis flies than any other country. The United States is also home to 10 percent of the freshwater fishes of the world, ranking seventh in worldwide species diversity. Despite this amazing diversity, we still do not know the best places to conserve these organisms.

[1] Reports are mentioned throughout this document that provide more detailed information on the topics discussed here. These reports will be made available through two web sites: the Freshwater Initiative web site located at www.freshwaters.org on the internet; and, the Freshwater Initiative web site located on the Conservancy's internal intranet (found at home.tnc for staff with Wide Area Network connectivity). These reports may also be obtained by contacting Jonathan Higgins (jhiggins@tnc.org or 320/759-8017). This document and future updates will also be made available through these web sites beginning in late February, 1999.

Habitat loss, pollution, exotic species introductions, and alteration of natural flow regimes from dams, channelization, and various land uses have had catastrophic impacts on the biotic and abiotic components of aquatic ecosystems (Ward and Stanford 1989, Richter et al. 1997). A comparison of the percent of North American terrestrial and aquatic species listed as extinct, imperiled, or vulnerable shows that the obligate inhabitants of freshwater are disproportionately in trouble (Master 1991; Stein and Chipley 1996). In fact, aquatic ecosystems in the United States alone are home to more than half of all of North America’s known imperiled and vulnerable animals. Within the United States, freshwater mussels, crayfish, amphibians, and fishes are the most at-risk taxonomic groups (Stein and Chipley 1996), with over two-thirds of freshwater mussel and half of crayfish species considered imperiled or vulnerable. In addition, more than one-third of U.S. freshwater fish species are at risk of extinction (Master et al. 1998). This scale of degradation leaves us with only a few remaining opportunities to protect high quality aquatic systems and their corresponding biodiversity. *We must evaluate and protect our remaining freshwater biodiversity before conservation opportunities vanish.*

In response to this need, the Conservancy has recently undertaken a major initiative to conserve freshwater biodiversity. The Freshwater Initiative involves three strategies:

1. Identifying the most important places to protect freshwater biodiversity.

2. Developing breakthrough strategies for reducing hydrologic alteration and water quality degradation at freshwater sites.

3. Creating a Freshwater Learning Center to support freshwater conservation teams, provide skill building and collaboration opportunities to this community, and share lessons beyond this community.

Through this Initiative, we hope to gain a level of competence in protecting waters that is on par with our capacity and skills in conserving land. This competence will help reach the Conservancy's goal of conserving all plants and animals by "protecting the lands and waters they need to survive." It will apply not only to our conservation efforts, but to those of other organizations, agencies, and individuals working in freshwater systems.

Strategy 1: Identifying Protection Priorities Through Ecoregional Planning

The Freshwater Initiative’s Strategy 1 is the strategy most closely related to ecoregional conservation efforts. The primary focus of Strategy 1 is to help ecoregional planning teams identify and evaluate aquatic targets and select sites to conserve those targets. A team of aquatic ecologists led by Jonathan Higgins will provide support to ecoregional planning teams through the end of calendar year 2001. Our goal is for ecoregional planning teams to use consistent approaches to identify aquatic targets and to incorporate sites into their portfolios that adequately represent the aquatic biodiversity of an ecoregion. Consistent methods among ecoregions will allow us to compare and analyze aquatic targets beyond ecoregional boundaries, assess each ecoregion’s stage of knowledge about aquatic targets, and develop meaningful measures of success.

Why focus on communities?

Recent analyses suggest we must broaden our conservation targets beyond species, and increase the number of sites we protect, to preserve the full range of our nation’s aquatic biodiversity (Master 1991; Master et al. 1998). Ecoregional planning promises to direct our conservation activities to the best places to conserve the full range of biodiversity and provide clearer focus where we already work. Currently, however, imperiled and vulnerable fish and mussels are the primary conservation targets of most Conservancy freshwater projects. A lack of data on other freshwater species and aquatic communities has thus far hampered efforts to include them in ecoregional plans, resulting in portfolios that do not achieve the goal of representing the full range of aquatic biodiversity.

Targeting biological communities can provide a proactive approach to biodiversity conservation because it protects whole assemblages of species before any single species declines into imperilment. Community targeting protects common species not otherwise a focus of conservation efforts, as well as those species that are not yet known. In addition, biological communities have properties, functions, and interactions of significant conservation value in themselves, and play an important role in the maintenance and evolution of biodiversity. Effective aquatic conservation will result only from the protection of ecological and evolutionary contexts, which they equate with biological organization above the level of individual species (Angermeier and Schlosser 1995). Therefore, incorporating aquatic communities with available species information into ecoregional plans will result in more comprehensive protection for aquatic ecosystems.

A Note On Aquatic Species

We assume that all ecoregional planning teams will compile aquatic species data as part of their ecoregional planning efforts. Accordingly, this document will not directly address how to collect and analyze aquatic species targets, but we can provide further advice if necessary. Sources of information about aquatic species include Natural Heritage Programs, state and federal government agencies, academic institutions, and natural history museums.

The Freshwater Initiative's Ecoregional Planning Approach: The Aquatic Community Classification Framework

The general approach to aquatic ecoregional planning builds on our experience in applying an aquatic community classification to identify conservation sites within the Great Lakes basin, the Illinois River basin, and select ecoregions.[2] This framework provides a hierarchical model of freshwater ecosystems that describes and predicts biological community diversity and distribution.

The classification framework characterizes aquatic ecosystems in abiotic and biotic terms (Table 1 and Figure 1). Biological communities are described at two levels of organization: alliance and association. The biotic classification units are related spatially to an abiotic hierarchy. From the coarsest to the finest in scale, the levels of the abiotic hierarchy are: ecoregion, ecological group, macrohabitat type, and habitat unit type. The abiotic classification provides a standard way to describe the range of physical settings associated with each biological community type and to characterize ecological units that contain potentially distinct community types (Angermeier and Schlosser 1995).

Application of the classification framework has focused on describing and mapping macrohabitats—ecological classification units of streams and lakes that potentially contain distinct biological community types. Using macrohabitats in the Great Lakes and other pilot areas allowed us

[2] For a detailed problem statement and discussion of classification see Chapter 1 & 2 of Higgins et al. 1998, Freshwater Conservation in the Great Lakes Basin: Development and Application of an Aquatic Community Classification Framework. This also summarizes methods used and outcomes in the Great Lakes Basin project.

to identify a comprehensive set of ecologically-defined conservation targets without having extensive biological data.

In addition to using macrohabitats as targets for ecoregional planning, we have developed an approach using *ecological groups* that provides a rapid and pragmatic way to identify and assess aquatic targets. Ecological groups are mapped units that coarsely describe the aquatic diversity in an ecoregion and are developed by aggregating watersheds that have similar patterns of climate, physiography, and species distribution (i.e., zoogeography). Ecological groups describe the variety of aquatic system types, so the identification and evaluation of targets is more focused, informed, and stratified. They also serve as a valuable communication tool to discuss aquatic diversity with experts.

Table 1. Definitions of Classification Framework Levels

Level	Description	Key Variables
Ecoregion	Large areas of similar climate and physiography that correspond to broad vegetation regions.	Climate Physiography General physiognomy of the vegetation
Ecological Group	Aggregates of watersheds that share ecological and biological characteristics. Ecological groups contain sets of aquatic systems with similar patterns of hydrologic regime, gradient, drainage density, & species distribution.	Physiography Zoogeography Watershed
Macrohabitat Type	Types of small to medium-sized lakes or lake basins, and valley segment types of streams within ecological groups. Note: lentic, lotic, and nearshore ecosystems are treated separately.	Surficial geology Local physiography Size, shape, and network position
Habitat Unit Type	Distinct subunits of macrohabitats that capture the physical variability.	Depth and light penetration Velocity (lotic) Substrate
Alliance	Coarse level of biological community organization. Corresponds spatially to macrohabitats.	Taxa that are diagnostic of groups of associations
Association	Finest scale of biological classification. Corresponds spatially to either macrohabitats or habitat units.	Repeating, distinct species assemblages

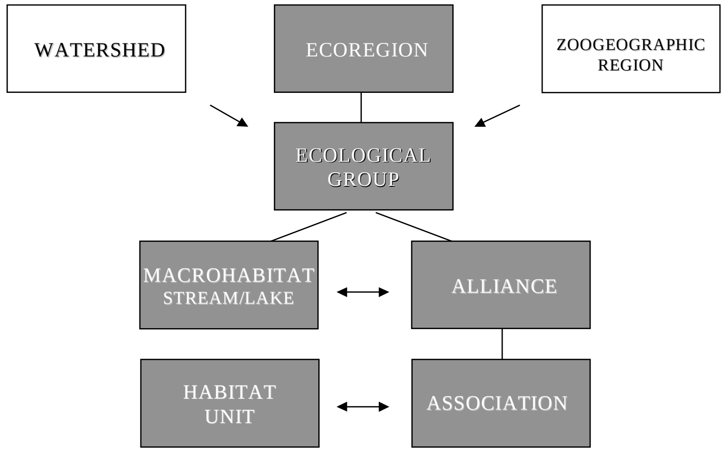

Figure 1. Classification framework for aquatic communities. The classification levels are shown in gray.

How the Freshwater Initiative Can Help

Over the course of the Conservancy's ecoregional planning effort, Freshwater Initiative ecologists will be providing guidance documents (such as this one), regional workshops, consultations, and product review to help ecoregional planning teams ensure their portfolios capture the aquatic biodiversity of their ecoregion. As our capacity allows, we will also actively engage with ecoregional planning teams to directly develop aquatic targets and identify sites. For example, in FY1999, we are providing substantial assistance to three ecoregions (Lower New England/Northern Piedmont, Headwaters of the Rockies, and Prairie Forest Border) and a have a more limited consultation role for the Sonoran Desert. The high level of help has included participating in planning meetings, consulting with experts to help develop the community target model, and providing GIS assistance and training. We will continue to play an active role in these ecoregions through completion of the aquatic portion of their planning. In the next two years, we hope to be able to play a direct role in about 20 additional ecoregions. For more information about the availability of the Freshwater Initiative aquatic ecologists assistance in conducting aquatic ecoregional planning, contact: Jonathan Higgins (312) 759-8017, or jhiggins@tnc.org.

General Approach

The general model for integrating freshwater aquatic targets into ecoregional planning[3] includes five steps:

1. Develop a general understanding of the variety and distribution of aquatic ecosystems and aquatic species patterns present in the ecoregion.
2. Identify and locate aquatic targets.
3. Select the best examples of aquatic targets.

[3] These same steps are relevant to any landscape or large geographic area planning endeavor.

4. Incorporate aquatic targets with terrestrial targets to design the ecoregional portfolio.
5. Identify information gaps and strategies to address them.

These five steps can be implemented in two ways:

Minimum Assessment. Develops and characterizes ecological groups and selects representative targets within each ecological group.
More Detailed Assessment. Develops and maps macrohabitats, finer-scale targets.

Minimum Assessment

Using ecological groups as a basis for selecting targets provides a coarse assessment of aquatic diversity in an ecoregion. This approach is relatively quick (see Appendix A for an estimate of time and resources required) and relies heavily on experts. The products are qualitative and thus provide a limited ability to quantify the abundance, spatial distribution, and quality of targets. The five steps of the minimum approach to develop aquatic targets using ecological groups are described below.

Step 1: Develop a general understanding of the ecoregion.

The first step in aquatic ecoregional planning is to develop ecological groups by gathering information about the variety and distribution of aquatic ecosystem types, their general patterns of species distribution, and their spatial distribution within an ecoregion. The identification of ecological groups should be the initial assessment of aquatic biodiversity in every ecoregion. The Freshwater Initiative aquatic ecologists will assist ecoregional planning teams to develop ecological groups.

Ecological groups are broad-scale areas that contain sets of aquatic system types with similar patterns of drainage density, gradient, hydrologic characteristics, connectivity, and zoogeography. Identifying and describing ecological groups allows us to stratify ecoregions into smaller units so we can better evaluate patterns of aquatic community diversity. Information including watershed boundaries, zoogeographic regions, ecoregional section and subsection boundaries, physiographic maps, geologic maps, and data on the flow characteristics or river systems, allows us to map and characterize ecological groups.

Ecological groups are mapped by aggregating 8-digit hydrologic catalog units (mapped by the USGS) based on the similarity of physiographic and climatic features as described by subunits of the USFS provinces (sections or regionally-accepted subregions) (McNab and Avers, 1994). Factors such as hydrologic characteristics and zoogeography also influence how these catalog units are aggregated.

Figures 2a and 2b (see next page) show an example of ecological groups from a portion of the Great Lakes basin. These groups are aggregates of watersheds that contain similar aquatic ecosystems and fish species assemblages. For instance, Group 1 contains three primary patterns of riverine ecosystems that share a common source of aquatic biota:

1. Large rivers that have headwaters on moderate gradient, medium textured materials in the Allegheny Plateau, which then flow through deep ravines of sedimentary rock onto a narrow lake plain and into Lake Erie.

2. Moderate and small rivers that begin on the northern edge of the Allegheny Plateau and flow across the lake plain into Lake Erie.

3. Small streams that are restricted to the lake plain.

There is also an area in this ecological group that is composed of coarse glacial deposits and contains many lakes and wetlands.

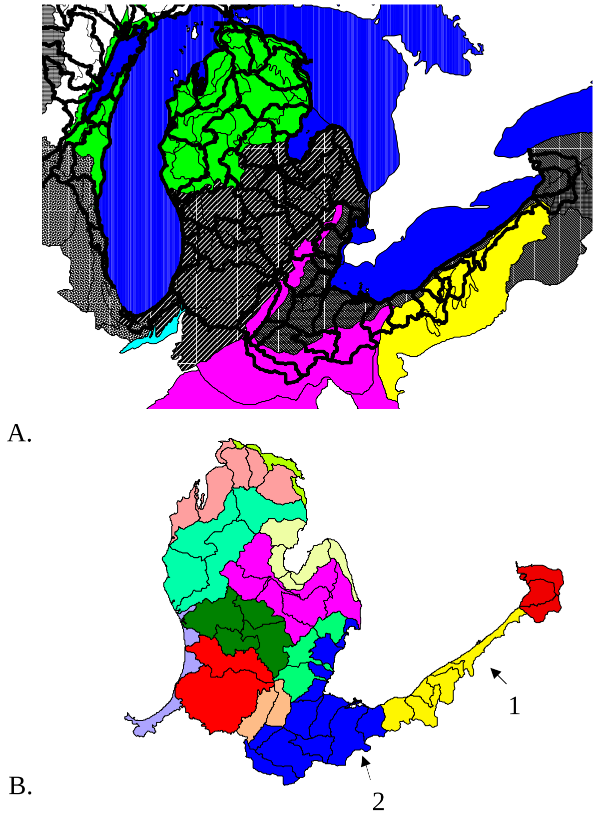

Figure 2. An example of aquatic Ecological Groups from the Great Lakes basin. A. Eight-digit catalog unit boundaries shown on top of ecoregional sections represented in different color patterns. B. Ecological Groups based on the watershed and section boundaries for the same area.

Just to the west of this ecological group lies Group 2, which contains the riverine ecosystems that make up the Maumee Lake plain. This group contains the following riverine and shoreline ecosystems with a common source of aquatic biota:

1. Large and medium, low gradient rivers on clayey lake plain with extensive estuaries on the Lake Erie shoreline. Their source of water is surface run-off.
2. Large, low gradient tributaries to the Maumee River. These rivers begin on clayey lake plain or fine textured end moraine, and their source of water is surface run-off.
3. Low gradient streams on lake sand. These represent a concentration of streams with slightly more groundwater.
4. Large, shoreline wetlands on Lake Erie.

The level of resolution and spatial scale of ecological groups will depend on the amount of information available and the ecological complexity in an ecoregion. Where there is good information on regional patterns of aquatic biota, ecological groups can be more clearly defined and more groups can be identified. There will also be more ecological groups where the landscape has many distinct ecological settings.

Step 2: Identify and locate aquatic targets.

As a minimum approach to aquatic ecoregional planning, experts identify and select targets that represent the diversity of ecosystems within each ecological group.

Ecoregional teams that have already completed terrestrial portfolios, or that lack the resources to develop finer-scale targets, can use ecological groups as a framework for identifying targets relatively quickly and evaluate how well already selected portfolio sites (based only on species and terrestrial communities) capture the aquatic biodiversity of the ecoregion.

By working with regional experts to determine attributes important for structuring aquatic communities in the ecoregion, ecoregional teams can describe the variability of aquatic ecosystems within an ecological group. Experts identify stream, river and lake systems that represent the ecological variability within each ecological group. System descriptions will provide finer resolution of the ecological variability found within each ecological group *and can be translated into a list of targets used in ecoregional planning.*

For example, suppose that experts in the Great Lakes basin suggest that stream size is an important factor distinguishing different biological communities within the large river systems in Group 1 (those that originate in the Allegheny Plateau and flow across the lake plain into Lake Erie). We would ask the experts to help identify examples of small, medium, and large river segments within these systems as possible targets. Although they are qualitative and not mapped across the ecoregion, these targets are defined at a scale that is practical for conservation action.

Step 3: Select the best examples of aquatic targets.

Selecting the best examples of aquatic targets using this minimal approach relies heavily on experts' personal knowledge of high quality, viable sites. Other information can be helpful to supplement this approach, such as land use/land cover maps, water quality sampling data, and maps showing hydrologic alteration (e.g., dams and channelization).[4] Because the minimum approach assumes an ecoregional planning team has a limited amount of time and/or resources, we assume that the analysis of these types of data will be cursory and qualitative. If a more quantitative approach is desired, please see the description of Step 3 under "More Detailed Assessment."

In some cases, high quality examples may not exist for a particular target, and it may be necessary to identify the best opportunities for restoration of natural aquatic systems.

Step 4: Incorporate aquatic targets to design the ecoregional portfolio.

Incorporating aquatic targets into a portfolio involves setting conservation goals for targets and selecting representative sites to meet these goals. In the minimum approach, these tasks are performed in an ad hoc *manner.*

Because a quantitative assessment of target abundance and distribution is not possible using the minimum approach, setting conservation goals must be qualitative. Expert opinion and

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[4] DePhilip (1999) lists many sources of data that can potentially be used for quality/viability analysis of aquatic targets.

professional judgement should form the basis for deciding how many examples of each target are to be protected and under what spatial stratification. Experts and teams members, for example, may elect to include more occurrences of small streams in a portfolio than medium or large streams, since these aquatic ecosystems typically occur more frequently.

The preferred approach is to choose representative sites to conserve aquatic targets in tandem with terrestrial targets. Alternatively, this can be a separate step from terrestrial targets, or can be completed after terrestrial sites have already been selected. It is critical that sites protect aquatic targets in the context of entire systems, as many of the processes that sustain these targets operate at larger scales. One strategy would be to identify sites with contiguous targets as they are more viable than targets dispersed among many sites.

Step 5: Identify information gaps and strategies to address them.

The minimum approach to identifying and locating aquatic targets provides a coarse description of the aquatic communities in an ecoregion. This description should be regarded as an approximation of what aquatic biodiversity exists in an ecoregion and where it can be protected. Information gaps may include geographic areas of the ecoregion where an expert was not available, lack of knowledge on specific types of aquatic ecosystems (e.g., experts may be well acquainted with large river segments, but not know much about headwater systems), and lack of knowledge of where best examples of targets occur. The level of confidence in a portfolio developed using the minimum approach can be improved through field investigation to verify high quality community occurrences; through continued inventory and analysis to identify additional high quality occurrences; and through a more detailed, quantitative development of aquatic targets that represent the aquatic diversity of the ecoregion (see Macrohabitats under the " More Detailed Assessment").

<u>More Detailed Assessment</u> - Developing Macrohabitats

Moving beyond ecological groups to describe macrohabitats predicts ecoregional diversity at a finer scale—the community level. Mapping macrohabitats is essentially mapping the aquatic ecosystem variability within ecological groups. This approach, while more time and resource intensive, develops a powerful spatial database that planning teams can use to evaluate the abundance and distribution of targets (helping to set appropriate conservation goals), and develop quantitative quality ranks for target occurrences.

Furthermore, this spatial database of macrohabitats facilitates a rapid "gap" approach to evaluate whether additional aquatic sites need to be added to previously-selected terrestrial portfolio sites. The five steps of the general approach are described below for the development of macrohabitats.

Step 1: Develop a general understanding of the ecoregion.

The identification of ecological groups should be the initial assessment of aquatic biodiversity in every ecoregion.

Knowing the characteristics that define ecological groups and the range in key factors such as hydrologic regime, size, or gradient, helps to define macrohabitat types. Please refer to Step 1 of the minimum assessment approach for more detail on ecological groups and their application.

Step 2: Identify and locate aquatic targets.

Aquatic communities are best defined by analyzing biological data to identify assemblages of aquatic species. In most ecoregions, though, there are not sufficient biological data to characterize the diversity and distribution of aquatic communities at a scale appropriate for conservation planning in an ecoregion. In these cases, we recommend that the team develop *aquatic macrohabitat targets*.[5] Macrohabitat targeting offers a strategic and comprehensive approach for many ecoregional planning teams to capture representative aquatic biodiversity defined by environmental or biophysical variables rather than solely by biological data.

Can you use biological data if you have it? Where biological data exist, they are most effectively used in tandem with abiotic targets as an overall approach. The Illinois River community classification used this approach.[6] In this effort, aquatic ecologists compiled fish assemblage data from state agencies and used multivariate statistics to identify community alliances. Figure 3 (next page) shows the distribution of community alliances based on fish assemblages. These alliances provided a coarse level indication of community variability in the Illinois River because they are based only on fish data, and the data are from a small subset of the stream types in the river basin. However, using alliances as targets in addition to macrohabitats achieves a greater level of certainty that representative communities are included in the ecoregional portfolio.

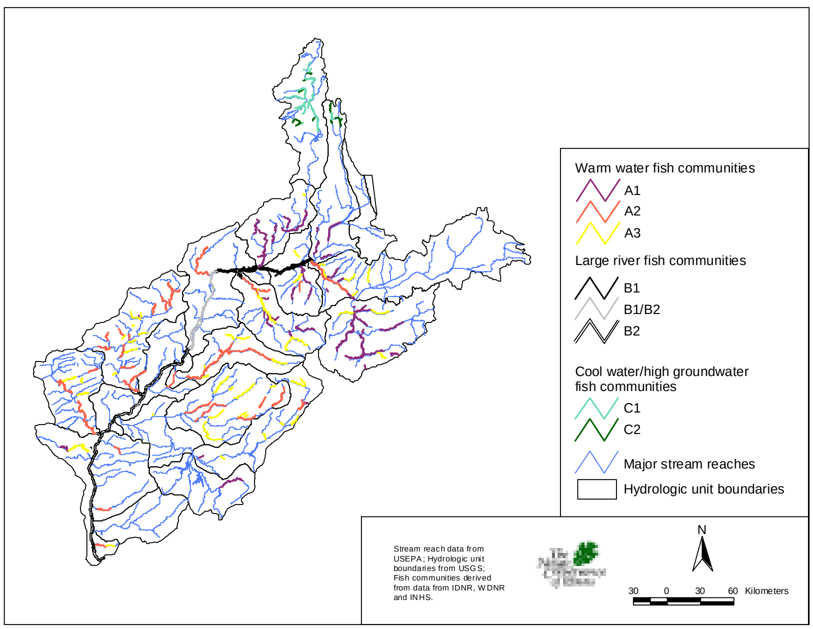

Figure 3. Fish alliances in the Illinois River basin. Map produced by the Illinois Nature Conservancy, Peoria Field Office.

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[5] For example, within the Illinois River basin, even though aquatic community data exists within specific watersheds, this information was not consistent across the basin. Accordingly, the planners also identified and targeted aquatic macrohabitats.

[6] For more information, please see Appendix "C" of the Illinois River Conservation Planning document. Also see chapter 6 of Freshwater Conservation in the Great Lakes Basin for a discussion of statistical methods to analyze biological community data. See footnote 1 for information about obtaining this document.

We can provide assistance in working with Natural Heritage Programs and other partners to obtain, evaluate, and analyze aquatic assemblage data. We also encourage ecoregional planning teams to work with us and Natural Heritage Programs to develop strategies for further aquatic inventory.

Defining and mapping macrohabitats. Macrohabitats are developed by working with regional experts to determine the attributes that are most important for structuring the distribution of aquatic communities in a given ecoregion. For example, in the Great Lakes basin we identified four attributes important in describing stream and river ecosystems—stream size, hydrologic regime, connectivity, and gradient. We chose quantitative variables to measure these attributes and developed classes within each of these variables that define ecologically meaningful differences at a fine scale. By identifying unique combinations of each class for the variables, macrohabitat types (e.g., small, high gradient streams that are connected to large rivers and are dominated by stable groundwater flow) were created. Each macrohabitat type represents a different physical setting thought to contain distinct biological communities and is therefore a distinct conservation target. Appendix B provides an example of types identified in the Great Lakes basin.

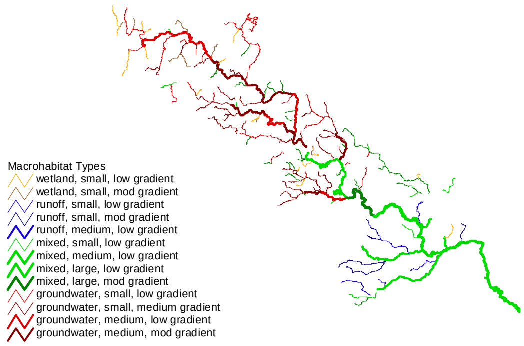

Figure 4. Stream macrohabitat types in the Peshtigo River, Wisconsin, based on detailed macrohabitat mapping.

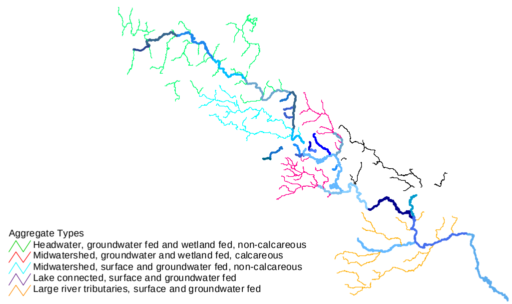

Figure 5. Less-detailed macrohabitat mapping. The smaller streams are aggregated into general types; the larger stream segments are classified individually into types represented in shades of blue.

Macrohabitat targets can be developed and mapped at varying detail, depending on available resources and desired products (Figure 4 and 5 above). The GIS procedure for mapping macrohabitats, described in more detail in Appendix C, is evolving. While our goal is to automate as much of the process as possible, macrohabitat mapping will still require that an aquatic ecologist review the automated products. We have provided time estimates for a highly detailed and less detailed macrohabitat procedure in Appendix A.

In the most detailed assessment, *all* components of the freshwater aquatic systems (i.e., all streams, rivers, and lakes) in the ecoregion are assigned a macrohabitat type. The product is a "wall-to-wall" map of all occurrences of all macrohabitats in an ecoregion. The most detailed option is analogous to what we did in the Great Lakes basin where we mapped and attributed about 15,000 stream and 18,000 lake macrohabitats. Then we used each macrohabitat type as a conservation target and worked with experts to identify the best examples of each type to capture the representative diversity of the region.

In a less intensive assessment, the ecoregional planning team may opt not to map all macrohabitats in detail. Currently, three ecoregion teams have decided to describe and represent larger streams on the maps individually, while smaller streams will be represented in aggregates (e.g., first and second order streams). We will provide additional information on these efforts via the web pages as the work in these ecoregions progresses.

Step 3: Select the best examples of aquatic targets.

Once aquatic macrohabitat targets are identified, the next step is to locate the best examples[7] *of all aquatic targets.*

Information on the quality of the occurrences of aquatic species and communities from Natural Heritage Programs and other sources is an obvious starting point for locating examples of targets. In a detailed assessment, macrohabitat quality information, including land use/land cover and biological monitoring data (e.g., Index of Biotic Integrity scores), are applied in a GIS to identify the best examples of macrohabitat types.[8] Expert opinion should be used to augment available macrohabitat quality data. In some cases, high quality examples may not exist for a particular target, and it may be necessary to identify the best opportunities for restoration of natural aquatic systems.

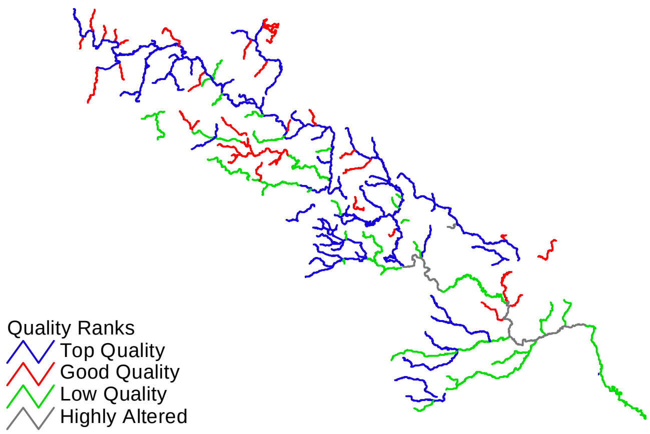

Figure 6. Quality ranking of stream macrohabitats in the Peshtigo River, WI.

In the Great Lakes basin, we identified the macrohabitat occurrences with the best water quality, the most intact hydrologic processes, and the highest quality instream habitat, as these potentially contain the best examples of natural biological communities. We ranked the quality of stream and lake macrohabitats based on available, spatially-referenced: 1) state water quality information; 2) surrounding land use/land cover; and, 3) easily discernible hydrologic alterations from maps. These three factors were combined into an overall quality rank to serve as a filter for identifying the best examples of each macrohabitat. Figure 6 (previous page) shows the quality rankings assigned to macrohabitats in the Peshtigo River in the Great Lakes basin project.[9]

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[7] The best examples include the locations of aquatic targets (aquatic species, communities and/or macrohabitats) that are of excellent quality and have the greatest chance for persisting into the future.

[8] DePhilip (1999) lists many sources of data that can potentially be used for quality/viability analysis of aquatic targets. We will provide more written guidance on quality assessment as work in current ecoregions progresses.

[9] For a detailed discussion of the quality assessment methods used in the Great Lakes project, see Higgins et al. 1998, Chapter 7.

Assigning an overall quality rank to each occurrence allowed us to create a thematic map indicating quality for each macrohabitat type.

Step 4: Incorporate aquatic targets into the ecoregional portfolio.

Incorporating aquatic targets into a portfolio involves setting conservation goals for targets and selecting representative sites to meet these goals. The purpose of setting conservation goals for each target is to capture the variability in the target as it occurs across the ecoregion. Choosing the goal for the number of occurrences can be based on the abundance and distribution of each target, stratified by ecological groups. In the Great Lakes we had not developed ecological groups. We thus set a minimum goal of capturing at least one high quality example of each macrohabitat type in each ecoregion section where it occurred.

The preferred approach is to choose representative sites to conserve aquatic targets in tandem with terrestrial targets. Alternatively, this can be a separate step from terrestrial targets, or can be completed after terrestrial sites have already been selected. In the Great Lakes, aquatic community targets will be incorporated after the first iteration of the terrestrial portfolio is complete. Preliminary aquatic priority sites were identified in parallel with the terrestrial ecoregional portfolio, however.[10] In the coming year, biological data and better resolution data on habitat quality will be applied to refine this list of priority sites.

Step 5: Identifying information gaps and strategies to fill them.

The use of macrohabitats to build portfolios will provide conservation planners with significant information regarding patterns of community-level diversity in aquatic ecosystems. But sites based on macrohabitat occurrence information should be considered provisional until the biological significance can be verified. The level of confidence in a portfolio developed using the macrohabitat approach can be improved by: completing the most detailed macrohabitat mapping if this was not done initially; consulting with regional and local experts to determine biological content and significance; conducting field investigation to verify high quality macrohabitat and/or community occurrences; and, carrying out biological inventory and analysis to build the biological community classification.

The macrohabitat type map provides a good tool for assessing biological sampling needs. Data gaps for specific types of macrohabitats can be readily identified and this information used to create an inventory strategy. The aquatics component of ecoregional portfolios will help to guide collection of biological data and thus support the building of a biological community classification.

Summary: Options to Identify Aquatic Targets

The following table summarizes the options for identifying aquatic targets.

Table 2. Aquatic target development options pros and cons.

TARGET	METHOD	PROS	CONS
Representative targets within ecological groups	Expert consultation to identify high-quality systems/settings that capture ecological	Products are a map of ecological groups and description of representative system	Potential for scale of target to vary. Limited ability to assess distribution of targets.

[10] See chapters 8 and 9 of Higgins et al. 1998 for a detailed discussion of the preliminary site selection process and outcomes.

	variability with ecological groups	types. Targets may be whole systems or smaller units within – both of which could be mapped. Quick; comprehensive	Developing conservation goals is *ad hoc.*
All macrohabitats	Aquatic ecologist uses GIS and manual review to assign attributes and macrohabitat types to all mapped hydrographic features (i.e., streams, rivers, lakes)	Products are individual database records for every macrohabitat. Most comprehensive. Allows for very detailed analysis; allows for targeting and conservation goal setting at the community level	Takes significant time/resources
Detailed mapping of larger macrohabitats; general mapping of smaller macrohabitats	Aquatic ecologist uses GIS and manual review to assign attributes and classification types to larger individual macrohabitats and aggregates of smaller macrohabitats.	Products are individual data records for larger macrohabitats and aggregates of smaller macrohabitats. Comprehensive; allows for targeting and conservation goal setting at the community level.	Too coarse to describe diversity of individual headwater macrohabitats

Assessment Steps: Selecting the Right Approach For Your Ecoregion

Every ecoregional planning team faces a different set of constraints that affect its ability to identify all aquatic targets (species and communities) and to design an ecoregional portfolio that best represents an ecoregion's aquatic biodiversity. Factors such as time, staff capacity, and ecological variability all influence how a planning team chooses to approach this work. We offer the following list of steps for ecoregional planning teams to evaluate: (1) what information on aquatic resources is available in their ecoregion, and (2) what is the capacity of the planning team to use this information.

1. Determine person from your ecoregion who will lead the effort to identify aquatic targets and incorporate representative sites.
2. Develop an aquatics team with expertise, if possible, in GIS, hydrology, and aquatic ecology. Identify how much time each person can spend on the effort.
3. Identify experts from academia, government, etc. who are knowledgeable about freshwater ecosystems in the ecoregion and who can help identify and select targets. Agencies to consult include Heritage programs, U.S. Geological Survey NAWQA Program, U.S. Geological Survey GAP Program, state natural resource agencies, U.S. Environmental Protection Agency, local and regional NGO's.
4. Determine the ecoregional planning team's time frame to identify targets, set conservation objectives, and select sites for aquatic communities.

5. Determine what the team knows about aquatic community targets. Are there existing heritage or other classifications?
6. About how many aquatic community targets can the team deal with? 50, 100, 500?
7. What data do you know of/have? Table 3 (next page) lists existing data layers available for the United States. Categories to consider include:

Species:	G1-G3 species of interest and their EOs G4-G5 species, particularly where range restricted and/or declining (if available) Migratory fish life-stage habitat (if available) Fish or macroinvertebrate species assemblage data (mostly water quality monitoring)
Spatial:	Ecoregions Geology Elevation Hydrography Watersheds
Zoogeography:	Aquatic zoogeographical regions, watersheds.
Quality:	Environmental quality information (land use/land cover, biomonitoring). Please refer to DePhilip (1999) for a comprehensive overview of quality data that can be used.

8. Are there neighboring ecoregions that have identified aquatic targets? Are the methods that they used transferable?
9. Check in with the Freshwater Initiative team to find out about new tools, methods, and neighboring efforts. See footnote 1 for more information about web sites and other avenues of information exchange.

Table 3. Data available for the US.

DATA LAYER	AVAILABLE FOR US	SOURCE
BASE		
Hydrography	Reach files by 8-digit catalog unit	EPA
Watersheds	8-digit catalog unit boundaries	U.S. Geological Survey
Digital Elevation Model (DEM)	1:250,000 tiles	U.S. Geological Survey
Geology (surface/bedrock)	Varies	Varies
Land Use/Land Cover	1:250,000 1976 Anderson Level II	EPA
Wetlands	National Wetlands Inventory (http://www.nwi.fws.gov/nwi.htm)	U.S. Fish and Wildlife Service
Vegetation (natural/potential)	Varies	Varies

Table 3 (Cont' d). Data available for the US.

DATA LAYER	AVAILABLE FOR US	SOURCE
BIOLOGICAL DATA		
Species Eos	Varies	Heritage Programs
Community Eos	no	Need to be developed
Assemblage Data	Varies	State natural resource agencies, universities, U.S. Geological Survey NAWQA programs (NAWQA)
Biomonitoring	Varies – for a summary of the status of programs/protocols check http://www.epa.gov/owow/monitoring/bio/section2.htm	
PHYSICAL DATA		
USGS Gage Stations	http://water.usgs.gov/lookup/getgislist	U.S. Geologic Survey
Chemistry	Varies	State natural resource agencies, universities, NAWQA
Habitat Assessments	Varies	State natural resource agencies, universities,

		NAWQA

QUALITY ASSESSMENT		
Dams	ftp://corpsgeo1.usace.army.mil/headquarters/geo_data/damdata	U.S. Army Corps of Engineers
Roads		
Soil Loss	http://www.nhq.nrcs.usda.gov/land/index/erosionmaps.html	Natural Resource Conservation Service
Chemistry	See DePhilip 1999	
Exotics	http://www.nas.nfrcg.gov	U.S. Geological Survey – Biological Research Division, Florida Caribbean Science Center

While strategies to accomplish the goals of ecoregional planning will vary by ecoregion, common to all is the need for a clear time line that outlines roles and responsibilities and allows team leaders to track progress. Appendix A provides a list of tasks and general time estimates the different options. We have also included two examples from current work. Appendix D provides the general timeline for the Prairie Forest Border ecoregion, the timeline developed for Lower New England, as well as a flow chart illustrating the relationship between that team's Aquatics Working Group and GIS Group.

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Appendices

Appendix A. Estimated time required to include aquatic community targets under different approaches. (Based on an average ecoregion of about 75 8-digit hydrologic units).

Table A1. Estimated time required to include aquatic community targets using Ecological Groups only (the Minimum Assessment).

TASK	**STAFF TIME (WEEKS)**	**WHO**
Information Gathering	1	GIS
Compile spatial data.	2	GIS
Identify driving variables w/experts.	2	ecologist
Locate best examples w/experts	2	ecologist
Complete review and documentation of sites (id gaps).	1	ecologist
Communication and project management.	4	team leader
TOTAL	**12**	

Table A2. Estimated time required to include aquatic community targets using high resolution mapped Macrohabitats (More Detailed Assessment).

TASK	**STAFF TIME (WEEKS)**	**WHO**
Information Gathering	2	GIS
Compile spatial data.	2	GIS
Identify driving variables w/experts.	2	Ecologist
Establish strategy and map.	50.5 .5	Ecologist GIS
Quality assessment of units.	1 1	Ecologist GIS
Select best examples with expert review.	2	Ecologist
Complete review and documentation of sites (id gaps).	1	Ecologist
Communication and project management.	4	team leader
TOTAL	**66**	

Table A3. Estimated time required to include aquatic community targets using medium resolution mapped Macrohabitats (More Detailed Assessment).

TASK	**STAFF TIME (WEEKS)**	**WHO**
Information gathering	2	GIS
Compile spatial data	2	GIS
Identify driving variables w/experts	2	ecologist
Establish strategy and map	8.5 .5	ecologist GIS
Quality assessment of units	1 1	ecologist GIS
Select best examples with expert review	2	ecologist
Complete review and documentation of sites (id gaps)	1	ecologist
Communication and project management	4	team leader
TOTAL	**24**	

Appendix B. Examples of Macrohabitat Types in the Great Lakes Basin.

Streams.

Macrohabitat	Hydrologic Regime	Gradient	Stream Size	Connectivity

Type Code				
21323	very low groundwater/very high runoff	high	medium	large stream
23111	mod. groundwater /mod. runoff	low	very small	small stream
31232	high groundwater /low runoff	medium	medium	medium stream
32253	very high groundwater/very low runoff	medium	large	large stream

Lakes.

Macrohabitat Type Code	Connectivity	Lake Size	Shoreline Complexity	Hydrologic Regime
1111	unconnected	small	round	catchment/runoff
1213	unconnected	medium	elongate	catchment/groundwater
11312	connected	small	complex	catchment/mix
14221	connected	large	elongate	surface/runoff

Appendix C. General GIS Procedure For Mapping Macrohabitats.

The following steps represent a general scheme for the GIS work. This is an update of the protocol used in the Great Lakes basin, and is described in chapter 4 of Higgins et al. 1998.

1. Create model for the region that relates spatial data to ecological factors through consultation with regional experts. Table C1 shows the model used in the Great Lakes.
   - Identify experts (internal and external).
   - Identify key driving variables describing: Hydrologic Regime; Temperature Regime; Chemistry Regime; Morphology (channel, valley, size); Connectivity (local zoogeography)
   - Define classes of variable for streams, lakes, and groups.

2. Prepare data layers.
   - Compile data.
   - Project data to common projection.

3. Prepare hydrology layer using macros:
   - Calculate stream order, link, downstream link, and downstream connectivity.
   - Create lake polygon layer and derive name, elevation, geology, and surface connectivity.

4. Set up the project in ArcView:
   - Import data layers.
   - Install extensions: TNC custom delineation tools, spatial analyst, other useful tools.
   - Set working directory.
   - Customize the control file (part of the custom tool package). This file must be saved in the same directory as the project file.

5. For streams:
   - Derive automated attributes for all arcs (functions in custom ArcView tools).
   - Overlay streams on DEM and geology (and other layers, e.g. soils, contour map)
   - Manually attribute arcs with key variables that cannot be automated.

6. For lakes
   - Fill in lake attributes that have not been automated (e.g., hydrologic regime).

Table C1. Classification model used in the Great Lakes.

AQUATIC ECOSYSTEM ATTRIBUTE	CLASSIFICATION VARIABLE	GIS LAYERS USED
Flow regime	Hydrologic regime	Geology, Hydrography, DEM
Temperature	Hydrologic regime	Geology, Hydrography, DEM
Chemistry	Hydrologic regime / Upstream connectivity	Geology, Hydrography
Channel form and constraint	Gradient Valley form (relationship between channel and valley)	DEM, Hydrography
Local zoogeography	Upstream and/or downstream connectivity	Hydrography
Regional Climate	Section	USFS ecoregions (Keys et al. 1995)
Regional Zoogeography	Aquatic zoogeographic subregion	USFS (Maxwell et al. 1995)

Appendix D. Sample Timelines

Regardless of model selected, we suggest developing a workplan to estimate and track time and resources associated with the effort, and to clarify the roles and responsibilities of the different team.

Table D1. Rough schedule for Prairie Forest Border ecoregional planning through September 1999.

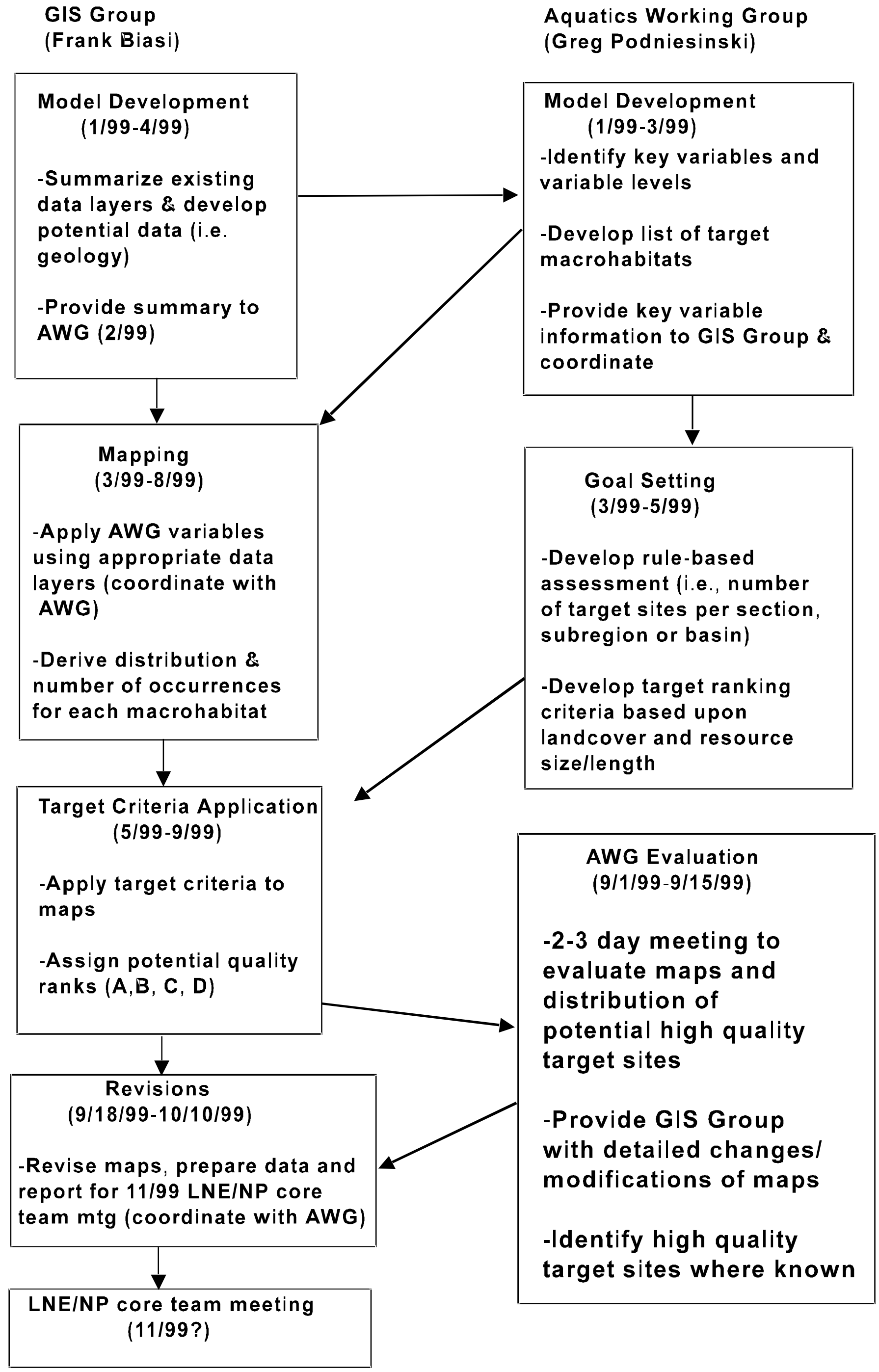
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Terrestrial Tasks	Targets meeting		Experts work-shop						Site design meeting
Aquatics Tasks	1. Consult experts 2. Compile data	(late) GIS mapping methods training for aquatic ecologist			Complete mapping	Quality assessment of macro-habitats and groups	Experts work-shop to select best examples		
Other Tasks		Set up Mackinaw River monitoring program							

Table D2. Timelines for GIS and Aquatics Working Groups for Aquatics Section of LNE/NP Ecoregional Planning

GIS Group Timeline	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Model Development												
Summarize existing data layers	x	x										
Develop new data layers	x	x	x	x								
Provide list of available data to AWG		x										
Mapping												
Apply AWG variables using GIS			x	x	x	x	x	x				
Map distribution & derive # of occurrences							x	x				
Target Criteria Application												
Apply criteria & assign potential quality ranks					x	x	x	x	x			
Revisions												
Revise maps, prepare data & report for LNE/NP Core Team meeting									x	x		
Aquatics Working Group Timeline												
Complete Team	x	x										
Model Development												
Identify Key Variables	x	x	x									
Develop list of target macrohabitats		x	x									
Provide key variable information to GIS group and coordinate mapping effort			x									
Goal Setting												
Develop rule-based assessment of aquatic target distribution			x	x	x							
Develop target ranking criteria				x	x							
Evaluation of Mapping												
2-3 day meeting to evaluate maps/targets									x			
Identify known high quality sites									x			
Provide revisions to GIS Group									x			
LNE/NP Core Team Meeting											x	

<u>Appendix D</u> (Cont' d).

Figure D1. Flow chart of responsibilities for Lower New England/Northern Appalachian ecoregion.


GIS Group
(Frank Biasi)
Aquatics Working Group
(Greg Podniesinski)
Model Development
(1/99-4/99)
-Summarize existing data layers & develop potential data (i.e. geology)
-Provide summary to AWG (2/99)
Model Development
(1/99-3/99)
-Identify key variables and variable levels
-Develop list of target macrohabitats
-Provide key variable information to GIS Group & coordinate
Mapping
(3/99-8/99)
-Apply AWG variables using appropriate data layers (coordinate with AWG)
-Derive distribution & number of occurrences for each macrohabitat
Goal Setting
(3/99-5/99)
-Develop rule-based assessment (i.e., number of target sites per section, subregion or basin)
-Develop target ranking criteria based upon landcover and resource size/length
Target Criteria Application
(5/99-9/99)
-Apply target criteria to maps
-Assign potential quality ranks (A,B, C, D)
AWG Evaluation
(9/1/99-9/15/99)
-2-3 day meeting to evaluate maps and distribution of potential high quality target sites
-Provide GIS Group with detailed changes/ modifications of maps
-Identify high quality target sites where known
Revisions
(9/18/99-10/10/99)
-Revise maps, prepare data and report for 11/99 LNE/NP core team mtg (coordinate with AWG)
LNE/NP core team meeting
(11/99?)