

CHAPTER 4: BIODIVERSITY / WILDLIFE HABITAT ASSESSMENT

Introduction

Biodiversity refers to the degree of variation of life forms within a given ecosystem, and is one measure of the health of ecosystems. Terrestrial (land) and aquatic (water) ecosystems are comprised of communities of organisms that are dependent on each other and on their environment, and, ultimately, we humans depend upon healthy ecosystems to provide important ecosystem and economic services.

Ecosystem functions conceptually include the whole spectrum of what ecosystems do: supporting the hydrologic cycle, cycling nutrients, filtering pollutants, fixing carbon, producing oxygen, supporting a large number of plant, animal, fungal and other species, evolution and adaptation of species, pollination and gene dispersal, generating soils, stabilizing slopes and numerous others.

To focus conservation priorities from the overwhelming complexity of possible ecosystem functions, several principles prove to be useful:

- Many of these functions are inherent in any healthy natural ecosystem.
- Many functions cannot be directly measured.
- Other functions we know are tied to particular kinds of places, and these do need a special focus.

The main focus areas for the Biodiversity/Wildlife Habitat assessment are aquatic and terrestrial habitats, landscape function, and connectivity. Other vital processes were included in the overall evaluation to address the roles that wetlands and stream buffers play in the ecosystem. The data used in the assessment are the best representations of spatial information for ecological functions statewide.

Certain places that support specific functions at high levels of integrity also support a broad range of other functions that we are not able to measure directly. Previously defined places, such as Significant Natural Heritage Areas (SNHAs) or Outstanding Resource Waters (ORW), or other intact large scale landscapes, represent the most important places to focus conservation action because they indicate high quality systems.

Methodology

The process and results of the Biodiversity and Wildlife Habitat Assessment were initially developed by an assessment team made up of N.C. Natural Heritage Program staff, and reviewed by field ecologists, biologists and botanists from several state environmental agencies and nongovernment partner organizations. The results were also compared to other inventories and studies of important natural resources in North Carolina. Most areas identified by the assessment

were largely consistent with existing focus areas of state and local conservation organizations.

The critical components that were selected to rank natural areas for the Biodiversity and Wildlife Habitat Assessment were determined through a rigorous evaluation process. Areas in the landscape were evaluated for their rarity and distinctiveness, their function, and the accuracy, precision and completeness of the data sets that were selected to represent them.

The assessment team chose to identify mappable indicators of the most site-specific ecological functions. Multiple data sets were reviewed and excluded based on redundancy, accuracy, precision, completeness and relevance to our conservation mapping goals. The data layers included are the best representations of ecological functions available.

For assessment of biodiversity, the available data represent three major components of ecological resources. These are:

- Biodiversity, both of aquatic and terrestrial species and communities;
- Large scale terrestrial landscapes, including core wildlife habitats and habitat connectors; and
- Other lands of particular importance to ecosystem processes, such as riparian buffers and wetlands.

Rare species and high quality natural habitats are indicators of landscapes that are currently functional. To ensure that our native species of plants and wildlife flourish, the significant natural areas that support them must be identified and preserved.

Terrestrial Measures: Conservation of biodiversity, as an indicator of a healthy ecosystem, requires the conservation of a large number of species, most of which have specific habitats and therefore require site-specific conservation. Some species are common and general enough in their needs that they don't need special attention. The biodiversity focus therefore was aimed mainly at species that are rare or are sensitive for other reasons.

Ecosystem integrity is represented by selecting high quality examples of natural communities that serve as coarse filters for less-known species that are not measured directly. For terrestrial natural communities, the Natural Heritage Program database of community occurrences and Significant Natural Heritage Areas (SNHAs) represent the best available information about the best examples of each of these community types.

Wildlife habitats were identified as large scale terrestrial landscapes that support processes that act over long distances, and include wide-ranging species that require large areas, such as large carnivores, edge-sensitive forest interior species, and species that depend on metapopulation structures. These

ecosystem functions generally have less need of high local integrity, and more need for contiguous large patches of habitats and the existence of connectors between them. Maps of Landscape Habitat Indicator Guilds were used as our primary assessment of larger-scale landscape function, as well as Important Bird Areas (IBAs) as defined by the Audubon Society. Landscape Habitat Indicator Guilds are identified by NCNHP staff and mapped statewide to evaluate landscape integrity and function. This is explained in more detail in Appendix D.

Other lands significant for biodiversity and wildlife habitat and maintaining healthy ecosystems include riparian buffers and wetlands. Wetlands support several important processes of hydrologic regulation and nutrient cycling. In the Coastal Plain, the Division of Coastal Management has rated wetlands for their level of function. The resulting data set (N.C. Coastal Region Evaluation of Wetland Systems - NC CREWS) was used where available. In the rest of the state, the National Wetlands Inventory (NWI) was used. The NWI contains little indication of wetland integrity, but is the only mapped data on wetlands currently available outside the coastal region.

Aquatic Measures: For aquatic natural communities, no classification or database like the NCNHP database for terrestrial communities exists, so several other data layers were used as surrogates, including: streams with Division of Water Quality Excellent or Good Bioclassification ratings, Outstanding Resource Waters (ORW) and High Quality Waters (HQW), wild brook trout streams and anadromous fish spawning waters. These data sets, represented by GIS data layers, distinguish areas of high integrity but do not allow addressing individual aquatic community types beyond a very coarse level.

Basis for Ranking

North Carolina's future prosperity depends on the adequate sustainability and protection of the full spectrum of ecosystem functions, which will require different methods of conservation over a wide range of sites and over large areas. Within the areas identified as important for ecosystem function, the relative ranking of data is intended to provide a focus on the areas that have the highest ecological significance. These are the areas for which the data are most specific and reliable, and areas that are the most distinctive (and least readily replaceable by other areas).

The ranking scale used in this assessment is a categorical ordinal scale. The rankings show relative significance of the areas but are not quantitative. Neither comparison of proportions nor addition of ranking categories is appropriate. The use of an ordinal scale is appropriate for a variety of reasons, including the incommensurate nature of the data and factors used, the difficulty in translating objective measures into quantitative measures of actual ecological value, the way in which quantitative methods can easily obscure the true nature of decisions, and the lack of quantitative data for many of the measures.

The relative ranking of each unit of land, or 30 by 30 meter area, was derived from rankings of the individual data layers representing different functions. Each data set was assigned a ranking between 1 and 10. Ten categories were condensed into seven distinct relative values and given a description for ease in understanding the relative conservation value assigned (Appendix C-1).

Data layer rankings were assigned using professional judgment and were based on a combination of qualities of the ecological values represented and the following factors:

- Resource rarity and distinctiveness
- Resource function
- Data precision, accuracy and completeness

The assessment team used these three factors as guiding principles to select and rank data sets. Professional judgment and peer review of the assigned rank determined the relationship of the data to the guiding principles.

Rarity and distinctiveness of the features mapped are important for determining how much focus is warranted on specific locations on the map. While every place is to some degree unique, places that support the rarest resources represent the greatest loss if they are destroyed. Among sites of more common resources, those with the highest quality or integrity are rare and most irreplaceable. If lost, only inferior examples remain to be conserved in their stead.

For conserving and sustaining diverse sets of resources, such as species or community types that are scattered across the landscape, the most careful conservation biology treatments have utilized methods for identifying portfolios of sites to represent all of the biodiversity elements of conservation concern (hereafter referred to as elements). While there are different ways of doing this analysis, portfolios that select multiple examples of each element and contain the best examples of each element offer the best chance of conserving diversity. Besides quality of occurrences, portfolio analysis includes a goal for how many examples of each element should be included. These goals may be equal, may be based on range beyond the analysis area, and may include regional stratification or other factors. Such an approach was used by The Nature Conservancy in its ecoregional planning process (Groves et al., 2002) and was used by Florida in its statewide land conservation analysis (Florida Natural Areas Inventory 2006). The portfolio selection process ensures a balanced focus, and prevents either the more common elements or the rarest elements from commanding the sole focus. SNHAs incorporate such representative portfolio analysis.

It is hoped that similar analysis to identify a balanced portfolio of the best examples can be used in other data sets in the future, as this approach allows

the sharpest focus on the most important sites. Where such analysis has not been done, rarity and range of diversity was used to determine how much focus to give to specific data layers. Data layers that included only very high quality examples contained few locations (such as ORWs), and were ranked higher than data layers that included numerous areas or mapped resources or levels of integrity that appeared to be more common (such as good stream bioclassification ratings). Where data layers contain both rare and common elements that are not distinguished, such as the different aquatic community types represented by the stream bioclassification ratings, they were ranked lower than if rarer elements were able to be distinguished.

For the conservation of the state's native biodiversity, protection of well-functioning ecosystems that are still essentially intact (possessing a high degree of "integrity") is one of the goals. By protecting high quality ecosystems, this assessment aims to conserve the majority of the state's species (not just the rarest ones), ecologically or taxonomically distinct populations, natural communities (including habitats for animals as well as plants), and the ecological processes that are responsible for both creating and maintaining the features of these ecosystems. Protecting as many examples of intact ecosystems as we can is also a goal since in natural systems redundancy is a primary factor ensuring stability and, hence, viability.

While a focus on rare species and communities is of value in a triage system of conservation -- targeting the most vulnerable elements of the state's biodiversity for the most immediate attention -- one of the aims of conservation should be to be as comprehensive in its coverage as possible. In this sense, making sure that all high integrity ecosystems receive some consideration -- whether or not they contain any rare species or communities -- is also of value. Most conservation agencies, in fact, use measures of ecosystem integrity as their primary means of setting their priorities, giving equal weight to virtually all ecosystems meeting a certain level of integrity.

Examples include:

- Division of Water Quality's nomination as ORW or HQW protection for any stream segment having an Excellent water quality rating is based on its Bioclassification (in which the rarity of species plays no explicit role);
- Ecosystem Enhancement Program's targeting of preservation credits in any watershed where ecosystems meet certain minimum criteria for integrity;
- Division of Coastal Management's targeting of all high quality shellfish areas, fish nursery areas, and submerged aquatic vegetation;
- Wildlife Resource Commission's targeting of all wild brook trout waters.

The Natural Heritage Program's targeting of high quality plant communities for conservation -- including common varieties -- also serves this goal: the presence of intact vegetation is one indication that the ecosystem possesses a high degree

of integrity, and therefore is said to have more probability for high function. However, the quality of the plant community is not a sufficient measure of ecosystem integrity by itself - an area can have essentially intact vegetation but still be missing many of its most characteristic species of animals. Other measures are also needed, including the measure of landscape integrity that are being addressed through use of the Landscape/Habitat Indicator (LHI) Guilds analysis.

By combining an attention to rarity/vulnerability with attention to comprehensiveness -- by giving weight to measures of ecosystem integrity and function in addition to imperilment -- this assessment comes closer to effectively reaching the objective of biodiversity conservation than through following either of the two approaches by themselves.

Accuracy of the mapped feature refers to both the spatial accuracy and the content accuracy of the data - does it represent the value its ranking suggests? Data layers that are lower in precision or had low spatial resolution are deemed less suitable for focused conservation action, and so were given lower ranking. Data layers that have poor resolution or are of questionable accuracy were not used. Confidence in the content of data layers is conceptually distinct from spatial precision and accuracy, but they have a similar effect on ability to focus on particular areas. Level of knowledge has a major effect on content accuracy. Data layers that are based on site-specific surveys generally represent more knowledge than those derived from remote sensing or model-based programs. Survey or remote sensing techniques that directly measure the factor(s) of interest represent a higher level of knowledge. Since this assessment uses the data layers to represent ecosystem functions, the more directly the data layer measures the ecological functions of interest, the higher the level of knowledge. Low accuracy is a reason to avoid using particular data layers, and those that were limited in these qualities were ranked lower.

Completeness is important because the assessment ranks places in comparison with other places. If only a small fraction of existing comparable places are represented, there is little confidence that the areas represented are more important than any other areas. Data layers that were not reasonably comprehensive were not used. However, completeness was necessarily balanced against the importance of a data layer in representing factors no other data layer could represent.

Maximum Ranking Approach

The ranking system follows the outline of a decision model or suitability model. The spectrum of ecological factors to be covered was determined by the scope of the project. The model focuses on factors that are site-specific. Mappable measures of these factors were identified, and GIS data layers identified to represent them. The factors covered in the project, how they were grouped, and

the data layers used to represent them, are shown in the appendices and described in detail below.

Some ecological processes, such as purification of air, soil formation, evapotranspiration and nutrient cycling, occur in a diffuse pattern wherever there is natural vegetation. These functions are included implicitly, and will be covered by places identified for the other purposes.

Each individual data layer was given a ranking or rankings between 1 and 10, or “moderate conservation priority” to “maximum conservation priority.” Where the data layer was quantitative or scaled, this inherent scale was used to derive multiple rankings. Many of the data layers represented only presence-absence (binary) values, which was assigned a single value on the 1 to 10 scale (e. g. presence of wild brook trout waters or shellfish harvest waters). A few had non-scaled categorical attributes that were assigned different values on the 1 to 10 scale (e.g. SNHAs, which were ranked 7-10 depending on their significance level). The 1 to 10 scale represented the final scale. Rankings for each data layer could consider the rankings of other data layers for comparison. These 10 rankings were then consolidated into seven categories of significance, ranging from “moderate” to “maximum” conservation priority (see Appendix C-1).

Grid cells (30 x 30 meter pixels) on the map that support more than one category of data were assigned the maximum value of the individual rankings of the data layers. In other words, a cell may receive a value for multiple data factors found to exist in that location, but only the highest score is shown. Using the maximum value offers several advantages: it is appropriate for an ordinal scale; allows the importance of the most important areas to come through, without being diluted by absence of other factors; and it is simple and transparent, and facilitates analysis and discussion about the meanings of the rankings. Rankings of each individual data layer can be thought of directly in terms of the final ranking scale, and compared directly between scales. In addition, it is less sensitive than other combination techniques to redundancy in input data or the risk of double-counting. There is also value in knowing the range of resources that may be underlying the maximum score. All of the scores can be seen through the development of a value attribute table (VAT) that shows all data found in that individual cell. This provides additional information and may indicate additional collaboration opportunities and potential multiple funding sources that focus on particular types of resources.

The primary disadvantage of using the maximum is that it does not give greater credit to areas with multiple values present. At each step of the evaluation process, the assessment team asked whether the presence of additional factors should raise the value of a cell beyond that of the maximum single factor. The conclusion was that it should not, and that taking the maximum was appropriate.

Data Sources and Ranking

Details for each data layer selected for inclusion in the Biodiversity/Wildlife Habitat Assessment and the basis for its relative conservation ranking are provided below.

Terrestrial Habitats

- **Significant Natural Heritage Areas**

Significant Natural Heritage Areas (SNHAs) are delineated by the Natural Heritage Program. They contain known locations of rare species, rare or high quality occurrences of natural communities, and/or are sites for important animal assemblages (such as colonial nesting waterbirds). Their boundaries represent the areas containing the rare species and natural communities within them, as well as the habitat that is necessary to maintain the target elements. In addition to the conservation target of each SNHA, numerous other species occur, and most ecosystem functions are well supported.

SNHAs are rated for significance using parameters developed by the NCNHP, NatureServe and The Nature Conservancy to measure statewide and global rarity for rare species and communities. Each SNHA receives two significance ratings, which measure different values:

1. Element Collective Value (C Value) rates each SNHA on the basis of the number and rarity of the elements it contains.
2. Element Representational Value (R Value) rates each SNHA on its importance in protecting the best occurrences of individual Elements.

This paired rating system provides two distinct values for each site, one which reflects the biodiversity of the state and one which reflects the overall biodiversity of each SNHA. Each site is assigned two values, a Representational Rating (R1-R5) and a Collective Value Rating (C1-C5).

R-RATING

Representational Rating. This rating is designed to indicate an SNHA's potential to contribute to a collection of the best sites for each tracked element within the state.

REPRESENTATIONAL RATING	DEFINITION
R1 (Outstanding)	Site contains one of the best two examples of G1 or G2 elements*.
R2 (Very High)	Site contains the 3 rd or 4 th best examples in the state of G1-G2 elements, and/or one of the best two examples of other elements.
R3 (High)	Site contains the 5 th to 8 th best examples in the state of G1-G2 elements and/or the 3 rd to 6 th best occurrences of other elements.
R4 (Moderate)	Site contains the 9 th to 12 th best examples in the state of G1-G2 elements within it and/or the 7 th to 10 th best occurrences of other elements.
R5 (General)	Site contains one or more viable occurrences that are not among the 12 best of G1-G2 elements or among the ten best for other elements.

*G-Ranks are a measure of global imperilment of elements of biodiversity. G1=Critically imperiled, G2=Imperiled, G3=Vulnerable, G4=Apparently secure, G5=Secure. G-Ranks follow NatureServe methodology.

C-RATING

Collective Rating. This rating evaluates the conservation value of each SNHA based on the number of tracked elements present, and the rarity of those elements, weighted in terms of both global imperilment (G-Rank) and state imperilment (S-Rank). The score of a site is calculated by summing the cumulative scores of the extant elements in the site, based on weights assigned to each level of G-Rank and S-Rank.

ELEMENT COLLECTIVE RATING	MINIMUM NUMBER OF ELEMENTS
C1 (Outstanding)	10
C2 (Very High)	7
C3 (High)	4
C4 (Moderate)	2
C5 (General)	1

SNHAs represent the most important finer scale sites for biodiversity in North Carolina – the best sites for the rarest species and the best examples of all natural community types as defined in the Classification of the Natural Communities of North Carolina (Fourth Approximation) (Schafale 2012). Protecting examples of natural community types should protect many other species and ecosystem functions as well. Each site represents a component of a representative portfolio and is not interchangeable with any other. The different levels of significance represent portfolios of different geographic scope.

In addition to their relative significance, SNHAs are relatively precise and well-studied. Each SNHA is individually drawn by a trained ecologist after studying the area on the ground and documenting the rare species and natural communities they contain. Protection of the full suite of SNHAs is needed to conserve the diversity of rare species and their habitats within the state. Loss of any one may result in the loss of one of the best examples of at least one rare species or natural community type, leaving North Carolina with only more degraded or less viable examples. In many cases, no other examples would be available to replace lost SNHAs.

SNHAs received a ranking of highest conservation value (CPT Ranking = 10), high conservation value (8) or medium-high conservation value (6), depending on their NCNHP-assigned significance. Sites rated as Outstanding and Very High (based on either the R or C rating) are both given the highest ranking since protection of the full set of these sites is required to meet the goal of minimally protecting all of North Carolina’s natural diversity. Sites rated as High are given only a slightly lower ranking because they are necessary for robust protection of the state’s biodiversity and for minimal protection of the biodiversity of the different regions of the state.

Sites rated as General are important to conserving biodiversity at the local level and provide stronger protection for the state’s biodiversity in general.

- **Element Occurrences**

Element occurrences (EOs) are areas of land or water where elements of biodiversity - rare species, significant natural communities, or animal assemblages - occur. Rare species and natural communities are important and sensitive components of biodiversity. The most important occurrences are incorporated into SNHAs. However, other “free-standing” occurrences not included within SNHAs have additional value for viability of the elements in North Carolina.

NCNHP ranks element occurrences based on their quality and viability (EO ranks), their precision (representation accuracy), and their currency (last

observed date) (NatureServe 2002), and these ranks were used in selecting EOs and assigning relative ranks for them in this assessment. Elements (species and communities) are also assigned ranks by NCNHP based on their imperilment (G ranks and S ranks) (Gadd and Finnegan 2012, LeGrand et al. 2012). Only occurrences that are believed viable and are reasonably spatially precise and accurate are used.

Occurrences with excellent or good viability (EO rank = A or B), and occurrences considered critically imperiled or imperiled at the global or state level (G1, G2, S1) received a medium conservation value (CPT Ranking = 5). In cases where two or more viable occurrences occurred within the same cell, that cell received a medium conservation value (CPT Ranking =5). All other lower-ranked EOs considered viable, current and spatially precise received a moderate conservation value (CPT Ranking = 4); these included elements considered vulnerable (but not imperiled) at a global or state scale (ranked G3 or S3 respectively) and occurrences with fair (but not excellent or good) estimated viability or integrity (EO rank = C).

- **Important Bird Areas**

Important Bird Areas (IBAs) are sites designated by the National Audubon Society that provide essential habitat for one or more species of bird, and represent sites important for the long-term viability and conservation of naturally occurring bird populations in North Carolina. IBAs include sites for breeding, wintering, and/or migrating birds, and may be a few acres or thousands of acres. IBAs may include public or private lands and may be protected or unprotected.

To qualify as an IBA, sites must satisfy at least one of the following criteria. The site must support:

- Species of conservation concern (e.g. threatened and endangered species)
- Restricted-range species (species vulnerable because they are not widely distributed)
- Species that are vulnerable because their populations are concentrated in one general habitat type or biome
- Species, or groups of similar species (such as waterfowl or shorebirds), that are vulnerable because they occur at high densities due to their gregarious behavior

IBAs represent a collection of sites that are assembled by a process of nomination and approval. Many of the areas are of high spatial precision; however, some have inclusions of seemingly degraded habitat.

Some IBAs are selected as the best examples for particular species or assemblages, and others are sites that are important but may be less unique.

Because they represent important areas but may not be the best examples, represent an incomplete set of habitats, and may contain inclusions of poorer habitat, IBAs are ranked lower than SNHAs or the more precisely mapped aquatic systems. Cells with IBAs currently receive a CPT Ranking of (6). Additional prioritization and delineation within IBAs is currently underway by Audubon, and will likely result in an adjustment in the current ranking in future iterations of the assessment.

- **Landscape / Habitat Indicator Guilds (LHIG)**

Landscape/Habitat Indicator Guilds (LHIGs) are groups of animal species whose presence is indicative of landscape integrity, i.e., where either large blocks of habitat persist or where a number of smaller blocks are sufficiently well-connected to support breeding populations of these species. These guilds are identified for a particular type of habitat, with both the habitat and the list of indicator species defined at the same time for a given guild (Hall 2008, 2008a, 2008b, 2009, 2009a, 2009b). The guilds, much like the SNHAs, are good indicators of functional ecosystems.

Guild indicator species are habitat specialists, but the habitats they occupy typically represent a combination of different natural communities. For example, the Wet Hardwoods guild in the Coastal Plain includes species that are primarily restricted to floodplain forests, but include the following five types of natural communities within their habitat range: Blackwater Bottomland Hardwoods, Brownwater Bottomland Hardwoods, Brownwater Levee Forest, Coastal Plain Small Stream Swamp, and Nonriverine Wet Hardwood Forest. The indicator species represent a wide range of species, including rare species, as well as more common species, many of which are target species for the Wildlife Resource Commission's Wildlife Action Plan.

The landscape units defined by these guilds are termed core areas, and are mapped by the Natural Heritage Program. Additionally, inter-core connectors are mapped where habitat bridges exist between two core areas. Unlike the core areas themselves, these connectors only need to provide habitat suitable for dispersal, not necessarily breeding. Where different guilds share at least some of the same community types within their habitat combination, spatial overlap between guilds is possible, as reflected in the intersection of core areas and connectors.

LHIG core areas and connectors were used in this analysis because they serve to identify areas that are important in supporting species or ecosystems that require landscape-scale blocks of habitat to survive. Conservation of large, intact blocks of habitat is critical for the preservation of the states' biodiversity and can play a particularly important role in plans to protect the state's ecological infrastructure. Identification of intact (or as intact as now exist) landscape units is complementary to NCNHP identification and prioritization of high quality SNHAs. Occurrences of rare species and natural

communities that occur in large intact landscapes, as indicated by LHIGs, are more likely to be included in SNHAs, and SNHAs embedded in them are more likely to be ranked as highly significant. However, guilds, core areas and connectors are not tied specifically to rare species. They are defined based on species selected to represent landscape-scale ecological functions. The habitats eligible for inclusion within LHIG core areas or connectors represent a wider array of types than those described in the Fourth Approximation (Schafale 2012), including successional habitats and some examples of silvicultural or agricultural lands. LHIG core areas can thus be defined even in the absence of other NCNHP elements or SNHAs and, consequently, cover a larger portion of the state and serve a wider range of species and ecosystems.

Guilds, core areas, and inter-core connectors are assigned element ranks (S-ranks). Additionally, clusters of core areas or connectors – which can overlap in space – are given a combined ranking based on the element ranks of the individual LHIGs and the occurrence ranks of the particular core areas or connectors.

The ranking strategy for the combined landscape units is still under development and may eventually include a portfolio (rarity) component similar to that used to rank SNHAs. However, one of the main purposes of developing the LHIG approach to landscape analysis was to cover the needs of a broader range of species and ecosystems than included in the set of traditional NCNHP conservation targets. The current approach takes into account the rarity of a given guild across the whole state, assigning it an S-rank similarly to other SNHA elements. The individual occurrences (the core areas and connectors) are evaluated solely on the basis of the concentration of the LHIG Indicators that are present in a given landscape/habitat unit (i.e., on factors that can be measured at any site independently of all other sites). For more information, see Appendices D and E.

- **Wetlands**

Wetlands are areas of land where hydric conditions are a dominant environmental factor. The standard definition of wetlands that fall under federal jurisdiction as waters of the United States requires that soils be saturated with water for at least two weeks during the growing season, that soils show characteristics created by saturation, and that vegetation be composed predominantly of hydrophytes (plants adapted to growing in water or on a substrate that is deficient in oxygen due to excessive water content) (USACE 1987). Wetlands play important roles in hydrologic cycling, water quality and nutrient cycling, as well as serving as important habitat and sites for many other ecosystem functions.

Wetlands across North Carolina were mapped by the National Wetland Inventory (NWI) of the U.S. Fish and Wildlife Service (USFWS 1983). In North

Carolina's outer Coastal Plain, wetlands maps were refined by the N.C. Division of Coastal Management, and were rated for function (high, medium and low) by a multi-factor rating model called the Coastal Region Evaluation of Wetland Significance (NCCREWS 2003). As a general class, individual wetlands are not highly unique. Rare types and particularly high quality occurrences are covered by SNHAs and community EOs, so this data layer represents the remaining wetlands. However, in the parts of the state where wetlands are represented by NWI (in the Piedmont and Mountains), wetlands are rare and very important. NWI mapping represents only a moderate level of accuracy, and does not have a scale to determine condition or integrity. These areas are therefore given a fairly low ranking. NC CREWS data represents a higher level of accuracy, and has an internal rating that allows differentiation among different levels of condition or function. The most functional wetlands with the highest level of accuracy are therefore ranked higher, and the least functional and least accurate are ranked lower.

Aquatic Habitats

- **Aquatic Significant Natural Heritage Areas**

Aquatic Significant Natural Heritage Areas (ASNHAs) are conceptually similar to terrestrial SNHAs. They represent the waters that are of most importance to North Carolina's biodiversity, and are defined based on the actual presence of rare species. Unlike terrestrial SNHAs, community types are not used; currently there is no classification of aquatic community types. Because land adjacent to streams is essential for protection of water quality, the area included for ASNHAs includes not only the water itself, but a buffer of 300 feet on each side of the streams and other water bodies. Streams within the watersheds of ASNHAs with federally listed species are given 200-foot riparian buffers (per WRC 2002), and 100-foot buffers are applied to all other streams contributing to ASNHA watersheds.

Because ASNHAs are the most important areas for North Carolina's aquatic biodiversity, some of them received the highest rating possible. ASNHAs rated as Outstanding or Very High significance represent the best examples of the most rare aquatic species or the best collections of rare species in the state, but not all of North Carolina's aquatic biodiversity is represented by them at even a minimal level. ASNHAs rated as High are more numerous, but are still rare, limited in extent, and among the best of their kind.

- **High Quality Waters (HQW)**

High Quality Waters is a supplemental classification developed by the Division of Water Quality intended to protect waters with quality higher than state water quality standards. A waterway can be named HQW by definition or can be designated as HQW. The following are High Quality Waters by

definition (<http://portal.ncdenr.org/web/wq/ps/csu/classifications#classes>, April 2011):

- Water Supply I or II waters;
- Shellfishing waters;
- Outstanding Resource Waters;
- Waters designated as Primary Nursery Areas or other functional nursery areas by the Marine Fisheries Commission; or
- Native and Special Native (wild) Trout Waters as designated by the Wildlife Resources Commission.

There are also waters that can be given supplemental designation as High Quality Waters. These include:

- Waters for which Division of Water Quality (DWQ) has received a petition for reclassification to either WS-I or WS-II, or
- Waters rated as Excellent by DWQ.

Only HQWs with a strictly biologically based definition were included in this model. Water Supply Watersheds were excluded, as were shellfishing waters since they are defined as all tributaries that flow into shellfishing areas. The designated stream reach, along with its 100-foot land buffer, is included in the model. While HQWs are significant for water quality in North Carolina, they do not necessarily harbor rare species and are of lesser quality than Outstanding Resource Waters; therefore, for this assessment they are given a lower rating (CPT Rating = 8) than those areas with rare species present.

- **Outstanding Resource Waters (ORW)**

Outstanding Resource Waters is a classification assigned by the Division of Water Quality, and this classification is intended to protect unique and special waters having excellent water quality and of exceptional state or national ecological or recreational significance. To qualify, waters must be rated as having excellent water quality by the Division of Water Quality and also have an “outstanding resource value,” as defined by DWQ

(<http://portal.ncdenr.org/web/wq/ps/csu/classifications#classes>, April 2011).

This resource value must be one of the following:

- Outstanding fish habitat or fisheries;
- Unusually high level of water-based recreation;
- Some special designation, such as North Carolina or National Wild/Scenic/Natural/Recreational River, National Wildlife Refuge, etc.;
- Be an important component of a state or national park or forest; or
- Be of special ecological or scientific significance (rare or endangered species habitat, research or educational areas).

As with HQWs, the CPT only maps ORWs that have a biological basis; recreation and special designation ORWs were omitted. The designated stream reach, along with its 100-foot land buffer, is included. ORWs represent aquatic communities that are in excellent condition, and often harbor rare species as well. They also represent a portion of the most significant aquatic communities in the state. Not only do they have excellent water quality, but they also contain outstanding resource values, including rare or endangered species habitat. They are rare and considered among the best, but do not represent a portfolio or selection of the best examples. They are well-studied streams that represent a high level of site-specific knowledge of community condition; therefore, they are given a high conservation value (CPT Ranking = 9). Because they are designated by a process of nomination and public acceptance, the completeness of this data layer is limited.

ORW NOTE: In the event that an ORW temporarily deteriorates, it can be simultaneously listed on the 303D list. This “temporary” action does not take the water body off the ORW list. Therefore, the ORW and 303D data should be cross-referenced when evaluating individual stream segments designated as ORW.

- **Stream Bioclassification (Fish and Benthic) – Excellent/Natural and Good**

The bioclassification of North Carolina streams uses a multimetric index that rates the quality of warm water streams. The presence, condition and numbers of the types of fish and benthic macroinvertebrates provide accurate information about the health of a specific water body. Bioclassification ratings are assigned by the Division of Water Quality following a standardized protocol. For this project, the stream reach in which the sampling point occurs, along with its 100-foot land buffer, is included. Areas designated as natural swamp waters are Coastal Plain waters that have been determined to be in good natural condition. These streams naturally have low dissolved oxygen and low diversity of aquatic insects and fish, so they do not have high bioclassification scores. However, they represent the best data available for identifying good examples of aquatic communities and were considered to be indicators of the same level of integrity as the excellent fish and benthic sites.

This is a widely accepted method for rating the quality of streams in North Carolina. Streams with high ratings that are consistent over time are areas of unusually intact aquatic communities. Because we do not yet have the ability to classify and map aquatic communities as we do terrestrial communities, this is one of several measures used to identify examples of aquatic communities in excellent condition. Since many coastal plain streams cannot be ranked according to the bioclassification, the "Natural" designation of swamp waters is valued the same as excellent fish or benthic macroinvertebrate sites.

Excellent/Natural rated waters represent a portion of the most significant aquatic communities in the state, and are given a CPT Ranking of (9). Excellent bioclassification sites and Natural Swamp Waters are rare and considered among the best, but do not represent a portfolio or selection of the best examples. They are based on well-studied sample points that represent a high level of site-specific knowledge of community condition. However, the extent of the high quality community beyond the sample point is not well known. Using the standard DWQ ratings, “good” bioclassification sites are not as high quality as the “excellent” sites; therefore they receive a slightly lower CPT Ranking of (7).

Bioclassification sites are analogous to EOs of terrestrial communities, with the high bioclassification score analogous to a high EO rank. Since most high quality terrestrial communities are included within SNHAs, and since aquatic communities have not been designated yet, the aquatic communities represented by the excellent bioclassification sites were given a higher rating than free-standing community EOs of high EO rank.

While “good” bioclassification waters are significant for water quality in North Carolina, they do not necessarily harbor rare species; therefore, they are given a lower rating than those areas with the rare species present. In addition, they are not as high quality as the “excellent” sites; therefore, they receive a lower ranking.

- **Stream Buffers**

A riparian buffer is the area of land adjacent to ephemeral, intermittent and perennial streams, rivers and other bodies of water that serves as a transition zone between aquatic and terrestrial environments, and directly affects and is affected by that body of water. Riparian ecosystems perform many functions that are essential to maintaining water quality, aquatic species survival and biological productivity. Riparian buffers represent the most effective and efficient way we can address water quality and habitat through spatial planning, and should be part of a larger holistic strategy for conservation of aquatic ecosystems. The overall implementation strategy should take into account increased impervious surface and stormwater impacts, and human practices that can bypass or circumvent intact riparian buffers.

Although effective buffer size depends on specific site conditions, such as slope and soil type, this assessment used several uniform width buffers for application across the North Carolina landscape. Buffers were applied to streams from the N.C. DWQ's Assessment Unit Hydrology data layer.

According to literature reviews and “the majority of scientific findings, land use practitioners should plan for buffer strips that are a minimum of 25 meters (82 feet) in width to provide nutrient and pollutant removal; a minimum of 30 meters (98 feet) to provide temperature and microclimate regulation and

sediment removal; a minimum of 50 meters (164 feet) to provide detrital input and bank stabilization; and more than 100 meters (328 feet) to provide for wildlife habitat functions. To provide water quality and wildlife protection, buffers of at least 100 meters are recommended" (ELI 2003). These recommended width measurements are from the top of the bank or level of bank-full discharge of one side of a water body.

As documented by the N.C. Wildlife Resources Commission (August 2002 and references therein):

"Wide, contiguous riparian buffers have greater and more flexible potential than other options to maintain biological integrity and could ameliorate many ecological issues related to land use and environmental quality. As expansion of developed areas continues into the watershed, wildlife habitat can change, become fragmented and even disappear. Riparian buffers provide travel corridors and habitat areas for wildlife displaced by development. In addition, riparian buffers serve to protect water quality by stabilizing stream banks, filtering capacity of stormwater runoff, and provide habitat for aquatic and fisheries resources."

By virtue of their high productivity, diversity, continuity and critical contributions to both aquatic and upland ecosystems, intact riparian ecosystems provide vital resources to North Carolina's fish and wildlife. Because these are distinctly valuable habitats, we have included riparian buffers on all streams throughout North Carolina. In our model, both the significance of the waters being buffered and their ratings are used in determining the width of riparian buffers. Buffers of 100 feet or 200 feet were assigned to all water related criteria.

For Outstanding Resource Waters, High Quality Waters, wild brook trout waters, anadromous fish waters, Excellent and Good fish and benthic bioclassification sites, and natural swamp waters, the 100-foot buffer is incorporated into the data layer along with the actual stream segments.

Priority watersheds have been designated by several natural resource agencies, including NCNHP and WRC. NCNHP priority watersheds are designated based on all 12-digit HUCs that drain to an ASNHA. WRC priority watersheds are designated based on areas identified for habitat conservation. Criteria include areas with endemic species and specific areas that are critical to the survival of State Wildlife Action Plan priority species (e.g., particular streams or spawning sites). Streams within these watersheds are given 100-foot or 200-foot buffers, with the larger buffers on streams in watersheds contributing to federally listed species habitat (WRC 2002). Protection of

buffers on tributary streams in these watersheds is essential to protecting significant waters downstream.

After stream buffers were defined based on distance from the stream, cells with high (>20 percent) impervious surface cover were removed. These degraded areas are important to water quality in the adjacent streams, but are in need of restoration rather than conservation of current conditions.

Suggested Buffer Widths, Categories and Assigned Rankings

Stream Buffer Width	Category	Assigned Ranking for Conservation Value
200 ft.	Watersheds with federally-listed species	High (7)
100 ft.	NCNHP/WRC priority watersheds	Medium (3)
100 ft.	All streams (without additional significance)	Moderate (1)

All stream buffers are limited in level of knowledge and spatial precision, since they are calculated by a fixed distance from the stream rather than from a more direct measure of their habitat quality, and carry no consideration of the specific condition of the buffer. However, all stream buffers are important to water quality and aquatic ecosystems, and thus have an important functional value to the local ecosystem. For these reasons, all riparian buffers are included in the analysis, and their ratings vary with the value of the streams they buffer.

Stream buffers in watersheds containing federally listed species are rated based on their critical importance for rare species and high quality aquatic communities, in addition to their contribution to general water quality. Most of the water in the aquatic area of interest comes from the upstream tributaries, and is filtered through the stream buffers on them. While slightly less important than the immediately adjacent buffers, which also provide shading, bank stabilization, organic matter impact and other functions, they are given a medium-high conservation value (CPT Rating = 7) for their strong contribution.

- **Wild Brook Trout Waters**

These are waters that contain the naturally occurring and reproducing strains of Northern and Southern Appalachian Brook Trout. The stream reach where the wild brook trout are known to occur, along with its 100-foot buffer, is included. Mapping and management of data related to Wild Brook Trout Waters is conducted by the Wildlife Resources Commission.

The Southern Appalachian Brook Trout is the only native trout species in North Carolina, and they, along with Northern Appalachian Brook Trout, serve as indicators of the health of the watersheds they inhabit. Robust wild brook

trout populations demonstrate that a stream or river ecosystem is healthy and that water quality is excellent.

These waters represent a portion of the most significant aquatic communities in the state. They are rare and considered among the best, but do not represent a portfolio or selection of the best examples. Wild Brook Trout Waters are based on well-studied sample points that represent a high level of site-specific knowledge of community condition, and therefore receive a CPT Ranking of (9).

- **Anadromous Fish Spawning Areas (AFSA)**

Anadromous fish spawning areas consist of portions of freshwater streams and rivers and the adjacent flooded wetlands that are used by anadromous fish for spawning of eggs. Anadromous fish include species that must migrate from the ocean upstream to freshwaters to spawn. Some species, such as striped bass and blueback herring, require strong current velocities and spawn in the mainstem river channels, while others, such as alewife and shad, prefer slower currents and spawn in small streams and flooded wetlands. Because of the important contribution of riparian areas to the life cycles of these fish species, 100-foot buffers are included in the mapped anadromous fish spawning areas.

Anadromous fish spawning areas provide a critical function for several different anadromous fish species. Many of these species are important commercial or recreational fishery species (striped bass), some are depleted due to habitat alterations and fishing pressure (alewife and blueback herring) or are state and federally listed (shortnose sturgeon). These species cannot survive if suitable spawning area is not maintained. For spawning to be successful and eggs to survive, high water quality conditions are needed in these areas (adequate oxygen levels, low sedimentation, and natural flows). Protecting these areas would strategically conserve not only a complex of important fish species, but would help maintain downstream areas for juvenile anadromous fish and other species.

Anadromous fish spawning areas are given a CPT Ranking of (8) because they represent habitat that is essential for multiple species, including rare species, and have data to support delineation. The Division of Marine Fisheries has noted that protection of all anadromous fish spawning areas is a high priority. Anadromous fish use areas were designated by the N.C. Marine Fisheries Commission and Wildlife Resources Commission based on extensive coast-wide sampling for presence of eggs, larvae and ripe females. Updated data on current spawning activity or results from DMF's Strategic Habitat Areas (SHA) analysis will be used to select the areas of highest priority in the near future.

As with other data layers used to represent aquatic communities, Anadromous Fish Spawning Areas show high community quality and are relatively uncommon, but do not represent a selection of the best examples. For this reason, they do not receive a maximum value ranking.

- **Oyster sanctuaries**

Oyster sanctuaries are subtidal oyster reefs that have been restored by the Division of Marine Fisheries and other nonprofit partners, primarily in the Pamlico Sound system. In these areas, natural materials have been added to restore the three-dimensional structure of the reefs. The areas are marked and designated for conservation. No harvest is allowed.

Subtidal oyster reefs in the Pamlico Sound system are severely depleted from historical levels, primarily due to overharvesting. Although the various fishing practices that originally damaged the oyster habitat have been eliminated or greatly reduced, disease and habitat degradation have slowed natural recovery. The restored oyster sanctuaries were strategically selected in areas where they historically occurred, would provide critical refuge for fish and invertebrates, would act as core spawning sanctuaries to release eggs and larvae to adjacent areas, and could improve water quality conditions through their filtering capabilities.

These areas are given a relatively high rank (CPT Ranking = 8) because their locations are well documented, they are regularly monitored by DMF staff, and they are relatively rare. They have become colonized with a diversity of organisms, including new oysters, and are providing fish refuge and foraging areas. Populations of subtidal oyster reefs are severely depleted, so these areas represent limited and historically important habitat.

- **Hard Bottom Areas**

Hard bottom habitats are exposed areas of rock or consolidated sediments, which are usually colonized by a thin veneer of live or dead biota, generally located in the ocean. Hard bottom, also referred to as live bottom, can be colonized with sponges, coral, algae and other invertebrates, supporting a very diverse community, including subtropical reef fish and a valuable snapper-grouper fishery. Hard bottom is mapped by the Division of Marine Fisheries.

This habitat is relatively rare and unique in North Carolina and greatly enhances the diversity of fish and invertebrates that can survive in North Carolina, and therefore received a medium-high conservation value (CPT Ranking = 7).

- **Shell Bottom in Shellfish Growing Areas (SGA)**

Intertidal and subtidal oyster reefs or concentrations of shell mapped by the DMF and located in waters having Division of Environmental Health shellfish

harvest classifications of open, conditionally approved open, and conditionally approved closed represent shell bottom occurring in areas of highest water quality.

Shell bottom is unique in that it is both a natural habitat and a culturally important fishery. The epifaunal habitat provides three-dimensional fish habitat in estuarine waters. The small crevices provide refuge for small and juvenile fish species, foraging areas for larger fishery species, and support a higher abundance and diversity of organisms compared to unstructured soft bottom. Oyster reefs also provide many ecosystem services, such as filtering pollutants from the water column, stabilizing sediments and reducing shoreline erosion. It is important from an ecological and economic standpoint to maintain shell bottom habitat and the oyster fishery.

Oyster beds in open harvest areas represent a high quality estuarine habitat, and received a relatively high conservation value (CPT Ranking = 8) ranking. Much supporting data exist for the mapped oyster beds. They are very vulnerable to water quality degradation from adjacent land use. Oyster beds in areas closed to shellfish harvest also offer valuable fish habitat. However, these waters are listed as impaired by DWQ. The water quality degradation that has been shown to co-occur with increased fecal coliform contamination (elevated loading of nutrients, sediments and toxins) indicates that these areas are of lower overall condition. Oyster beds in closed areas could be included at a lower ranking or omitted.

Mapping of oyster beds has not yet been completed for Brunswick County and the Pamlico Sound. In Brunswick County, oyster beds are known to be very abundant, but they are currently unmapped and much area is closed to harvest. Oyster sanctuaries described in this report will capture some of the Pamlico Sound oyster beds. Further evaluation of specific oyster beds and completion of mapping in all areas could support an increase in ranking of a subset of the oyster beds.

- **Fish Nursery Areas (FNA)**

The Division of Marine Fisheries designated certain estuarine areas as fish nursery areas. Past and present sampling indicates that these areas support a high abundance and diversity of juvenile fish species, particularly for estuarine dependent species that are spawned offshore during winter and migrate into the estuary. These nursery areas generally consist of shallow soft bottom in the upper reaches of tidal wetland creeks. While a few species tend to dominate the composition, over 175 juvenile species have been documented. Areas are designated as primary or secondary nursery areas. Juveniles tend to settle out first in the shallowest and most upstream sites (primary nursery areas), and then migrate downstream to slightly deeper water (secondary nursery areas). There are about 147,000 acres of designated nursery areas in North Carolina.

These areas are considered by DMF to be the highest quality nursery areas for many of the most common and important fishery species in North Carolina, including shrimp, flounder, blue crab, spot and croaker, as well as a diversity of other species. Maintaining these areas in good condition is critical to the health of the entire estuarine system; therefore, they received a CPT Ranking of (8).

The location and description of these areas is well documented, and juvenile fish data has been collected since the 1970s. Analyses have been conducted on the fish data and environmental factors associated with these areas of high productivity. These areas are not particularly unique from each other, but are critical to sustaining NC's productive fisheries.

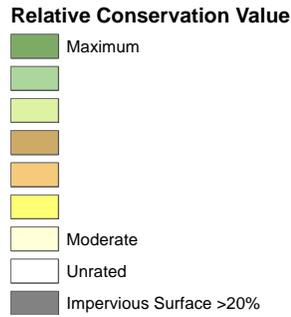
- **Submerged Aquatic Vegetation Beds (SAV)**

Submerged aquatic vegetation habitat is bottom that is recurrently vegetated by living structures of submerged rooted vascular plants, and includes the unvegetated areas between grass patches. This habitat occurs in subtidal and intertidal zones and may be colonized by estuarine or freshwater species. This habitat has been partially mapped by federal and state agencies. There are thought to be approximately 200,000 acres of SAV in North Carolina (Deaton et al. 2010).

SAV habitat is well known for its numerous fish and invertebrates. More than 150 species have been documented using this habitat, mostly as a nursery area for summer spawned estuarine dependent species, such as black sea bass, red drum, spotted sea trout, weakfish and hard clams. Bay scallops, which are currently severely depleted in population, are highly dependent on this habitat for survival. Protection of this habitat would allow a greater diversity of organisms to survive in North Carolina's coastal waters.

SAV maps have been developed through a combination of remote sensing and field monitoring. There is currently not enough data to support prioritization within grassbeds; once the environmental factors that enhance SAV growth are better understood, a subset of SAV habitat could be selected as a higher priority. Currently, SAV habitat is given a CPT Ranking of (6).

Biodiversity/Wildlife Habitat Assessment Legend



Key to Identify Tool results for the Biodiversity/Wildlife Habitat Assessment			
Category Name	Value	Individual Input Layers	Source for Input Layers
NCNHP	10	Significant Natural Heritage Areas – Outstanding and Very High Ranking	<i>NC Natural Heritage Program</i>
	8	Significant Natural Heritage Areas – High and Moderate Ranking	
	6	Significant Natural Heritage Areas - General Ranking	
	5	Element Occurrences – High ranking	
	4	Element Occurrences – Other	
Wetlands	7	Coastal Region Evaluation of Wetland Significance (CREWS) – Exceptional	<i>NC Division of Coastal Management</i>
	6	Coastal Region Evaluation of Wetland Significance (CREWS) – Substantial	
	5	National Wetland Inventory (NWI)	<i>US Fish and Wildlife Service</i>
	2	Coastal Region Evaluation of Wetland Significance (CREWS) – Beneficial	<i>NC Division of Coastal Management</i>
Guilts	1-10	Landscape Habitat Indicator Guilts	<i>NC Natural Heritage Program</i>
DWQ	10	Outstanding Resource Waters	<i>NC Division of Water Quality</i>
	9	Stream BioClassification – Excellent	
	8	High Quality Waters	
	7	Stream BioClassification – Good	
	1	All other streams	
FishHabitat	9	Wild Brook Trout	<i>NC Wildlife Resources Commission</i>
	8	Anadromous Fish Spawning Areas	<i>NC Division of Marine Fisheries</i>
FishNursery	8	Fish Nursery Areas	<i>NC Division of Marine Fisheries</i>
Watersheds	7	Stream buffer tributaries to Federally-listed (Threatened & Endangered) Species	<i>NC Natural Heritage Program</i>
	3	Priority Watersheds	<i>NC Natural Heritage Program, NC Wildlife Resources Commission</i>
Marine	8	Oyster Sanctuaries	<i>NC Division of Marine Fisheries</i>
	6	Submerged Aquatic Vegetation (SAV)	
Hardbottom	8	Open Shellfish /Shellbottom	<i>NC Division of Marine Fisheries</i>
	7	Hard Bottom	
	5	Closed Shellfish /Shellbottom	
IBA	6	Important Bird Areas	<i>Audubon Society, NC Chapter</i>
Impervious	-1	Impervious Surface above 20%	<i>US Environmental Protection Agency</i>