Natural Resource Network

Connecting Research, Teaching and Outreach

# Biodiversity Principles and Applications: Conference for Natural Resource Professionals in New Hampshire Summary

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# Key Quotes from the Conference

"Even though 'biodiversity' is such an important term, finding meaningful definitions for biodiversity and ecosystem management is difficult. Definitions range from complex to simple."

*John Sargent, New Hampshire State Forester*

"Generalized definitions of biodiversity are too vague and expansive to be useful in management decisions...

Directed questions targeting the levels of biodiversity will enhance the possibility of answering them more effectively and meaningfully...

By protecting threatened habitats many plants and animals that are in danger of decline can also be preserved...

There are severely endangered populations that are not on protected land and are disappearing rapidly. Should there be protection for species like this?

How much land area do you need in order to protect a given habitat or species?

Focusing on keystone species (species that have the most effect on other species) might be a more appropriate way to determine sizes of habitats in need of protection...

Cuts, that occur through habitat fragmentation, that were previously termed 'transition zones' and that were thought to enhance biodiversity actually reduce biodiversity. This "edge effect" as it has been coined may be an extremely important factor to consider in management plans...

A good way to account for possible dynamic systems in management would be to preserve large areas so you can have a shifting mosaic of communities in different stages...

Every level (species, community, regional, etc.) of biodiversity is important to maintaining the natural balance of the Earth's animals, plants, and chemistry. When pieces are lost, the system can go out of balance. The corrective measures needed to fix a system that is out of balance are extremely costly if not impossible. A self regulating, healthy system is far less costly and much easier to maintain."

*Lisa Standley, Environmental Consultant and Keynote Speaker*

"When discussing the implications of within-species diversity care must be taken in a 'Noah's Ark' approach since a population with a greatly reduced number will automatically loose much within-species genetic diversity. For example, the peregrine falcon that has been reintroduced successfully in some areas is not the same as the native form found previously. The previous form is now extinct and the new type has been introduced from other, genetically different stock."

*Tom Lee, UNH*

"Evolution is typically viewed as something that has happened in the past, or that it is a historical science. However, evolution is a process that is happening today. Biodiversity is like a drama, comedy, or tragedy since it is an evolutionary play that takes place in an ecological theater."

*Jim Taylor, UNH*

"Forest communities demonstrate chaotic change that can be predictable only at certain scales. Dynamic change over time occurs from place to place. Biodiversity in forest communities does not scale up easily. That is, the processes at one level are different from the processes at another level. Unless all possible scales and processes of diversity are taken into account the wrong conclusions can be made."

*Charles Cogbill, Ecologist*

"Data suggest that predators take advantage of a highly fragmented environment and that predators occur in higher frequency in these sorts of environment. It is important that we offset or mediate the effects that we have generated with these large scale changes."

*John Litvaitis, UNH*

"Because the IBI(Index of Biological Integrity) is such a multi-parameter, information-rich approach, it increases the ability to document the ecological health of the system."

*Michele Dionne, Wells National Estuarine Research Reserve*

"The mission of the State Natural Heritage Program is necessary in today's world because the planet is experiencing the greatest species decline since the massive extinction that occurred with the demise of the dinosaurs. Loss of species diversity on this planet is similar to loosing rivets on an airplane. The plane can do without some of those rivets, but if it loses one too many the whole craft falls apart. The Natural Heritage Inventory works as a kind of early warning system that sounds off when too many 'rivets' have been lost from the Earth 'aircraft.'"

*David Moore, N.H. Natural Heritage Inventory*

"The New Hampshire Scientific Committee On Biodiversity is in the process of designing a primer that illustrates the processes that cause and affect biodiversity and that gives an overview of the status of genetic, species, and community diversity in the state. It is vitally important to expand this sort of model and to set up scientific technical committees to coordinate monitoring efforts."

*John Kanter, N.H. Dept. of Fish and Game*

"Assessment at the landscape level is important because there are certain limitations to the species level approach. Only some species out of the total present are even known. Little is known about the life histories of many species. It is likely that the lesser known organisms carry out important ecosystem functions. Assessors may miss important ecological processes...

ECOMAP does not follow political boundaries the way that many other resource maps do."

*Marie-Louise Smith, U.S. Forest Service*

"E.O. Wilson said, 'A knowledge of biodiversity will mean nothing unless there is a motivation to use it.' Today this is the case. There is a need for ecosystem and biodiversity management and we must manage ourselves. People must cross jurisdictional and functional boundaries in order to share expertise, to teach different capabilities and to encourage diverse viewpoints. This information exchange and management must go on regardless of election results."

*Kathryn Staley, White Mountain National Forest*

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# Introduction

On January 17, 1995, the Natural Resource Network of New Hampshire with support from the University of New Hampshire Cooperative Extension and Department of Natural Resources hosted a conference on Biodiversity Principles and Applications. The conference was for natural resource professionals working in New Hampshire. Over 175 people including teachers, outreach professionals, researchers, resource managers and administrators, and graduate students attended the conference in Newington, NH. Its purpose was to build a common understanding of concepts of biological diversity and integrity. The variety of outstanding speakers and time allowed for questions gave participants an opportunity to enhance and deepen their knowledge of biodiversity. This increased knowledge better equips professionals for resource management of biodiversity in New Hampshire.

This paper will provide natural resource professionals, scientists, teachers, policy makers, legislators, and the general public with a written overview of the major points, ideas, and definitions presented and discussed at this meeting. Synopses of presentations are layed out following the meeting agenda.

# Welcome

Lorie Chase, Natural Resource Network Coordinator, introduced the meeting commenting that it would be "... a conversation which would build our understanding of biological diversity and integrity." She also stated that natural resource professionals from all over the state were in attendance.

John Sargent, New Hampshire State Forester, welcomed participants. Sargent related the first time he had heard the term biodiversity. Five years ago at a staff meeting for the National Association of State Foresters in Washington, D.C., a staff member suggested that Sargent should take the time to learn about biodiversity. Sargent told meeting participants it was a good warning since he doubted there was another word that caused more concern or more consternation to the Northern Forests Lands Council members than the word 'biodiversity.'

Sargent has obviously learned much since that day five years ago. So have many others, as a result of extensive outreach programs about biodiversity and ecosystem management. He stated even though the term is such an important one, finding meaningful definitions for biodiversity and ecosystem management is difficult. Definitions range from complex to simple. For example, the recent publication, Finding Common Ground Conserving the Northern Forest, defines biodiversity as "...the variety and abundance of species, their genetic composition, and the community, ecosystems, and landscapes in which they occur. It also refers to the ecological structures and processes that occur at all of these levels." On the other hand, the U.S. Forest Service defines biodiversity as "..the variety of life and its processes." Sargent emphasized that biodiversity and its processes can occur at a variety of different scales, such as local, regional and global. He urged managers and professionals not to lose sight of the possible scales that they might be working with.

Sargent ended with a plea for continued interest, learning and application of knowledge. He said, "...don't let it stop with this conference. Use other conferences and places to put into practice what we learn here. We can't fear it, we must accept it, and we must work with it."

# Definitions and Issues of Biodiversity

## Keynote Address

Lisa Standley

*Lisa Standley is Managing Director of Environmental Services for Vanasse Hangen Brustlin, Inc. Her interests are in systematics of sedges (a type of plant), the ecology of rare plant species, and in birding. Standley originally became interested in biodiversity as an undergraduate. She studied plants and was intellectually intrigued at the great diversity of form and function she observed. Her keynote address was a prism that focused on exactly what biodiversity is and the issues that surround it.*

Generalized definitions of biodiversity are too vague and expansive to be useful in management decisions. For example, the Council on Environmental Quality (CEQ) defines biodiversity as "... the variety and variability of life, and the diversity of genes, species and ecosystems." To answer questions like, "What is the effect of this action on the biodiversity of some system," the definition of biodiversity must first be broken down into types of biodiversity. By looking at the components one can then go about getting meaningful answers to these sorts of questions.

There are five types of biodiversity. First is regional ecosystem (community) diversity. Examples of the tremendous diversity of regions in New England include alpine, sub-alpine, tundra, deciduous and coniferous forests, coastal plains ponds, streams, rivers, bogs, salt marshes, dunes, and intertidal and subtidal bays and estuaries.

Next is local ecosystem diversity. Within some given area there can be a variety of local ecosystems that are a physical response to the substrate of that area. That is, diversity within a local ecosystem is a response to factors like slope, elevation, alluvial fans, desert flats, and streams.

Within-community diversity. This is the diversity of species within a certain community. For instance, insect diversity in tropical rain forests and the diversity of wood warblers in North temperate forests would be examples of within-community diversity.

Taxonomic diversity is the diversity of species within genera, families, and orders. This definition is different from the more ecological ones described so far, but is useful in systematics and is a type of biodiversity. For example, there can be many species within one genus.

Finally, genetic (intraspecific) diversity is the diversity within a species or population. This sort of diversity is the most difficult to conceptualize since it occurs within one species. Genetic diversity can be illustrated by pointing out that two populations of the same species might be geographically isolated from one another for a long period of time and hence will have different genetic structure.

Targeting these levels of biodiversity with directed questions enhances the possibility of more effective and meaningful answers. There are a variety of issues that are important to consider when defining our questions more precisely.

Community preservation which focuses on the regional or local level and tends to be directed at rare, uncommon, or unusual communities. For example, the coastal heath and grassland community found from Cape Cod to Long Island is globally rare. A wide variety of organisms that require a specific threatened habitat are in danger of decline as well. By protecting threatened habitats many plants and animals in danger of decline can also be preserved.

Preservation of species diversity is a management method that has been in place for a variety of endangered or threatened species. To protect certain species, like the desert tortoise for example, large areas of land must be protected too, since the animal requires large ranges. There are many species, such as Canics polymorpha (a plant) that are severely endangered and which have no protection measures. Canics polymorpha, for example, globally has a total of 25 populations which are all found in New England. These populations aren't on protected land and are disappearing rapidly. Should there be protection for species like this?

Habitat size is addressed by the question, "How much land area do you need in order to protect a given habitat or species?" The answer may depend on what one is trying to protect. Typically, the focus is on rare or endangered organisms or habitats. Is this the right approach? Focusing on keystone species (species that have the most effect on other species) might be a more appropriate way to determine sizes of habitats in need of protection. For example, timber wolves in Yellowstone (and other top predators) can be considered a keystone species since they have a great effect on the rest of the community.

The next issue, habitat fragmentation, has been re-evaluated. Recent research has shown that previous ideas about the relative harmlessness of power lines and road cuts is wrong. These sorts of divisions, even if they are small, can effectively reduce the functional size of the broken-up communities. Work documented in a recent edition of Conservation Biology found that a cut as little as 25 feet across could effectively reduce the size of the adjacent forest. Also, cuts like this can serve as barriers dividing what once was a whole community. This "edge effect" as it has been coined may be an extremely important factor to consider in management plans. Cuts that were previously termed 'transition zones' and that were thought to enhance biodiversity actually reduce biodiversity. Research has shown the number of species in the zone itself may increase but this increase is correlated to a reduction in species within the major communities broken by the zone. Neotropic migratory songbirds, for example, require large areas of forest for breeding ground. Edges create corridors for predators of these birds. The number of species of birds that will use this area is then reduced.

The fifth issue concerns dynamic systems. Certain systems may not be as stable and long-lived as many people believe. For example, the pine-barrens habitat requires periodic fire for its natural community structure and biodiversity. Species in that habitat have evolved with a long history of periodic fires. A good way to account for possible dynamic systems in management would be to "...preserve large areas so you can have a shifting mosaic of communities in different stages."

The last two topics, regional and property issues, were perhaps the most difficult to address. For each region a suite of questions related to the above listed issues should be asked. For example, is it possible, or even appropriate, to try to protect biodiversity at the property owner's level?

It's vitally important to use tractable, component definitions of biodiversity which are most appropriate for some studied system when trying to get at realistic, rational, and meaningful answers. "We can't do it all," since a total lack of development and forestry is impossible. We must "...define concerns, ask the right questions, and get the right data."

Standley was asked, "Why is biodiversity important?" Standley listed three specific reasons why the commitment to preserving biodiversity is necessary. First she addressed economics. Our understanding isn't complete. There may be species out there that will be economically very important. Then she referred to the dynamics of the natural world that we live in, stating that every level (species, community, regional, etc.) is important to maintaining the natural balance of the Earth's animals, plants, and chemistry. When pieces are lost, the system can go out of balance. The corrective measures needed to fix a system that's out of balance are extremely costly if not impossible. A self regulating, healthy system is far less costly and much easier to maintain. Third, there are aesthetic and philosophical reasons for protecting biodiversity. It's our duty and responsibility to protect it to the greatest extent we can.

# Levels of Biodiversity

Thomas D. Lee

*Lee has been an Associate Professor of Plant Biology at the University of New Hampshire since 1980. His research interests focus on natural and human disturbances on forest ecosystems.*

Since "...repetition is a good teacher," a brief review of some terms and units associated with biodiversity follows. A population is a group of individuals of the same species that occupy some area. A species is a group of interbreeding populations. A community is a group of different species populations that occur together in time and space. An ecosystem is a community plus its physical surroundings. Finally, a landscape is a large scale unit of Earth's surface area that encompasses different physical features which support a mosaic of different communities. Definitions of biodiversity need to address not only the variety of life at different levels but also the variety of processes affecting biodiversity.

The issue of species diversity is one that many people understand most easily. Species diversity, or species richness, is some measure of the number of species in an area. There are also patterns of evenness of species abundance. Evenness measures quantify the different numbers of species in different habitat types. Often these patterns of numbers of species are associated with some physical gradient. For example, the abundance of breeding birds changes over latitudinal gradients. Two areas can have the same species richness (number of species) but can have very different levels of evenness. That is, one area may have some number of species all of which are very abundant, while another area may have the same number of species but many of those species may be present only in very low abundance with only one or two species that are very abundant. These differences are termed 'high' versus 'low' evenness. Both richness and evenness say something about the species diversity of a system.

One can see a large amount of diversity within and between populations of the same species. Definitions of some simple genetic terms demonstrate how it's possible to have within-species diversity. A gene is an inherited piece of DNA that influences the form, function, and/or the behavior of an individual. An allele is an alternate form of a gene. For example, there might be two alleles for hair length of mammals, the 'long' and 'short' alleles. A genotype is an individual's collection of genes and alleles. Individuals might have genotypes that are different because each individual could have a different allele for the same gene.

Within-species diversity is well illustrated with work done by Bob Eckert, a forest geneticist at the UNH. Eckert has studied genetic diversity within populations of Atlantic white cedar, by examining 16 genes in eight different populations. Each gene had one or more alleles. He found that even though he was only looking at 16 genes there was genetic diversity within populations. There were different alleles for the same gene present in different individuals in the same population. Eckert also demonstrated that certain New Hampshire populations actually have unique alleles that don't occur elsewhere.

Another example that demonstrates within-species diversity is the pink lady slipper, a plant found in New Hampshire. It has a pink corolla in the south and a white corolla in other places. Since color is genetically determined there must be genetic diversity within this species.

Also there is within-species diversity in *Bison bison*. The plains bison show different morphological traits than other 'sub-species' of bison but all 'sub-species' can still interbreed. These differences in morphology are genetically determined, hence genetic diversity exists within the species *Bison bison*.

Finally, pitch pine, a tree that has an evolutionary history closely linked with fires, has different forms depending on fire frequency. Pitch pines in areas where fires are common are short and stubby and occur in the 'shrub' form. Cones of these tree are very different than the trees that aren't frequented by fire. Shrub form trees produce cones that don't open until fire disrupts them. Trees with a history of infrequent fire are taller and more robust, they reproduce later in life, and they don't produce cones that require fire for opening. These genetic differences within the pitch pine species are a direct result of the environmental affect of fire history.

These examples of genetic differences within one species are known as ecotypes. An <u>ecotype</u> is a locally adapted population within a species in which the genetic differences are due to natural selection. This is a very important kind of between-population genetic variation.

When discussing the implications of within-species diversity, care must be taken in a "Noah's Ark" approach since a population with a greatly reduced number will automatically lose much within-species genetic diversity. For example, the peregrine falcon that has been reintroduced successfully in some areas isn't the same as the native form found previously. The previous form is now extinct and the new type has been introduced from other genetically different stock. Careful evaluations need to be made in regards to within-species diversity if one doesn't want to lose genetic diversity.

Above the species level of biodiversity there are two approaches for consideration, taxonomic and ecological. Organisms are classified taxonomically in a hierarchical ladder. At the community level, two communities may each have the same number of species, or the same species richness. But at the higher level of genera, there may be fewer genera represented in one community than the other. There is less taxonomic biodiversity at that level of the hierarchy.

Genera that belong to the same family have more in common genetically than genera from different families. The biodiversity depends on the level of the classification hierarchy being considered. Two hypothetical tree communities can be used in an example. Community A has red oak, white oak, black oak, beech, paper birch, and sweet birch. Community B has red oak, sugar maple, sweet birch, hop hornbeam, white ash, and basswood, They have the same species richness; but at generic and family levels of biodiversity, Community B is more diverse taxonomically with more genera and families represented.

Some species are very different from other species. The Tuatara, a reptile in New Zealand, is very unique. In terms of genes this reptile has no close relatives and is, therefore, special. Perhaps the Tuatara is more important than one of a whole group of lizards which have very similar genetic material. When making decisions about what area to protect for taxonomic diversity, one area may have greater variety of species, but another may have fewer species with very different material.

Using an ecological approach, communities, or ecosystems, are classified into types which can be mapped for the region. The community types in the landscape can then be counted, demonstrating the diversity in that landscape. In southeastern New England the mosaic might include forest community types such as pitch pine-oak, oak-white pine, oak-beech, hemlock, beech-hemlock, and rich mixed hardwood. Generally in the East the diversity of species is high and the community level of diversity is low. In the arid West, generally the species level is low, but the diversity of communities is higher. Community diversity is important because communities often differ in the processes that go on within them. It must be recognized that different levels of diversity interact. For example, community diversity affects species diversity because some species, such as moose, need more than one community.

# Processes of Biodiversity

The next part of the meeting was a panel of speakers who presented the processes of biodiversity. The speakers were introduced by Laura Falk, a Forest Resource Planner for the N.H. Division of Forest and Lands. The panel discussed the processes that create, maintain, and reduce biodiversity: evolution, natural ecology and disturbance, and human impacts.

## ■ Evolution

James T. Taylor

*Taylor is Associate Professor in the Department of Zoology at the UNH. He is the author of The Amphibians and Reptiles of New Hampshire, published by the N.H. Department of Fish and Game.*

Evolution is typically viewed as something that has happened in the past as a historical science. However, evolution is a process that is happening today. Biodiversity is like a drama, comedy, or tragedy since "...it is an evolutionary play that takes place in an ecological theater." Any ecological process has the potential to be an evolutionary process as well.

Evolution is a change in the genetic variation in a population. This can happen by changes in chromosome number or by changes in the genes themselves. Evolution requires genetic variation. It's a population process which means that a viable (not too small) population must be present in order for evolution to occur. Evolution may result in new species, but may also result in new forms within a population (see Lee's discussion on within-species diversity above).

The processes that cause evolution to occur are mutation, migration, genetic drift and natural selection. Mutation is the source of genetic variation and new forms of genetic material appear because of it. Migration is the movement of genetic material between populations. The presence or absence of migration may lead to changes in genetic variation in any one area. Genetic drift is random changes in genetic variation and occurs only in small populations (i.e., endangered, rare, or threatened). Drift in small populations can quickly result in the loss of genetic variation. Natural selection is an ecological and evolutionary process defined by differential reproduction in various genetic forms. Individuals with more surviving offspring are selected for, and individuals with less surviving offspring are selected against.

Natural selection is environmentally directed evolution and the only ecologically directed evolutionary process. Processes of natural selection include adaptation and fitness. An adaptation is a characteristic that enhances an individual's ability to produce successful offspring. Fitness is simply the ability to produce offspring. "If you have higher fitness then you can produce more successful offspring than anybody else,...you may be weak, ugly, or stupid, but if you leave more offspring than anybody else you are more fit than they are."

An example of an organism that shows the results of natural selection included a waterbug that has an adaptation to carry its eggs around on its back. Individuals that do this have higher fitness than those that don't because more eggs survive as offspring if the parent carries them around on its back.

Two ecotypes exist within the garter snake species. New England and Oregon populations of garter snakes are genetically different as a result of natural selection. Both ecotypes eat salamanders. There is a highly toxic salamander found only on the West coast and snakes from the Oregon region can eat those salamanders. East coast snakes die when they eat the toxic salamander. This adaptation allows individuals to have higher fitness than those individuals without the adaptation. This ecotypic differentiation is an example of natural selection.

A final example shows how evolution is a current process. Timber rattlesnakes are highly specialized hunters with infrared sensors that detect heat radiation from potential prey. They inject digestive fluid into their prey. These are yet other examples of adaptations that have resulted in higher fitness for individuals through the process of natural selection. There are a variety of color morphs in this species including the yellow, beige, brown, black, and gray forms. This variety in morphology indicates within-species genetic diversity since color is genetically determined.

The only population of Timber rattlesnakes left in New Hampshire is made up of about 25 black-phase snakes. The presence of only one color morph in the population suggests that genetic diversity in this population has been reduced compared to other populations. There may be two explanations for the reduction in diversity. First, the black form could be the result of natural selection on the snakes, since black snakes may be able to be more heat efficient in the cold area where they are found. Second, the black form could be the product of genetic drift. The second explanation is probably more likely since the population is extremely small and the chances of random loss of genetic diversity are great. The potential for at least one process of evolution, migration, has been eliminated for this population. Migration won't occur because the population is too small and other populations are too far away for migration to be remotely possible. Members of this population of snakes are already exhibiting signs of reduced genetic diversity that occurs because of genetic drift in small populations. Some animals exhibit birth defects associated with the reproductive tract while others show coloration defects such as albinism.

In conclusion, the above example illustrates how evolutionary processes are now occurring. It's important to talk about evolutionary processes in reference to biodiversity and to its management, since these processes affect populations in the past, present, and the future.

## Natural Ecology and Disturbance

Charles Cogbill

*Charles Cogbill is a "freelance academic" and an ecological consultant with Sterling College, Vt. He has been a forest ecologist for 30 years, studying the montane forest and working extensively with the Hubbard Brook Long Term Ecological Research Project. He is a member of the recovery team for the alpine endangered species in the White Mountains, and he has done 20 years of research on acid rain and its effects on red spruce.*

Forest communities demonstrate chaotic change that can be predictable only at certain scales. Dynamic change over time occurs from place to place. Biodiversity in forest communities does not scale up easily, because the processes at one level are different from the processes at another level. The amount of information about diversity that can be gained from the satellite image of New England is very different from the more detailed information that can be gained from a photograph of Franconia Ridge in New Hampshire. The photograph showed evidence of processes such as fire, wind disturbance, regeneration, and soil disturbance not shown in the satellite image.

Biases exist with some forest ecologists who work with communities. Forest systems are dynamic and spatially complex so they must be approached at levels larger than the species level. The accepted paradigm that communities are predictable sequences and demonstrate 'succession' isn't useful.

The Hubbard Brook Experimental Forest is a case study that shows how things may not always be what they seem in communities and how applying the succession paradigm to certain systems can be misleading and counter-productive. Hubbard Brook is regarded as the world's best and most well documented example of pattern and process in an ecosystem. It was believed Hubbard Brook was an example of natural processes at work in an old, undisturbed, pristine, steady-state forest. More recent work has shown that this isn't true because Hubbard Brook actually has a history of land-use including cutting of small trees and clear-cuts. This history of disturbance occurred at different intensities in different places. The philosophy has changed as researchers realized that Hubbard Brook had a site specific land use history.

Unless all possible scales and processes of diversity are taken into account, the wrong conclusions can be made. Forest communities are chaotic and only predictable at certain scales. Understanding the past is important for predicting the future. The paradigm of succession must be used with caution since most systems are dominated by disturbance rather than stability.

## Human Impacts

John A. Litvaitis

*John Litvaitis is Associate Professor in the Natural Resources Department at UNH. Litvaitis focuses his research on wildlife ecology.*

There has been a long history of human impact on natural communities. Human impact may be very different from natural disturbance by altering species composition in a variety of non-natural ways. These impacts include disruption of historical small scale fires, and removal and/or addition of animals like beaver or large herbivores. Suburban housing lots, large cities, agriculture and forest management each contribute in different ways to impact on the local biodiversity patterns of a system. Recent thinking on avoiding problems of human impact suggests creating human disturbance that mimics natural disturbance.

Historical human disturbance can have lasting effects on community structure. About 100 years ago there was large scale agriculture in the Northeast so nearly all of the forest was removed. Most of the forest we see today is second growth. In the 1900's to 1940's, most of the forest was going through an early successional change. The New England cottontail prefers this type of community and experienced an increase in its population at this time. In the 1960's, however, the early successional community began to be replaced by a different community type. This caused a dramatic change for a suite of early successional species. The New England cottontail declined and so did the bobcat, which relies heavily on rabbits as a food source. Bobcats, of course were also in decline because of bounties, pelt acquisition, and coyote colonization. Song birds also declined dramatically. This entire sequence of events was directly related to the fact that the forest had been entirely cleared 100 years earlier.

Today, forest fragmentation can have a tremendous effect on community structure and diversity. Forest fragmentation in the last two decades has been extensive. There has been a great increase in the human population and a corresponding decrease in the surrounding forest communities. When habitats are reduced, the remnant patches become isolated. These small patches are very susceptible and corridors between patches are extremely important.

Data on the New England cottontail demonstrate how reduced patch size can have a large effect on community structure. Larger patches have larger numbers of animals but smaller patches have relatively fewer animals. Smaller patches tend to have male biased sex-ratios. Animals found in small patches are typically in poor physical condition. These animals are in areas where predation is an increased threat since patch size is so small. Behavior of the animal actually changes since it must forage in a risky habitat. This predation risk may be related to the 50% reduced survival rate in overwintering animals in small patches (as compared to large patches). These data suggest that predators take advantage of a highly fragmented environment and that predators occur in higher frequency in these sorts of environment. It's important that "...we offset or mediate the effects that we have generated with these large scale changes."

# Assessment of Biodiversity

## Aquatic Systems

Michele Dionne

*Michele Dionne is Research Director of the Wells National Estuarine Research Reserve in southern Maine. She has studied freshwater and marine systems at several institutions, including, most recently, post doctoral studies at Virginia Tech. Dionne is particularly interested in monitoring aquatic systems using an index of biotic integrity.*

The need to monitor aquatic systems is made evident by issues of human impact. Human activity upland affects diversity of both freshwater and marine systems. Laws and regulations of local, state and federal governments require protection and monitoring of aquatic systems. Measurement of change indicates what has been accomplished by regulation and protection. The Index of Biotic Integrity is the most well recognized and useful tool for monitoring biological systems. Developed for use on freshwater systems in the Midwest by James R. Karr, the index has been adapted for use in salt water systems in the Northeast.

Threats to aquatic biodiversity are habitat loss/degradation, exotic species, exploitation, chemical and organic pollution, climate change, and secondary extinction (refers to change in species due to human effect on other species). In the Northeast, habitat degradation is influenced by forestry, water control, agriculture, industrial effluent, and residential development. Aquatic systems seem to be more threatened than terrestrial systems and are less well studied. Human induced effects are directed at those factors which influence aquatic systems: energy source, water quality, habitat quality, flow regime and interactions between species.

Biotic integrity equates with biodiversity. Ecosystems are composed of elements and processes.

Components of biological diversity include elements or structures (genes, population/species, communities/ecosystems, and landscapes) and processes or functions (nutrient cycling, photosynthesis, water cycling, speciation, competition/predation, and mutualisms). The Index of Biotic Integrity (IBI) was designed to assess chemical, physical and biological aspects of aquatic ecosystems. There is no one way to measure all of those aspects so the index incorporates twelve metrics. Using insects, species richness and composition, trophic composition, and abundance and condition are measured and then compared to a benchmark.

Because the IBI is a multi-parameter, information- rich approach, it increases the ability to document the ecological health of the system. Each parameter has a different sensitivity to different kinds of human impact or disturbance. The index can track or monitor change better than a single indicator and is sensitive to different levels of degradation. It leads to biologically meaningful evaluations. It's flexible for special needs and its results are easy to relate to the general public.

## Terrestrial Systems: Natural Heritage Program

David Moore

*David Moore is the coordinator and botanist for the New Hampshire Natural Heritage Inventory. He held a similar position in Missouri with the Missouri Natural Heritage Program before coming to New Hampshire.*

State Natural Heritage Inventory programs were set up by The Nature Conservancy. The New Hampshire Natural Heritage Program is actually part of an international data base of conservation information. The mission in the Natural Heritage program is to preserve and protect endangered plants and animals by protecting their natural communities. This mission is necessary in today's world because the planet is experiencing the greatest species decline since the massive extinction that occurred with the demise of the dinosaurs. Loss of species diversity on this planet is similar to losing rivets on an airplane. The plane can do without some of those rivets, but if it loses one too many the whole craft falls apart. The Natural Heritage Inventory works as a kind of early warning system that sounds off when too many 'rivets' have been lost from the Earth 'aircraft.'

The conservation network set up by the Natural Heritage Inventory is based on the principle of gathering and disseminating important data. This conduit of information is accessible to academics, professionals, and to the general public. Species are ranked according to rarity by collecting data from a variety of sources. First, rare species are identified scientifically. Next, the Inventory program examines historical records and compares them to data on species distribution and abundance. Finally, the Inventory program gathers information from experts on particular species or communities. This information is compiled and then mapped. The data collected are dynamic rather than static, since the information available on distributions and abundances of species is always changing.

These compiled data can be used for land use planning, resource extraction planning, and biodiversity management plans. The information stored by the conservation network is available on a voluntary basis. In 1988 the conservation network responded to 100,000 information requests. By 1993, there were 300,000 requests. There are examples of endangered species in the data base which include the Karner blue butterfly, the wild lupine and the small whorled pogonia. There are also threatened communities listed such as the alpine zones of New Hampshire. These examples of decline in diversity demonstrate the need to protect diversity and to use the Natural Heritage Program as a stewardship vehicle. "Do we have the right to take away biodiversity from future generations...from our children?"

## Terrestrial Systems: Diversity in New Hampshire

John Kanter

*John Kanter is the Non-game and Endangered Wildlife Coordinator for the New Hampshire Department of Fish and Game.*

A broad yet specific overview of biotic richness in New Hampshire is useful when assessing levels of terrestrial biodiversity. Patterns of vertebrate diversity in New Hampshire are perhaps best known. There are about 500 species of vertebrates (including fish) in the state. There are 200 bird species, 60 mammal species, 22 amphibian species, and 21 reptile species. Some of these species are ubiquitous, while others are rare and require very specific habitat types. Ten vertebrate species are listed as endangered at the state level, three of these are listed as federally endangered.

Bird diversity has been regularly monitored by the Fish and Wildlife Department and by the Audubon Society. Since at least 1980 there have been declines in bird species richness. New Hampshire has lost at least two of its mammal species, the timber wolf and the mountain lion while it has gained coyotes. Because wolves and lions were exterminated, the coyote was able to move in and occupy this predatory 'niche.' Pine martens, another mammal species, are on the state's threatened species list. Timber rattlesnakes in New Hampshire are listed as endangered and since the only known population consists of less than ten slowly reproducing adults, the snake will almost certainly become extinct in the state (see Taylor's discussion above). Wood turtles have been proposed for federal listing. They occur at very low densities, probably as a result of the top dollars paid for them in the international pet trade.

There is almost certainly a decline in amphibian species but there are no hard data yet to support the anecdotal evidence. A program through the University of New Hampshire is currently being developed to address this lack of data. Jim Taylor will organize volunteers to go out and assess the distribution and abundance of amphibians in the state. Another program, run by the Audubon Society, uses volunteers to assess the presence and diversity of vernal pools, the temporary ponds of freshwater required by a variety of amphibians.

Patterns of invertebrate diversity are less well known, probably because there are many, many more species of invertebrates than vertebrates. In New Hampshire there are 12,000 known species of insects alone, with another 3000-4,000 insect species that have not yet been identified. Even so, some of these species are dramatically rare. New Hampshire has the only known occurrence of the Karner blue butterfly. Butterflies and moths that live in the pine barren habitat are becoming rare since this habitat type is declining. The tiger beetle is another state-listed insect.

Kanter concluded his presentation with an important suggestion of the conference. He briefly discussed the newly-formed group, the New Hampshire Scientific Committee on Biodiversity (NHSCOB) and outlined its mission. The NHSCOB is in the process of designing a primer that illustrates the processes that cause and affect biodiversity and that gives an overview of the status of genetic, species, and community diversity in the state. It's vitally important to expand this sort of model and to set up scientific technical committees to coordinate monitoring efforts. These programs would require time and money. Funding of such committees could include the revenue from conservation license plates that may be made available in New Hampshire. This revenue could be used to fund scientific monitoring programs at the state level. Wildlife diversity funding initiatives and the recently proposed surcharge on wildlife appreciation products could also generate revenue.

## Landscape Level

Marie-Louise Smith

*Marie-Louise Smith is a research ecologist for the U.S. Forest Service. She is pursuing her PhD at the University of New Hampshire.*

Assessment at the landscape level is important because there are certain limitations to the species level approach. These limitations include: 1). Only some species out of the total present are even known, 2). Little is known about the life histories of many species, 3). It is likely that the lesser known organisms carry out important ecosystem functions, and 4). Assessors may miss important ecological processes.

It's necessary to focus on assessment at the landscape scale since there are repeatable patterns of physical environment, human impacts, and habitats. We need to consider space and time as well as species since "...content (species) can't be considered more important than context (time and scale)."

Species assessment can be an effective tool for focusing on biodiversity. Since humans relate well to human spatial and temporal scales, vertebrates are useful species for such a focus. Vertebrates also make good indicators of environmental quality, are good attention getters, and can serve as legal levers that focus attention on ecosystems in need of help. However, "...we don't need to wait until things (species) are in poor shape and have become 'indicators.'" The landscape level approach might be a more realistic and meaningful approach in assessing diversity in biological systems.

There are two ways to assess biodiversity at the landscape level. The first assessment system is the Wildlife Habitat Management Units (WHMU). This program uses three main components of assessment to come up with the proposed management units. Assessment of content, for example, gathers data on species habitat use and preference. The habitat uses are then grouped by community type. Second, context assessments address the ecological land types with a consideration of the spatial requirements of species within their community type. Finally, monitoring of indicator species is performed at a variety of spatial and temporal scales. The data compiled through these three components are integrated, and appropriate habitat management units proposed.

The second way to assess landscape level biodiversity is the Ecological Land Classification and Mapping Framework (ECOMAP) created by the U.S. Forest Service. ECOMAP is a hierarchical framework to stratify Earth into increasingly smaller units of increasingly uniform ecological potentials. A unit in this case means a biophysical division. Biophysical elements are physical elements that seem to influence biotic elements. Basically, physical characteristics are used to construct the units. Units are defined at a variety of spatial scales from extremely large (many states) to very small (local/regional). ECOMAP doesn't follow political boundaries as many other resource maps do.

# Goals and Decisions for Management

Kathryn Staley

*Kathryn Staley is the Strategic Planner for Aquatic Resources for the U.S. Forest Service in the White Mountain National Forest.*

E.O. Wilson said, "A knowledge of biodiversity will mean nothing unless there is a motivation to use it." Today this is the case. There is a need for ecosystem and biodiversity management and, "...we must manage ourselves." Five points relevant in making decisions and goals for the conservation of biodiversity are: 1). People must cross jurisdictional and functional boundaries in order to share expertise, to teach different capabilities and to encourage diverse viewpoints. 2). This information exchange and management must go on regardless of election results. 3). Management must include the design, interpretations, and interpretation of decisions. 4). Decisions must be made using the best and most accurate science. 5). People must be aware that what goes on in backyards can affect biodiversity there and elsewhere.

# Small Group Discussion

After Staley's talk, participants broke into small groups to discuss goals and decisions for management. There were two questions participants were asked to think about and discuss in relation to management decisions: 1). How do we, in a democratic society, set landscape-level goals for biodiversity? For example, how might we decide whether the goal is to maintain current native diversity, return to "1640" diversity, or maintain current native-plus-introduced diversity? 2). How do landowners set biodiversity goals for the management of property, and how can they manage to further society's landscape-level biodiversity goals? These questions were intended to encourage adoption of the terms, ideas, and concepts from the presentations for management of biodiversity. The small groups reported their discussion to the whole group. One group recorded their responses to Question Two. They are listed here as representing some of the discussion which took place. Gerald Lang of the Natural Resources Conservation Service recorded and submitted the notes.

1. First, economics drives most landowners' goals, but many are also interested in "doing the right thing."

2. In some parts of New Hampshire, the real issue should be in trying to save the land from being fragmented by development, rather than managing the natural resources. Concern over what type of timber harvesting method is used has less importance if the land is being converted to houses.

3. We need to explain the overall environmental big picture in terms local landowners can understand and see the possible impacts on themselves and their future generations. They need to know their options for using their land with minimal impacts to the regional environment and ecosystem.

4. We need to educate landowners and specifically work with those who have expressed an interest in "doing the right thing" by maintaining the wildlife habitat and biodiversity on their land.

5. We need to be sure the technical professionals understand what landscape-level biodiversity goals for an area are, how they may be changing, and how an individual's use and management affect these goals.

6. We could use cost sharing or other incentive programs to encourage landowners to manage their land to meet society's goals.

7. We could set up tours and workshops to show what some landowners interested in biodiversity have done as examples for others.

8. It also would be good to reserve natural, unmanaged areas for long term comparison to managed woodlot areas throughout the state.

# Where Do We Go From Here?

The Biodiversity Principles and Applications Conference for Natural Resource Professionals in New Hampshire was in many ways a starting point. It was an opportunity for a variety of professionals to come together and to learn about the terms, definitions, concepts and assessment of biodiversity. This sort of detailed baseline knowledge is necessary for effective management of biodiversity. The next steps must include the integration of this information into resource management plans and programs to make them realistic and meaningful.

As professionals, we must take the initiative to apply what we learn here to our own areas of expertise and to work with and support scientific and technical committees formed to design effective management plans. We must be able to think across jurisdictional boundaries during this process. We should seek more detailed and informative data on how biodiversity in different systems is created and maintained. We can gather strength from our collective experience and vantage points to break new ground in the effective management of biodiversity.

## The Natural Resource Network Research Reports

The Natural Resource Network presents this material as a part of a series of research reports and publications of interest to educators, resource professionals, landowners and the public. Additional copies are available from the University of New Hampshire Cooperative Extension Publications Center, 120 Forest Park, UNH, Durham, NH 03824.

The mission of the Natural Resource Network is to enhance interaction among the natural resource research, teaching, and outreach communities in New Hampshire by providing an ongoing mechanism for identifying, addressing and communicating natural resource issues.

Natural resource professionals are working toward improved ways to conserve and use the natural resources of New Hampshire. The Natural Resource Network was formed to improve the interaction among researchers and those who provide outreach education in many kinds of programs. Teachers, outreach professionals and resource managers can bring research-based education to diverse audiences. At the same time, those audiences, or consumers, identify issues and needs for educational programs which can be addressed by controlled research. Well informed and knowledgeable professionals, free-flowing exchange of information, an advantageous and gratifying professional environment, and natural resource planning are goals of the Natural Resource Network.

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