Albemarle County Biodiversity:

A Report on its History, Current Conditions, and Threats, with Strategies for Future Protection

Prepared by the Albemarle County Biodiversity Work Group
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PREFACE

This report focuses on one of the mandates of Albemarle County's Comprehensive Plan: to preserve and restore the County's biological diversity (hereafter, "biodiversity"). To that end, we first define biodiversity concepts, outline the guidelines for protection, and review the history of and threats to biodiversity in the County. We then provide a road-map for achieving biodiversity protection, by identifying key areas, services, and species/community groups to preserve. We emphasize a need for education at all levels about the importance of biodiversity. Lastly, we make recommendations to the Board of Supervisors concerning the establishment of the standing Biodiversity Committee called for by the Comprehensive Plan, and to that committee about strategic steps to take in order to study, monitory, preserve, and restore the County's rich biodiversity.

The mandate for conservation of "Biological Resources and Biodiversity" is given in Chapter 2, "Natural Resources and Cultural Assets", of the Albemarle County Comprehensive Plan, as follows:

> **GOAL:** Recognize the importance of protecting biological diversity in both the Rural Area and the Development Areas for the ecological, aesthetic, and economic benefits to the community.
>
> **OBJECTIVES:**
>
> • Increase the community's awareness of the importance of biodiversity to encourage protection of biological resources;
>
> • Through a Biological Resources Inventory, develop a systematic knowledge of the types and distributions of biological resources in Albemarle County, and develop an understanding of the requirements of our living systems;
>
> • Conserve ecological communities to ensure their continued genetic diversity, and protect ecosystems that provide essential services to humans.

A standing Biodiversity Committee is to be established to carry out this Goal and Objectives. To set the stage for this Committee, a temporary Biodiversity Work Group (BWG) was initiated in early 2002 and was given the charge "to advise and coordinate in the development of a Biological Resources Inventory and to issues related to biological resources in the County."

The Comprehensive Plan states that the tasks of the Committee would be to:

1. develop public education materials on biodiversity;
2. develop methods for and oversee a Biological Resources Inventory to be conducted for the County;
3. solicit regional cooperation among nearby counties in collaborating on a regional inventory;
4. determine criteria for identifying the types of biological resources to be inventoried;
5. assess prospects for donations to the inventory of time, expertise, or other resources from the community, including the University of Virginia;
6. evaluate methods of conducting the Inventory;
7. recommend one or more approaches for conduct of the inventory to the Board of

Supervisors, with estimates of costs;

8. assist staff in developing an action plan that specifies detailed steps for achieving protection of Biodiversity as outlined in the Comprehensive Plan; and
9. provide periodic reports to the Board of Supervisors on the state of biodiversity in the County.

The Biodiversity Work Group has begun much of this work, and has suggested revisions both to its own task list and to the task list for the standing committee in order to clarify goals and set realistic standards. These revisions are intended to help the County achieve the same ends called for by the Comprehensive Plan, but with more clarity and efficiency. The following are the revised tasks taken on by the Work Group:

Table A: Biodiversity Work Group Tasks

Original Work Group Tasks	*Revised Work Group Tasks*
Develop methods for and provide expertise and guidance in developing a Biological Resources Inventory for the County	Inventory and collect currently-available biodiversity data.
Determine criteria for identifying the types of biological resources to be inventoried	Identify biodiversity data gaps, prioritize data needs, and develop a general strategy for addressing data gaps and achieving an assessment of the state of biodiversity in the County. Identify a structure for an ongoing, constantly-updated assessment of biodiversity resources to be adopted into the Comprehensive Plan, with an estimate of costs.
Evaluate methods of conducting the Inventory	
Recommend one or more approaches for conduct of the Inventory to the Board of Supervisors, with estimates of costs	
Assess prospects for donations to the Inventory of time, expertise, or other resources from the community, including the University of Virginia	Assess prospects for donations to the Inventory of time, expertise, or other resources from the community, including the University of Virginia
Provide time, data, and other support to assist with completion of the Inventory	Provide time, data, and other support to assist with establishment of the foundation of a County-wide biodiversity assessment.
Assist in development of preliminary materials for public education on biodiversity	Assist in development of preliminary materials for public education on biodiversity
Make recommendations regarding the size, composition, and necessary expertise for the permanent Biodiversity Committee	Make recommendations regarding the size, composition, and necessary expertise for the permanent Biodiversity Committee

This Report represents the completion of over two years of work by the Work Group.
The BWG interpreted its charge broadly, using the following principles. First, biodiversity is

interpreted, as stated in the Natural Resources and Cultural Assets Plan, to incorporate all living things, from genes to species to communities, ecosystems and finally, entire watersheds. Second, biodiversity is essential for the functioning and health of ecosystems and for provision of the ecological services on which all living organisms, including humans, depend. Third, the wellbeing (an term encompassing the economic, ecological, and aesthetic/spiritual condition) of Albemarle's citizens is directly related to the diversity and health of Albemarle's environment. Fourth, while biodiversity has aesthetic and economic values, its protection is also an ethical responsibility.

The Natural Resources and Cultural Assets Plan stresses the development of an "Action Plan" for achieving the aforementioned Goal and Objectives, and recommends that the Biodiversity Committee implement this Plan using the information obtained from the biological resources inventory. The BWG wishes to stress that the dictionary definition of "inventory" as a static "catalog" does not strictly apply to living systems, which are "moving targets" in continual flux. Furthermore, the BWG recognizes that decisions concerning conservation and maintenance of living systems will be made in a complex political sphere with changing conditions and priorities. Establishing goals for preserving key ecosystem components in a region undergoing rapid development with a citizenry having different value systems will be a considerable challenge. A biodiversity assessment provides a critical databank for proper decision-making, but one that is constantly changing, is never 100% complete, and has some degree of uncertainty. An assessment will never to be sole guide to "correct" decisions, and the Work Group recognizes that decisions are often made with incomplete biological information. Nonetheless, as information accumulates, models can be developed from existing data to fill in the gaps.

Following this Introduction, the structure of this Report is as follows:

- Section II reviews concepts and principles critical to biodiversity conservation, including ecosystem health, which then provides the context for the remainder of the Report. The central theme is that a large-scale approach to protection (i.e., large habitat blocks, entire watersheds, etc.) is key to preserving both services and species, rather than using a piecemeal, species-by-species approach.
- Section III provides a thorough review of the ecological history and threats to biodiversity protection within Albemarle County. This reveals the level to which current biodiversity has been reduced since the colonial era, and frames the question of how much biodiversity is possible under current and future human impact scenarios.
- Section IV reviews methods for assessing and monitoring both species and ecosystems.
- Section V describes the current state of biodiversity in the County and reveals the extent (or lack) of our knowledge of the distribution, abundance, and trends of most of the County’s natural resources. These resources include both the species/community entities as well as the larger ecosystem elements of concern such as wetlands, stream corridors, large forest tracts and other “important sites” from a geological or biological perspective.
- Section VI focuses on education and outreach, one of the most important tools in demonstrating the value of biodiversity to the public at large. Educating the adult public – the citizenry, legislators, and planners – as well as through conventional school curricula is critical.
- Last, Section VII makes recommendations at several levels: to the Board of Supervisors,

we recommend how the Standing Committee should be comprised; to the Standing Committee, we make a series of recommendations for how such a committee should develop a strategy for long-term conservation of biodiversity in the County, and what some tactics might be to achieve this, and last, we suggest what the immediate needs are as "band-aid" measures to protect biodiversity, recognizing that precious time may pass while the Standing Committee is formulated and becomes fully engaged and functional.

- An additional document contains the Appendices, which include the longer lists and tables referred to in this report.

BACKGROUND AND GUIDELINES FOR BIODIVERSITY CONSERVATION

Aldo Leopold stated in his classic *Sand County Almanac* what has become the guiding principle for modern conservation: “To change ideas about what land is for is to change ideas about what anything is for... To keep every cog and wheel is the first precaution of intelligent tinkering.” The following guidelines are intended to express the implications of Leopold's words through the lessons from ecology and population biology and to derive conclusions regarding sound biodiversity conservation strategies.

Fundamentals of Ecosystems

In the abstract, “biodiversity” can include all the natural diversity of an area, whether or not the genes, organisms, or habitats are native to that place or representative of healthy natural systems. In this report, our focus is on biodiversity that is natural for its location. Protecting biodiversity in this manner requires a landscape context built on healthily functioning native ecosystems. This makes it important to understand what ecosystems are and how they function.

Ecosystems

Ecosystems--short for "ecological systems"--are fundamental units of nature. They range in size from small wetlands, meadows, or forest patches to watersheds and entire ecological regions. But ecosystems of any size share defining factors--they occupy a defined place, they continue through time, they take in materials and energy and let out heat and wastes, and they include interacting habitats and organisms.

But ecosystems are more than a collection of parts. It is the way in which the related parts function that forms the system--in much the same way that the parts of a machine must interact for the machine to function. The major differences between machines and ecosystems are found in their complexity and their predictability. Machines have been called "organized simplicity," in which actions and reactions are predictable, while ecosystems represent "organized complexity," in which series of random events can lead to a huge number of possible results. And as a system gains more parts and processes, complexity only increases.

Ecosystems are highly complex because of the dizzying array of biodiversity, physical parts, and processes they contain. It is precisely because of this complexity that keeping all the "cogs and wheels" is essential for any attempt to achieve sustainability. For any system, it is essential to understand what parts may be removed or changed before the system is unable to function.

Ecosystems operate at many scales of time and space. Further, they are structured hierarchically--any ecosystem can contain smaller ecosystems, and can be one of many systems contained by a larger system. (A forest might contain smaller wetlands, patches of different forest types, and streams, but also form part of a larger river watershed containing other forests.)

The most important consequence of this structure is *constraint*--meaning that the behavior of any ecosystem is limited by the behavior of its components. Some constraints are imposed by species. (For example, an introduced exotic species might threaten extinction of other species, thus fundamentally altering the biological community and the functioning of the ecosystem.) Another example is habitat alteration by human activities, such as dam-building or deforestation, which fundamentally alter stream flows, groundwater recharge, quality of light for plant growth, and many other factors in ecosystem function.

The hierarchy of ecosystems is easier to see if you group environments into classes reflecting their extent in time and space. In Albemarle County, for example, the landscape can be seen as nested groups of watersheds of various sizes. At the highest level of organization, the Rivanna, James, and other major watersheds--each of which is readily outlined on a map--can be seen as the largest units of ecosystem organization within the County. These often occupy tens of thousands of acres. The next smaller level is that of individual landscape units. These areas include many individual habitats, which provide for the ecological, behavioral, and genetic interactions among species.

Within the hierarchy of ecosystems, it is a truism "everything is connected to everything else." Of course, some connections are stronger than others, but untangling the webs of ecosystem complexity is extraordinarily difficult. This means that altering those connections carelessly can have wide-ranging and possibly irreversible impacts. We know from scientific study and practical experience that changes at any level of ecosystem organization can stabilize or disrupt other levels. At the community level, this can occur when a change in one species transmits changes to other species that, in turn, may affect a chain of events in others. A change carried out for one purpose will often have multiple unintended consequences.

Historically, Albemarle County, together with much of the eastern U.S., has lost large predators (wolves, cougars, etc), resulting in an increase of smaller predators (raccoons, feral housecats, etc.), with potentially devastating consequences for ground-nesting birds, lizards, snakes and others, which can be accompanied by an explosion of small rodents and insect pests — and so on down the line. In another example, deforestation has often increased erosion, leading to sedimentation of streams and serious degradation of aquatic habitats, which result in significant changes to the species found in our streams. Other such "top-down" cascades of events are mentioned later in this document. "Bottom-up" cascades are also possible, for example when forested areas are cleared of underbrush, resulting in depletion of insect-eating birds, followed by an increase in insect pests that can have serious consequences for the forest itself.

Ecosystem Health

The "health" — that is, the efficient functioning and sustainability — of an ecosystem depends on the interrelationships among its components, at all scales from watersheds to species populations. As described above, these relationships can be difficult to document and predict. The best insurance against loss of ecosystem health is to guard ecosystems at all levels, with their biodiversity intact. Cascades of negative effects, mentioned above, are particularly difficult to predict, but, in fact, not all cascading relationships are negative. Those that have evolved over long time periods are a natural feature of healthy ecosystems, and give rise to properties of resiliency, persistence, and health. These positive relationships must be distinguished from the perturbations of inappropriate human development, unnaturally rapid species depletions and extinctions, and introductions of exotic-invasive species.

Ecological concepts that apply to top ecosystems are:

- **Resistance** is a system's ability to maintain its structure and/or behavior under conditions of stress.
- **Vigor** may be measured by productivity or throughput of materials and/or energy.
- **Resilience** is shown by a rapid rate of return to former conditions following system change.
- **Persistence** is a measure of continuance of some characteristic of a system through time.
- **Organization** may be assessed by comparing the diversity of components, their degree of mutual dependence and interactions at different time and space scales.

Biodiversity plays an essential role in all of these aspects of health. However, whether species-rich environments are more "healthy" (or "stable") than relatively species-poor ones depends on the nature of the systems themselves in terms of their developmental and evolutionary history.

The concept of "health" therefore involves recognition of what is "natural" for a particular ecosystem to be sustainable. Because ecosystems can adapt to stress and change, no static "inventory" of all components at any one time can describe an ecosystem under all conditions throughout time. One of the essential features of conservation, management, or planning for a healthy environmental future is to preserve and maintain biodiversity in all aspects, so that ecosystems' ability to adapt and thrive is not degraded. This involves adoption of the "precautionary principle," meaning that actions should do no harm—the same principle as applied to human health.

Communities, Species, and Genes

Where a number of distinct species can be grouped based on similar uses of habitats and by close interactions, they are considered a "community." For instance, a mixed-hardwood forest might consist of 8-10 species of trees in Albemarle. Communities can comprise many species populations that depend for their diversity and interactions on the higher-level diversity of ecosystems.

Some species may have considerable influences on ecosystem conditions; examples include those species that browse or graze on vegetation (such as deer, whose currently elevated populations change forest structure by denuding forest understories), or the vegetation itself, which can affect microclimates. Thus, species present in a community in part reflect possibilities offered by the physical environment, but also may create alternative conditions. Close ecological linkages also develop *among* species, through specialized predator-prey, parasite-host, and plant-pollinator relationships, all of which can produce strong interdependencies among species. Thus, decimation of one species in close relationship with other ecologically linked, dependent species can cascade into entire communities and into changes in ecosystem properties.

In Albemarle County, many naturally-occurring factors have spatially divided regional and local species populations, including:

(1) environmental divisions into a patchwork of habitats, with only some patches suitable for a species of interest;
(2) isolation by distance, whereby many organisms live in small neighborhoods within their total range, unable to move due to energetic costs and risks of movement; and
(3) division of the landscape by animals into territories and home ranges.

These factors all strongly influence how genes are distributed among species populations. Isolated populations eventually become genetically quite different from other nearby populations, due to natural selection (changes in reaction to local conditions), random genetic drift (chance variations in frequencies of genes transmitted from one generation to the next), and series of random mutations. In contrast, populations that can easily meet are often quite genetically very similar, due to flow of genes carried by pollen, seeds, or individual organisms.

Restricted gene flow among populations has consequences for a species' ability to adapt and pass genes on to future generations. Isolation can limit a population's ability to adapt to environmental change by increasing the chance of inbreeding (which brings out rare and sometimes maladaptive genes), and by limiting opportunities to exchange genes with other populations. Gene flow among populations reduces inbreeding and leads to a sharing of genetic variations that can be valuable in adapting to changing conditions. (On the other hand, gene flow can disrupt selection for traits particularly valuable in the local environment of a population.)

Furthermore, landscape connections influence a species' prospects for long-term persistence in an area. Small, local populations are particularly vulnerable to being wiped out by bad luck (e.g., chance encounters with predators) or exceptional difficulties (e.g., long drought). If, however, such a population is connected to others nearby (in a group known as a "metapopulation"), immigration from neighboring populations may create a new population in the same area occupied by the one that went extinct. Local extinctions, followed by replenishment by neighbors, are believed to be regular events in regional populations of some species. However, if nearby populations do not exist or cannot reach the area, replacement of the extinct population will not occur.

When blocks of habitat are fragmented (as is occurring throughout Albemarle County), connections between populations are degraded or severed. This disconnection is regarded as a major threat to species diversity, because it alters fundamental genetic and demographic processes, and can lead to extinction of some populations. If connections are maintained, subpopulations that go extinct can eventually be replaced as neighboring populations expand into their range. The primary strategy that has emerged in conservation biology for providing connectedness among subpopulations is creation or maintenance of corridors that link large, intact blocks of habitat.

Considerable evidence exists that landscape features and their spatial arrangements influence survival of plants and animals. First, large contiguous blocks of habitat (perhaps greater than 5,000 acres) reflect the conditions under which native species have evolved and have sustained themselves. The black bear is one example of this type of native animal. Large habitat blocks also support large populations less likely to go extinct through a run of bad luck, and some require habitats (such as forest interiors) that occur only within large habitat patches. Second, corridors of native vegetation connect larger patches of habitat, facilitating species dispersal from one patch of habitat to another; such movements reduce inbreeding and permit replenishment of subpopulations. Third, habitat buffers along streams and rivers provide migration corridors for aquatic and wetland species.

Species communities, much like ecosystems, vary greatly in spatial scale, from a few meters to thousands of miles. It follows that only by planning at multiple scales can such a spectrum of biological phenomena be preserved.

Ecosystem Services

The services that healthy ecosystems, with a diverse complement of species, can provide are many and extremely diverse. The term "service" is meant here as a contribution to human welfare. Unfortunately, neither economic theory nor social planning has historically taken ecosystem services into account. Recently, however, this situation has changed dramatically following examples of catastrophic economic consequences when ecosystems are not fully taken into account as part and parcel of human activities at all levels.

The scientific literature is now replete with descriptions of how healthy ecosystems provide welfare to human societies. Daily (1997) lists the following "conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life":

- purification of air and water
- mitigation of floods and droughts
- detoxification and decomposition of wastes
- generation and renewal of soil and fertility
- pollination of crops and natural vegetation
- control of the vast majority of potential agricultural pests
- dispersal of seeds and translocation of nutrients
- sources of crop varieties, medicines, and industrial enterprise
- protection from the sun's harmful ultraviolet rays
- partial stabilization of climate
- moderation of temperature extremes and the force of winds and waves
- support of diverse human cultures
- provision of aesthetic beauty and intellectual stimulation that lift the human spirit.

Human societies ignore these services at their peril, as some historical civilization declines have illustrated. Fragmentation of habitat, replacement of forests and fields with lawns and pavements, exotic species, and feral pets all provide documented examples of how loss of species and ecological functions impinges on the services of nature and the wellbeing of the human population. Most of these examples have been documented elsewhere, but provide warning signs for Albemarle County, where warning signs are emerging.

Scientific understanding of ecosystems and how they provide services is incomplete, but has advanced enormously during the past century. These services are still poorly understood among the public. A major purpose of this document is to address this lack of awareness and knowledge, and to provide the County with suggestions for addressing the connection between biodiversity conservation and the welfare of Albemarle's citizens (see Section V on biodiversity education).

Approaches to Protecting Biodiversity

Public Awareness of Biodiversity

Perhaps the largest challenge or constraint in effecting land use policy change is public awareness and attitude. Albemarle County has already identified biodiversity protection as a legitimate and important goal through its Comprehensive Plan. However, in order to work toward that goal, citizens and their representatives will need a sound understanding of ecosystem functions and the character of the County's biodiversity. This understanding is the foundation of consensus on desirable and effective biodiversity protection programs and how they relate to other public policies and decisions.

Protection of Biodiversity

Given the inherent complexity of ecosystems discussed above, it becomes clear that protection of habitats and ecosystems before they are degraded is a top priority for a biodiversity program. A biodiversity assessment, like the one begun by this report, is the first step. Once important areas are identified at various scales—from landscape-scale habitat connections to individual occurrences of rare species—then a conservation program can begin to prioritize and implement protections before those areas are degraded.

Restoration

Both remediation and restoration are actions taken after damage, loss or major alterations are made to an ecosystem or to a particular suite of species. When impacts to habitats are expected or have already occurred, restoration and remediation can be used to offset those impacts. Restoration, however, should never be considered a panacea for the widespread destruction of natural habitats; instead, for any given development project, the first consideration should be "How can we minimize disturbance to this natural system?" Both restoration and remediation are expensive and demonstrate that proactive, precautionary approaches to protection of natural resources (before they are degraded) make better ecological and economic sense.

A difficult but necessary component of restoration is a clear definition of the endpoint(s) of the restoration. Generally requiring that the restored vegetation and animal communities be sustainable at a particular percent composition or numerical goal may be reasonable, but those goals must be realistic, must recognize that natural variation will occur over time, and therefore must incorporate long-term monitoring in the process.

Ecosystem & Watershed Planning

One of the fundamentals of conservation is a recognition and appreciation of spatial scale in planning (Dramstad et al. 1996). Site-by-site conservation efforts, while very important to protecting the County's overall biodiversity, are not sufficient on their own to protect ecosystem health and function. Planning for protection at the scale of ecosystems, or large, recognizable management units such as watersheds, is also needed to ensure that landscape-scale processes can continue.

Because physical features, e.g., mountain ridges and stream corridors, and certain species ranges (large raptors, bears, bobcats) often cover several political boundaries, effective conservation often involves "ecoregional planning" for large areas. Albemarle County can participate in regional and statewide conservation efforts by adopting land-use policies and programs that support large-scale habitat protection and connectivity, and by taking part in integrated planning efforts with several neighboring counties as well as other political entities such as the Thomas Jefferson Soil and Water Conservation District and the Thomas Jefferson Planning District Commission. The County is also in a unique position to cooperate with The Nature Conservancy's Piedmont Program, which has begun a Rivanna River initiative that encourages stream corridor easements, restoration, etc.

Management & Monitoring

Management at various scales—from monitoring and protection of an individual site to addressing cumulative impacts to large-scale landscape features—is necessary for conservation to be effective. Simply labeling areas as protected and leaving them alone is usually not sufficient to ensure their long-term protection. Protected areas and other lands with conservation value must be monitored to ensure that those values are not degraded, and often need active management (such as replanting, elimination of invasive species, etc.). Since most types of land management are expensive, the County will benefit most by educating and working with private and public landowners to find ways with economic incentives to manage lands, streams and wetlands with biodiversity in mind.

Biodiversity protection activities, such as conservation-easement programs, can improve the success of conservation efforts by ensuring that appropriate management requirements are adopted and maintained. Technical and funding assistance is sometimes available from state and federal government programs, both to localities and to landowners.

Comprehensive Planning

Public policies, such as those set by Albemarle County's Comprehensive Plan (which mandated this biodiversity assessment), often have multiple and complex implications for biodiversity. Land use policies in particular (and the regulations, programs, and management activities that support them) must be examined for their biodiversity impacts, just as they are examined for their impacts on health, safety, budgets, water resources, and community character. Impacts and needs change over time, and conservation efforts must adapt to those changes to remain effective.

County Comprehensive Plans are living documents, subject to periodic revision. Therefore the opportunity exists for the Biodiversity Committee to provide input to both the Rural Areas and Development Areas (DISC) sections of the Plan and the programs and regulations that they guide. A recent (December 2003) addition to the draft RA portion of the County Comprehensive Plan is the concept of equality of "conservation lands" with other primary land uses, including agriculture/forestal, residential, and commercial. Such a concept represents a major advancement in wise land use planning. Establishing the location (and protection and management needs) of critical conservation elements is an obvious first tactic toward this end. Another direction to be explored is integration of conservation planning between the development areas and rural areas. One example would be greenway corridors connecting the rural upper reaches of North and South Forks of the Rivanna to the Pantops area of Charlottesville.

SUMMARY: STRATEGIC GUIDELINES FOR BIODIVERSITY PROTECTION

The following table summarizes the principles that an effective biodiversity protection program must follow. These guidelines are based on the ecological and strategic principles discussed above. See the Recommendations section for a discussion of how the principles might be added in Albemarle County. These guidelines should be kept in mind as the standing Biodiversity Committee and the County establish a more detailed biodiversity program.

Table B: Strategic Guidelines for Biodiversity Protection
Protect and restore large blocks of contiguous terrestrial ecosystems (especially forests) and extensive aquatic ecosystems. Large habitat areas provide for larger (and more resilient) populations, maintain gene flow, provide interior habitat for area-sensitive terrestrial species, improve the viability of mobile aquatic species, allow ecosystem processes to occur across connected areas of varied habitat types, and provide the space necessary for a natural mosaic pattern of terrestrial habitat types and successional ages. Planning for large areas that can assure maintenance of the health of ecosystems and their ecological processes requires a landscape- or watershed-level approach to setting land and water policies. Planning for individual elements (e.g., endangered or depleted species, unique habitats, etc.) will require a parallel site-specific approach—see below. A central management goal is to prevent, minimize, or reverse current trends towards fragmentation and simplification of ecosystems and their habitats.
Protect and restore the connectivity of terrestrial and aquatic habitats. Connectivity is the key to genetic exchanges for healthy populations, allows for movement between habitats and regeneration of reduced or extirpated populations, and provides for ecosystem and community resilience in the face of ecological change (from local site disturbances to global changes).
Maintain and reestablish multiple representative examples of native ecological community types and sites with the physical elements necessary for those communities to exist. Maintaining representativeness ensures that the area's full native biodiversity is found in the area, and redundancy (having multiple examples) ensures that impacts to any single population or community will not remove that element from the landscape. The multiple examples should be distributed across the area (for example, in multiple watersheds), rather than concentrated where a single disturbance could affect them all. In cases where native community types are no longer found, protecting sites with the physical factors (geology, soils, etc.) that would foster those types can increase prospects for future restoration of biodiversity.
Protect and buffer ecologically valuable areas and Important Sites. Critical areas (e.g.,

wetlands, riparian corridors, etc.,--see Section Seven for a recommended list) are those landscape and aquatic elements that are particularly important to healthy ecosystems and their services. Known occurrences of rare species and community types (see Appendix A for an initial list of these Important Sites) are often the last refuges of those elements of the area's biodiversity. Protecting and buffering both types of sites, in concert with protecting larger-scale habitats and connectivity, provides a foundation for protecting and enhancing the area's biodiversity.
Recognize and convey the importance of biodiversity and ecosystem services. Provide community education and foster awareness of biodiversity and understanding of its importance. Biodiversity is directly affected by human policies and actions. Acknowledgment of the human role in ecosystem health is the first step toward protection and restoration. Citizens and decision-makers must be aware of biodiversity, ecosystem services, land-protection mechanisms, and appropriate management practices, and reflect that awareness in public policy decisions that affect biodiversity and ecosystem services.
Maintain active protection, monitoring, and management programs. This requires protection of existing intact habitats and populations; active management of protected areas (versus benign neglect, which leads to degradation); action to quickly and effectively take advantage of conservation opportunities and respond to threats; and restoration of habitats damaged by past actions.

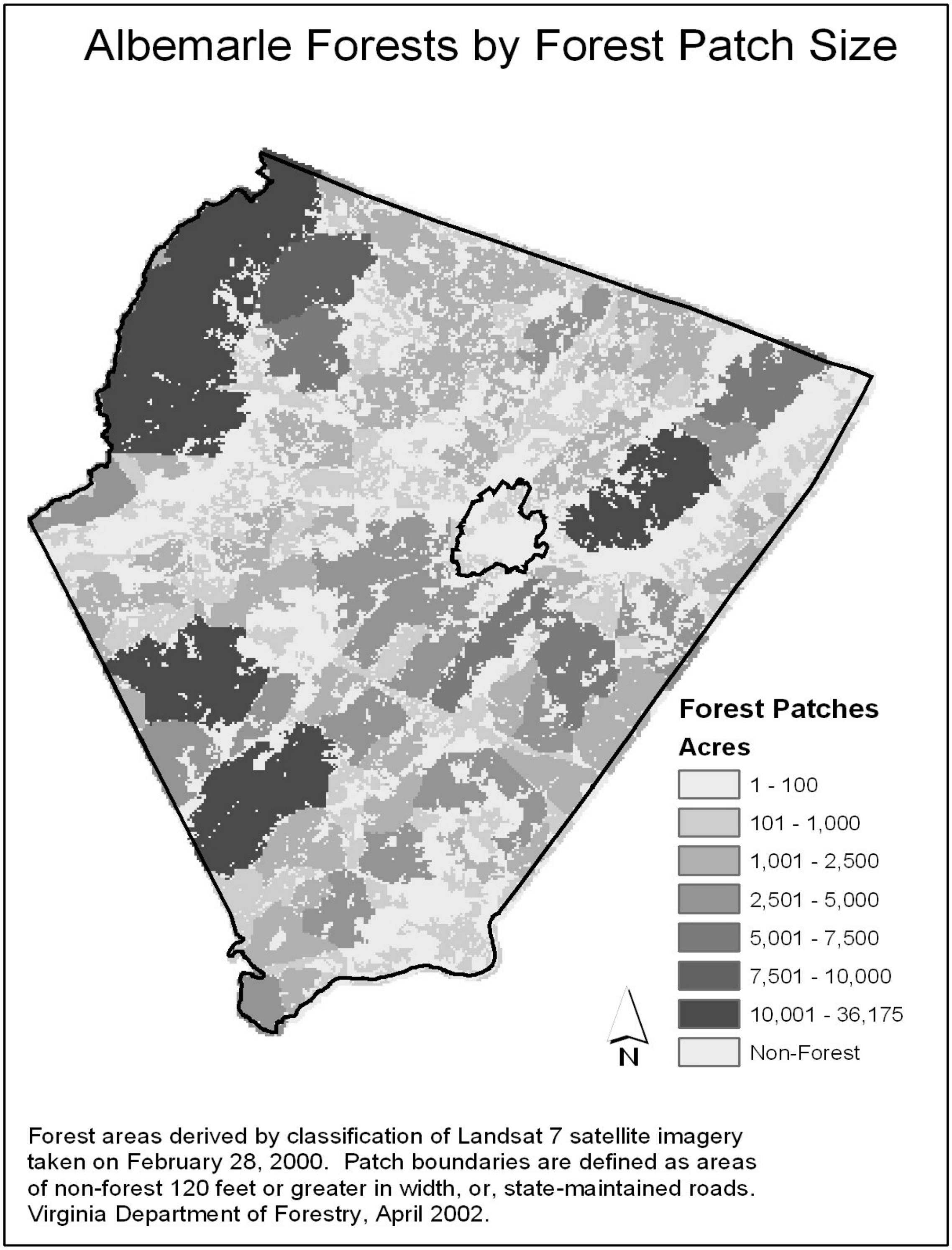

Figure 1: Albemarle Forests by Forest Patch Size. Maintaining and reconnecting large blocks of forest is a critical goal for biodiversity conservation.

HISTORIC IMPACTS AND MODERN THREATS TO THE CONSERVATION AND RESTORATION OF BIODIVERSITY IN ALBEMARLE COUNTY, VA

INTRODUCTION

In order to develop strategies for conserving and restoring biodiversity in Albemarle County, it is essential to understand both the historic impacts and modern threats to the ecosystems that support biodiversity. Reviewing the past helps to explain how current conditions came to be and why some threats still linger as legacies of the past. Discussing the locally-driven, modern threats provides the most important information for identifying strategies to conserve and restore biodiversity. Finally, global and national influences both impact and set the context for many local, modern conditions. These large-scale issues can only be confronted through the local community's engagement with the larger world.

Virginia, including Albemarle County, has one of the longest histories of European settlement in the United States. Since European colonization, the landscape has been altered significantly again and again, resulting in major changes to the biological communities of the county. Even before Europeans arrived, Native Americans were altering the landscape. Because waterways flow from and through the landscape, changes in the land dramatically altered water features and natural communities too. Waterways have been altered through direct manipulation as well. The landscapes, waterways, and natural communities seen today are distant, highly-modified "descendants" of those seen by the Native Americans.

A less well known, but critical historic impact and modern threat is that of invasive, exotic organisms. In his Pulitzer Prize winning book, *The Diversity of Life*, E. O. Wilson states that the invasion of exotic species is second only to destruction of physical habitat as a threat to native species and ecosystems the world over. A recent report by the Environmental Protection Agency (USEPA 2000) reached a similar conclusion in the U.S., finding that invasion by exotic species is the second leading cause of endangerment for rare species. Albemarle County, along with most other areas in the U.S. and the world, suffers from the effects of invasive exotic organisms, both in natural and agricultural settings.

Combining knowledge of the legacy with an understanding of current and potential new threats can help us develop biodiversity conservation and restoration strategies for the future. Human activity is the source of many of the problems that wildlife species and natural communities must confront. Land use changes--especially the conversion of rural or undeveloped land to developed sites--directly impact biodiversity. Suburbanization and other forms of development not only reduce the amount of land in natural or semi-natural conditions, but also create a fragmented landscape. Habitat fragmentation creates a host of threats and stresses to natural systems. These threats are both direct and indirect and impact both aquatic and terrestrial systems. Direct physical alterations to waterways, such as construction of dams and impoundments, have negative effects for native biodiversity. Many such alterations are not only historic but are occurring today.

Some of the forces that stress and therefore threaten biodiversity originate at locations far removed from Albemarle County, thus minimizing the effect that local efforts could potentially have in addressing the threats. Local activities may contribute to the source of the problem, but much broader efforts would be needed to reduce the threats. Examples of two threats to local biodiversity that originate at geographic levels far beyond Albemarle County – airborne pollution and climate change - are discussed.

With a history of massive impacts to the landscape, an abundance of invasive species, environmental changes occurring at national and global scales, and uncertainty about what the future may hold, one might be tempted to despair. However, reaching such a conclusion would mean ignoring the great deal of biodiversity and potential for biodiversity that remains (described in the chapter on the "current status of biodiversity"). Knowing the legacy helps the community understand how current conditions came to be, what the current and future threats are, and the degree of recovery that is realistic to expect.

We should not overlook the fact that an amazing biological world still exists in Albemarle County. Furthermore, the existing ecosystems continue to provide natural services essential to human communities. The lessons of the impact of land use changes initiated hundreds of years ago also can serve as a poignant reminder that today's land use will be the legacy for tomorrow's Albemarle County. Our remaining biodiversity will either be conserved and enhanced or it will become distant memory for those who follow.

HISTORY OF LANDSCAPE AND WATERWAY ALTERATION AND EFFECTS ON BIODIVERSITY

Terrestrial Communities and Landscapes

We cannot be certain what the area's forests were like before the colonists arrived, but a picture can be developed based on early writings and records of explorers, traders, surveyors, and colonists. The Native Americans arrived here more than 10,000 years ago, shortly after the most recent glacier started to melt and retreat. (This glacier remained to the north and never reached Virginia, though it came very close.) The fires that Indians frequently set to facilitate hunting and improve foraging for berries, seeds, nuts, etc., had a major effect in shaping the forests that developed as trees migrated back to the north, following the glacier as it retreated. These forests came to be dominated by oaks, pines, and the American chestnut, all of which benefited from or depended upon periodic fire to create the relatively open and sunny conditions that the species required to regenerate.

The native tree species in Albemarle County forests today are the same species that were present in the pre-colonial forests, with the exception of the American Chestnut. That species has been reduced from a canopy tree to small stump sprouts that rarely get larger than a few inches in diameter before being killed back again by the chestnut blight. Though the native species are the same, important changes have occurred. Much of the forest was cleared for agriculture. Only the steep mountainsides and steep, rocky, river bluffs remained in forest, and were often grazed by cattle, horses, and hogs. The great majority of county forests today are growing on land that was once used for agriculture.

Essentially, all of today's forests of the county were logged at some point. In the colonial period, accessible forests were periodically logged for wood for fuel, fences, lumber, and other uses. Many of the less accessible forests in the steeper mountains, however, were still largely intact until the late 1800s when large-scale, intensive, commercial lumber companies began to migrate down to Virginia from states farther north. This lumbering strategy originated in New England and moved south and west as the forests were cut. The development of railroads played a major role in the cutting of the forests, delivering lumber to distant markets and hauling the logs out of the woods in many parts of Virginia. During the period from the late 1800s to the 1930s, practically all of the remaining forests that had trees large enough to yield lumber were harvested. Consequently, most of the trees in the county today are less than 100 years old. However, a few very large, old trees can be found around old estates.

One consequence of the deforestation was the fragmentation of the forest habitat. Large forest patches are critical as habitat to many species. Obviously organisms need a certain amount of space to find food and places to live and breed. Some forest species need space to avoid predatory or parasitic species that penetrate from the edge of the forest. Also, as described elsewhere in the report, large, interconnected habitat patches are important to the flow of genes in plant and animal populations.

Fires largely have been eliminated from county forests for more than 50 years, for reasons involving human safety and protection of property. One consequence, however, is that periodic fires no longer affect forests as they had for thousands of years before European colonists arrived. This change makes it very difficult for oaks and pines to regenerate, especially on moist and fertile sites. Consequently, the composition of our forests is slowly changing to fewer of the shade-intolerant species such as oaks and pines and to more of the shade tolerant species such as maple, beech, and black gum.

At the site scale, biodiversity is greatly reduced on land that was once cleared, farmed, and later abandoned. When forestland is cleared, plowed, and cultivated, the natural plant communities formerly growing there usually are completely extirpated. Seeds, spores, roots, and rhizomes that remain from the previous vegetation disappear over time. Those that germinate or sprout are destroyed the next time the field is plowed or cultivated. Soil erosion also plays a role a role in reducing biodiversity. One researcher estimated that an average total depth of 5.5 inches of soil was lost in the Piedmont of southern Virginia and North Carolina between the years 1700 and 1970. By contrast, the amount of soil lost in pre-colonial times was "minimal," (Trimble 1974). As soil washes away, all associated seeds, pieces of roots, etc., go with it. Repeated heavy woodland grazing, without plowing and cultivation, has less impact. In time though, erosion and compaction seriously degrade original plant communities, and finally destroy them.

Abandoned, seriously eroded and compacted soils are often not able to sustain all of the species that originally grew on them, even if seeds and spores arrive. In addition, species vary greatly in their ability to reestablish themselves. Species that establish rapidly are those that produce abundant seed that is readily distributed by wind or wildlife, and that can grow and compete successfully on degraded soils. Many tree and herbaceous species fit this description. Species that produce few seeds and which are not wind disseminated or transported by wildlife invade slowly and with difficulty. These poor establishers are the species frequently missing in present-day plant communities on former agricultural land.

Grasslands were likely only a minor feature of the Albemarle County landscape before Europeans arrived. They contributed to biodiversity, but were not abundant. Average rainfall in Albemarle County (about 46 inches annually) is too high for easy establishment of large grasslands, which require frequent fires. (Grasslands, however, may have been more common as nearby as the Shenandoah Valley.) The native grass communities that were present would have been mostly composed of warm season species (big and little bluestem, Indian grass, and broomsedge) and much different from the introduced species common today (blue grass and fescues) in pastures, hay fields, and lawns. The shelter of the tall, warm season grasses would have benefited many mammals (e.g., least shrew, cottontail rabbit, meadow jumping mouse, fox, etc.), birds (e.g., bobwhite quail, whip-poor-will, grasshopper sparrow, meadowlark, blue grosbeak, indigo bunting, field sparrow, kestrel, hawks, etc.), and reptiles (e.g., black rat, corn, mole, copperhead, black racer and eastern king-snake, and box turtle).

Overall, the reduction and fragmentation of terrestrial habitats, particularly forests, has brought declines in biodiversity around the nation, state, and Albemarle County. The H. John Heinz III Center for Science, Economics and the Environment (2002) reports that 20% of native U.S. forest species are at risk with 1.5% (or 1 out of every 66 species) extinct. Much of this decline is a direct result of landscape change. The National Biological Service (1995) states that at least 80% of plant extinction has been due to habitat destruction, particularly from agriculture, mining, and urban and suburban development. (The National Biological Service is now the Biological Resources Discipline within the U.S. Geological Survey.) In Virginia, according to The Nature Conservancy, 154 of 2,546 vascular plants are in a state of risk as are 69 of 737 vertebrate species, including 13 of 82 mammals, 7 of 323 birds, and 5 of 61 reptiles (Stein et. al. 2000). Though data for Albemarle County are anecdotal (see naturalist accounts elsewhere in the document) rather than quantitative, terrestrial biodiversity losses in the county have been at least as severe as state and national losses given the county's extensive history of landscape alteration.

Aquatic and Wetland Communities and Ecosystems

As with the forests, it is difficult to know in detail what the streams looked like before European colonization. Certainly, the stream and river system of Albemarle County has been altered dramatically. The greatest changes to streams have come as a result of changes to the landscapes of the watersheds. Of course, these landscape changes were the very ones described in the preceding sections. It is likely that massive sedimentation from the intensive forest clearing and farming was a defining event in creating the river systems seen today. Not only was the amount of forest clearing and farming great, but it was done in the absence of even minimal, modern conservation measures. While muddy streams after large, and even small, storms are the norm today, there is evidence that it was not always so. A study of erosion in the Southern Piedmont (including portions of central "Virginia") quotes several early European observers describing clear streams under storm flow conditions (Trimble 1974). Loss of topsoil and gully formation occurred throughout the county. The sediment loads entering streams during this era probably could not be transported downstream by the river system as they would have been at natural, more modest volumes. As a result, the abundant sediment was deposited in the stream valleys on the floodplains. Anecdotal evidence indicates that more than ten feet of sediment were deposited on some floodplains and is still being exported today.

There were many likely physical impacts of these changes. It is probable that most stream banks were raised relative to the stream surface. An increase in the distance between the stream surface and floodplain would mean a lower frequency of water accessing the floodplain during storms and concomitantly more containment of the force of stormwater in the stream channel. The steep stream banks and powerful flows would have meant greater availability and erosion of streambank sediment and more transient sediment moving in the stream. Water in streams would be muddier more often, even after small storms. Volume of wetland habitat near streams would have been reduced by a relative lowering of the water table (visible as stream surface). Floodplains, normally diverse habitats characterized by diverse "microtopography," hydrology, and soil chemistry, would have become flat, homogenous, and relatively dry because of the blanket of sediment. They likely also were transformed from old, dark, organic-rich soils to younger soils higher in mineral content (Trimble 1974).

Biological problems stemming from these changes likely included a reduction in both volume and diversity of stable habitat (wood, unsilted rock, and channel features like pools) for fish, insects, and other organisms. High sediment concentrations (seen as muddy water or turbidity) would lead to breathing and feeding problems for aquatic animals. The elimination or reduction of wetland conditions and microtopography in many floodplains would have reduced habitat volume and diversity in these areas. This reduction of habitat quantity and quality could have lowered biodiversity significantly.

While the alteration of streams and their margins through changes in the watershed is a major issue, direct alteration of stream-side areas has been important as well. Stream-side areas, particularly floodplains, have a long history of human disturbance. The rich, level soils have been attractive for farming. Many wetlands have been drained for farming and other land uses. It is common to find functioning drain tile systems and ditches draining wetlands to county streams. Other wetlands have been degraded by plowing or grazing without attempting to alter basic water flow patterns.

Wetlands, both adjacent to streams and isolated, are a habitat certainly reduced since European settlement. The estimate is that Virginia has lost 42% of its wetlands (both coastal and inland) since the 1780s (USFWS 2003). Addressing more recent times, R.W. Tiner (1987) reported that 57,000 acres of inland vegetated wetlands were destroyed in Virginia between 1956 and 1977. He attributed 30% of the loss to urban and other development, 45% to agriculture, and 25% to pond and lake impoundment. Albemarle County never had wetlands on the scale of Tidewater Virginia, but the losses in the county probably were similar in to those in the rest of the state on a percentage basis.

Human constructed impoundments are the only type of aquatic habitat that has increased since European colonization. The Tiner study (1987) found that impounded water habitat increased by 35,000 acres in Virginia from 1956 to 1977. The construction of impoundments for reservoirs, flood control, and recreation has been a major agent of waterway alteration since the late 1800s. While providing essential benefits such as water supply, these impoundments have had several negative impacts on river systems. Ponds, while operating on a smaller scale than the large impoundments, are more widespread and raise similar issues. The impacts associated with impoundments include flooding natural wetland and stream habitat, blocking off large sections of the stream network from fish and mussel migration, reducing water quality by changing water chemistry and temperature, altering natural flow regimes to which species are adapted, and hosting undesirable species.

An indirect impact on wetlands may have been the extirpation of the beaver. One author has estimated that in much of North America beaver dam density was as great as 300 dams per square mile (Outwater 1996). If this estimate held true in Albemarle County, there would have been more than 200,000 beaver pond wetlands in the jurisdiction. If each beaver dam created a wetland only 20 feet in diameter, there would have been 2.5 square miles (1,580 acres) of beaver wetlands scattered across the county landscape. In addition to creating habitat, these ponds could have been a major sink for stream sediment. During colonization, beavers were eliminated from the county because of the fur trade, but they have returned and are now quite common. Ironically, in some cases, beaver now occasionally threaten patches of rare plants with flooding.

In some instances, human-made ponds have "naturalized" somewhat serving as remnant wetland habitats, something like beaver ponds or vernal pools. Some of the "notable places" identified by local naturalists occur in these settings. Most often the habitat value is a result of trees being allowed to grow around the pond (preferably not on the dam) and sediment filling parts of the pond creating shallow areas. However, most ponds are built with the intention of mowing or grazing to the edge and the overall effect of new ponds on the aquatic network is usually negative for the reasons described earlier.

Other human activities have changed the stream system as well. Efforts in the 1700s and early 1800s to improve navigation on the James and Rivanna Rivers, through creation of locks, clearing of tow-paths, and removal of rocky and woody navigation barriers certainly had major impacts on these rivers. Mills, which were found on large and small streams, would have had significant impacts. Poorly designed road culverts continue to create many small stream blockages.

Effects on aquatic biodiversity have been even more dramatic than those observed in terrestrial ecosystems. Overall, the indirect and direct alteration of aquatic habitats has been tremendous and must have had huge impacts on aquatic biodiversity in Albemarle County as in the nation at large. The U.S. is ranked first in the world in numbers of species of crayfish, freshwater mussels, freshwater snails, stoneflies, mayflies, and caddisflies. The country is seventh among the nations of the world in freshwater fish diversity with 801 species. (There are only 193 fish species across all the nations of Europe.) However, this freshwater diversity is at extreme risk. For example, in the U.S. 67% of freshwater mussels, 37% of freshwater fish, 51% of crayfish, and 18% of dragonflies and damselflies are vulnerable, imperiled, or extinct (Figure 2, Master et. al. 1998). In Virginia, 20% of fish species are vulnerable, imperiled, or extinct (Master et. al. 1998). With the county's intense land use history, there is no reason to think that aquatic biodiversity has fared any better in Albemarle County than elsewhere in the United States.

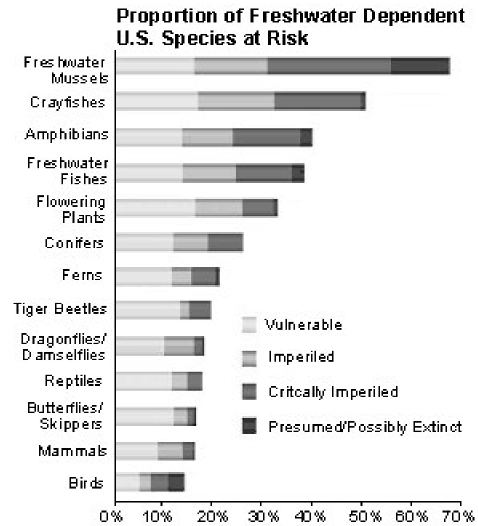

Figure 2. Nature Conservancy analysis of risk to water dependent species in the United States (Master et. al. 1998).

These losses are associated with all aquatic habitats including slow-water wetlands as well as streams. Nationally, the decline of wetlands has been associated with the decline of organisms dependent on them such as frogs, lightning bugs, dragonflies, and many less well-known plants and animals. In the United States, 40% of amphibians are vulnerable, imperiled or extinct (Master et. al. 1998).

HISTORY OF THE INTRODUCTION OF INVASIVE PLANTS AND ANIMALS, PLANT PESTS, DISEASES, AND FERAL ANIMALS

Invasive Alien Plants

Invasive exotic or alien organisms are plants and animals that were brought to North America after colonization by Europeans began in the 1600s, became established and are now growing on their own, and are harmful to the environment. Though some exotic organisms were transported here accidentally, many others were brought to the U.S. intentionally as farm animals or for crops, horticulture, medicines, and other purposes. In many instances, we have benefited greatly by their presence. This report is concerned with those organisms that cause harm, the invasive exotic organisms.

The Natural Heritage Division of the Virginia Department of Conservation and Recreation, in cooperation with the Virginia Native Plant Society, has published a list of over 100 invasive alien plant species found in the state. (The list can be found at <www.dcr.state.va.us/dnh/invinfo.htm>.) Of these, approximately 30 are considered highly invasive in natural areas and native plant habitats. Twenty-seven of these highly invasive plant species are found in the Piedmont region of the state and 23 are found in the mountains. Albemarle County is situated primarily in the Piedmont, but the western-most portions of the county are located in the mountains. Aquatic plant invasives like Hydrilla (*H. verticillata*) threaten native aquatic plants and can clog aquatic habitat. Thus, invasive alien plants have the potential to significantly damage areas throughout the county.

While no formal surveys have been done to document damage from alien plants in Albemarle County, Ivy Creek Natural Area (ICNA) is an example of a county natural area with significant incursion of invasive plants. ICNA was farmed intensively for well over 100 years, but since 1973 has been allowed to return to forest or to fields maintained by mowing and other interventions. There is also a system of maintained hiking trails. Among the worst invaders in ICNA are oriental bittersweet, tree of heaven, and multiflora rose. These plants are overshading trees and herbaceous plants in the forest, thus weakening them by preventing photosynthesis, and eventually killing many of them. Oriental bittersweet is also able to "strangle" trees it climbs by twining around the trunk, eventually cutting off the transport system of the tree. The sheer weight of the vines can also break branches and even uproot the tree. Also, tree of heaven is thought to have allelopathic properties, meaning it produces chemicals that can inhibit the growth of other plants in its vicinity. These three invasive plants all spread easily to other areas. Recently, ICNA has begun a small-scale experiment in controlling the worst of the invasives.

In Shenandoah National Park, which occupies a significant portion of the mountainous western region of the county, the National Park Service is working to curb the worst invaders: oriental bittersweet, Japanese knotweed, garlic mustard, tree of heaven, and princess tree. Especially troublesome in the part of the park in Albemarle County are the princess tree and tree of heaven, (both are in the Moorman's River area) and oriental bittersweet (around Loft Mountain). The Shenandoah National Park program is being used as a model for organizing the control of invasives in other national parks (J. Akerson, NPS, pers. comm.). However, it is an uphill battle to try to keep these invasives under control, and it is also costly.

The agricultural sector also experiences severe damage by invasive alien plants. In a recent report, the Council for Agricultural Science and Technology stated that a conservative estimate for the impact of invasive plants on croplands in the U.S. in 1994 was $20 billion. Estimates for losses in Albemarle County were unavailable. In Virginia as a whole, the estimated losses due to weeds alone, for 8 important crops, were over $38 million in 1993 (Hagood et. al. 1995).

Invasive Alien Vertebrates and Invertebrates

There is no list of invasive animals comparable to that for invasive plants. However, a number of vertebrate and invertebrate invasive animals are known to exist in the county, and can disrupt natural areas and damage agricultural areas as well. Among vertebrates, birds such as European starlings and English (house) sparrows can take food and nest sites needed by native species of birds. Non-native mammals inhabiting Albemarle County include pets such as house cats (which hunt and kill many native birds, rodents, and snakes) and dogs. The introduced Norway rat is also a problem for some native species. The red fox found here is probably a hybrid of the introduced European fox and native red foxes from neighboring regions (gray foxes are native to Virginia).

Feral animal populations, domestic species that escape and establish self-supporting populations, are often a threat to native wildlife. Feral cats are known to kill large numbers of birds and small mammals. Feral dogs can also negatively impact native wildlife. Though not known to occur in Albemarle County, feral hogs are a very serious problem in some areas of the southeastern U.S. and beyond. They are legend for the amount of disturbance and damage they can inflict on native plant communities.

The introduction of exotic, aquatic species of fish, mollusks, crayfish, and plants has almost certainly impacted native populations. The intentional introduction of major predator game fish such as smallmouth bass (*Micropterus dolemieu*) probably has shifted food chains from the top down. The introduction of exotic species at all levels could have impacted native species through shifting of food chains and creating competition for resources.

Currently, interest in the mosquito fish (*Gambusia holbrooki*) as a prevention measure for West Nile virus poses a threat to native species. The mosquito fish probably does no better than native fish at controlling mosquitoes, but may throw off natural food chains.

The extremely invasive zebra mussel (*Dreissena polymorpha*) was recently discovered in a quarry in northern Virginia. It has established itself in the Great Lakes region, Lake Champlain, and other fresh water areas in the U.S., and has had severe impacts (e.g., clogging of water intake pipes) while proliferating and spreading rapidly. The zebra mussel has the potential to damage native mussel populations by smothering native mussel shells and competing for food. The exotic, fingernail (*Sphaerium* spp.) and Asian clams (*Corbicula fluminea*), already in Albemarle County, may pose threats to native mussels as well.

Among non-aquatic invertebrates, there are a number of invasive insects severely impacting area forests, including the gypsy moth and hemlock wooly adelgid. The gypsy moth was imported to the U.S. from Europe as an experiment to start a silk industry. It was released in Massachusetts in the 1800s and gradually moved south. It first infested Virginia forests in the 1980s, weakening many trees, especially oaks. Infestations can cover large areas and leave trees vulnerable to other stresses such as drought and disease. Many oaks in the mountains and Piedmont have died as a result of gypsy moth infestations.

The hemlock wooly adelgid was accidentally imported to this country from Asia in the 1920s and infests our hemlock trees, many of which are dying as a result. Eventually, it is thought that the only hemlocks that will remain in our forests are those individuals that are isolated enough that the adelgids cannot get to them. In Shenandoah National Park, only about 8% of the hemlocks sampled still have most of their needles.

The American beech has been attacked by an exotic insect, the beech scale, as well as by an exotic fungus that can eventually girdle the tree. Another more recent pest brought to the country on illegally smuggled budwood is the chestnut gall wasp, first reported in 1974. This wasp will compound difficulties in reintroducing American chestnut to our forests.

The Asian tiger mosquito is another example of an insect accidentally imported from Asia, reportedly in water held in scrap tires brought to this country. This mosquito has made it difficult for gardeners and others who want to be outside, and is believed to be a potential vector for West Nile virus.

Invasive Fungi, Microorganisms, and Viruses

Numerous examples exist of disease-causing microorganisms from other countries finding their way to the U.S. These organisms can weaken or kill humans as well as various other animals and plants. Some examples of invasive organisms that have attacked native plants and animals in Albemarle County (as well as other areas) are: chestnut blight (from Asia), Dutch elm disease, butternut canker, dogwood anthracnose, and west Nile virus. Our beautiful and valuable American chestnuts (with very few exceptions) exist now only as stump sprouts that die usually just as they are old enough to produce nuts. The American elms that once graced American streets have been largely eliminated from cities and towns, though some remain in forested areas. Many flowering dogwoods, the state tree of Virginia, have died, especially in moist habitats. And we do not yet know the extent of damage caused by west Nile virus, which can infect and kill many wild birds as well as some humans.

It is impossible to know what the future will bring, but scientists agree that more "invasions" by exotic species are inevitable. As a case in point, the beech-bark disease has only recently moved into western Virginia. Many exotic species use land disturbances as opportunities to spread. Physical features that involve disturbance or openings, such as railroads, highway corridors, utility rights-of-way, etc., often serve as avenues for travel and invasion by exotic species.

LOCAL THREATS TO CONSERVATION AND RESTORATION OF BIODIVERSITY

Legacy Threats from Historic Land Uses

The sections on historic landscape alteration and invasive species make it clear that there has been much physical and biological change to the county, particularly since European colonization. Though the land uses are different today (in fact the county is much more forested than in the 1800s) the legacy of early land use persists as a threat to current biodiversity. Topsoil has been lost, species removed, the landscape fragmented, seed banks depleted, stream valleys filled with sediment, rivers dammed, and so on. The natural process of recovery from some of these problems, such as topsoil regeneration or achievement of stream equilibrium, will take thousands of years. Also, these old issues interact with new stresses. For example, the addition of impervious surfaces (roofs, driveways, and roads) to watersheds from new development leads to higher storm flows that accelerate stream bank erosion. Understanding legacy impacts to biodiversity helps in understanding modern threats and opportunities for restoration.

Suburbanization and Other Land Use Changes

At the national level, a 2001 technical review by the U.S. Environmental Protection Agency (EPA) cites sprawl as one of the alarming trends affecting the environment. Between 1954 and 1997, urban land area in the lower 48 states almost quadrupled, from 18.6 to about 74 million acres. The American Farmland Trust (2002) reports that the rate of urban growth far outpaces population growth: from 1982-1997, U.S. population grew by 17% while urbanized land area grew by 47%. The rate of land development has quickened in recent years. During the five years from 1992-1997, more land area was developed than in the previous ten-year period (1982-1992). The newly developed land came primarily from forestland, pasture and range, and cropland.

These national trends continued during the period from 1997-2001. The most recent data compiled for the 2001 National Resource Inventory (USDA Natural Resources Conservation Service 2003), the same studies used in the American Farmland Trust's report, indicate that almost 9 million acres of land were developed during the 5 year period. Forest conversion represented almost half of the total (4.2 million acres), with the conversion of cropland (1.8 million acres), pastureland (1.5 million acres), and rangeland (1.2 million acres) comprising the remainder.

Similar trends occur at the state and regional levels. From 1992-1997, 105,000 acres of prime farmland in Virginia were lost due to conversion to development. Only 10 states lost more acres of farmland during this period. This represents an increase of 76% over the rate of loss in Virginia during the previous five-year period. (American Farmland Trust 2002).

According to the Virginia Department of Forestry, approximately 180,600 acres of forestland in the state were lost between 1992 and 2001. Urbanization (with accompanying development) was the single biggest factor in the loss of this forestland. Of all the forested acreage cleared statewide, 62% was for urban development while 37% was converted to agricultural use. In Albemarle County alone, 21,918 acres of forestland were lost during the 1992-2001 period (from USDA Forest Inventory Analysis data posted on the Virginia Department of Forestry website – http://www.vdof.org.).

Loblolly pine plantations have become an important component of the forests of Albemarle County, especially in the eastern portion of the county. Though native to Virginia, the upper Piedmont is not part of the natural range of loblolly pine. In many instances, the loblolly plantations have displaced native hardwood and mixed pine-hardwood forests, locally reducing both plant and animal diversity.

At the local level, population growth and development of rural lands stress the county's natural resources. According to U.S. Census Bureau data, Albemarle County's population grew significantly between 1990 and 2000, from 68,040 to 79,236, or a rate of 16.5% for the decade. Albemarle was part of the significant regional population growth that occurred during this time. Of the 7 counties that border Albemarle, only one, Nelson, grew at a slower rate (13%) during the 1990s. (See Table C.)

Table C. Population growth and the number of building permits issued in Albemarle and surrounding counties from 199l-2000. Building permit data excludes mobile homes, garages and other outbuildings, additions and renovations, and commercial construction. For multi-unit structures, the data indicate the number of units permitted rather than the number of structures. Population data is from U.S. Census Bureau. Building permit data is from Weldon Cooper Center, University of Virginia.

County	*1990 Population*	*2000 Population*	*Percent Increase*	*Population Increase*	*Building Permits Issued, 1991-2000*
Albemarle	68,040	79,236	16.5 %	11,196	7,157
Augusta	54,677	65,615	20 %	10,938	4,880
Buckingham	12,873	15,623	21.4 %	2,750	561
Fluvanna	12,429	20,047	61.3 %	7,618	3,121
Greene	10,297	15,244	48 %	4,947	1,767
Louisa	20,325	25,627	26 %	5,302	2,697
Nelson	12,778	14,445	13 %	1,667	1,324
Orange	21,421	25,881	20.8 %	4,460	2,271
Rockingham	57,482	67,725	17.8 %	10,243	4,714

The regional population growth during the 1990s was accompanied by a significant amount of new, residential construction. Table C indicates the number of new residential units that were permitted for construction during the decade. The combination of population growth and new construction results in the loss of undeveloped land, and the fragmentation of remaining lands, with negative implications for biodiversity.

In 2003, Albemarle County's Department of Planning and Community Development compiled data pertinent to revising the Rural Areas section of the Comprehensive Plan. These data reflect many of the trends occurring at broader geographic levels. From 1992 to 1997, more than

16,000 acres of farmland were lost in the county. The current amount of land in farms is well less than half the amount of farmland found here in the 1920's. From 1985 through 2000, approximately 242 new parcels were created each year in the county's Rural Area (land zoned RA). Approximately 42% of these new parcels were between 2 and 5 acres in size, and 76% of the new parcels were smaller than the 21 acre minimum size that county policy calls for. A review of the County's annual Development Activity Reports from 1979 through 1992 indicates that 5,969 new lots were created in the Rural Area during that time period. A total of 70,533 acres (15% of the county), or 2,939 acres per year, were subdivided in the process.

The data above reflect significant alterations to the physical landscape that directly impact biodiversity and other natural resources. The EPA's 2001 report indicates that 95% of the species listed under the Endangered Species Act are threatened by habitat loss, habitat fragmentation, or other alteration to habitat. The threat of habitat loss is simple to understand: a wildlife population cannot exist without a place to live. The negative impacts of habitat fragmentation are often more complex and not always obvious.

Landscape Change and Threats from Fragmentation

Habitat fragmentation occurs when a contiguous area of habitat is transformed into a number of smaller habitat patches, or fragments. Some of the more common fragmenting features of the Virginia Piedmont include roads, utility corridors, and railroads. A survey of scientists and land managers at The Nature Conservancy (TNC) indicates that road and utility corridors pose critical threats to biodiversity health in 55 of 89 conservation areas across the country (TNC 2000).

The effects of habitat fragmentation are numerous (see Saunders et. al. 1991, Wilcove et. al. 1986 for full discussions). One obvious effect is the physical separation of habitat patches, which can isolate wildlife populations. The isolated populations are at higher risk for loss of genetic material and even extirpation. Species that require large areas of habitat may be lost. For instance, some songbirds native to Albemarle County require large forested areas in order to successfully reproduce (Robbins et. al. 1989). Similarly, wide-ranging species such as the black bear do not fare well in fragmented landscapes. Brody and Pelton (1989) found that black bears in the Appalachian Mountains avoid areas of high road densities, and are less likely to cross high-traffic roads than low-traffic roads.

Fragmentation causes an increase in edge habitat, the area where two or more different types of habitat meet. For example, edge occurs where pasture meets forest, or meadows meet farm fields. Increased edge habitat often results in increased populations of already abundant wildlife species while less common species may suffer. Though the white-tailed deer is native to all of eastern North America, the populations are far too large in much, if not all, of Albemarle County, as elsewhere. Many wildlife experts believe the deer population in Virginia is larger now than it ever has been. (In addition to the creation of edge habitat, hunters and automobiles are less effective as predators than wolves, mountain lions, and American Indians were in pre-colonial times.)

Overpopulation of deer and other native species (including raccoons, crows, etc.) can pose problems to natural systems. Over-browsing by deer of preferred plant species is making it very difficult for many tree species, and other kinds of plants such as lilies and orchids, to regenerate and replace themselves. Numerous studies document elevated levels of predation and parasitism of bird nests along forest edges, thus negatively affecting reproduction. Fragmenting features also often produce the unintended consequence of providing an avenue for non-native plants to invade the landscape, thus causing further ecological degradation.

The quality of habitat patches and natural communities can also be negatively impacted by fragmentation. Altered physical characteristics (e.g., increased exposure to wind and sunlight) can lead to other physical alterations (e.g., decreased soil moisture), which in turn can affect species composition.

A human-dominated and fragmented landscape typically results in the greatly reduced presence of natural processes. Through time, wildlife and natural communities have evolved with and adapted to natural disturbances and processes such as fire, flood, drought, predator-prey interactions, and many others. The reduced presence or loss of these and other natural processes in the landscape can have significant, negative impacts on biodiversity resources.

Landscape Change and Threats to Waterways

The modern suburbanization of the county may be exacerbating the sediment problem inherited from previous generations. High flows generated by impervious surfaces can increase the problem of streambank erosion in stream valleys already overloaded with sediment. High stream velocity in small streams can be viewed as a pollutant. A landscape hardened with roofs, roads, and lawns generates greater stormflows that erode the vulnerable streambanks. New sediment generated from accelerated erosion of today's landscape becomes "legacy" sediment for future generations. In the stream, sediment smothers habitat. Muddy or turbid water can clog gills and interfere with organisms that feed by site.

Sedimentation is only one example of "nonpoint source pollution," which is one of the largest modern threats to stream ecosystems. Nonpoint source, or diffuse, pollution comes off the landscape in general rather than from the end of a pipe. It includes nutrients, organic chemicals, metals, bacteria, and sediment from the land that reduce water quality. Sources include lawn and farm fertilizers, runoff from roads, houses, and parking lots, waste from pets and farm animals, septic fields, atmospheric deposition, and more. Nonpoint source pollution has been recognized as a primary threat to the Chesapeake Bay as well. All of Albemarle County drains to the Bay, most of it via the James River. Sediment that fills reservoirs can lead to the creation of new reservoirs, thus flooding more stream habitat and creating additional stream blockages.

The current threat to wetlands comes mainly from urban and suburban development though agriculture still has major impacts. During the Tiner study period (1956-1977), when Albemarle County farming was in relative decline, development activity was likely a bigger factor than agriculture in wetland loss. One problem facing the county's wetlands is that many are too small and isolated to be protected by current local, state, and federal regulations.

Riparian areas and flood plains continue to be impacted by farming. Cattle in the streams pose a particularly vexing problem because of the multiple impacts affecting the buffer, stream bank, instream habitat, and instream pollution. Threats to riparian areas from new development continually need to be addressed. Sometimes however, land use change can create opportunities to restore riparian areas.

There may also be a threat to wetlands in the potential reaction to West Nile and other mosquito born diseases. Most of the mosquito species identified as common carriers of West Nile virus are associated with human habitats (old tires, bird baths, dog bowls, children's toys, etc.). Many wetlands host predators that control mosquito populations, while back yard habitats do not. It will take education and restraint to prevent unnecessary impacts to wetlands in the name of West Nile virus.

Impoundments are a significant existing threat to stream ecosystems. None of the dams in Albemarle (e.g. Woolen Mills on the Rivanna River, South Fork Rivanna, North Fork Rivanna River water intake, Advance Mills on the North Fork Rivanna River, Sugar Hollow Dam on the Moormans River), have fish passages and some would be extremely difficult to retrofit. These blockages keep anadromous fish (e.g., shad and herring, species that live in oceans and bays but breed in streams and rivers) from reaching the upper reaches of much of the county. This issue will grow in importance as barriers are removed or maneuvered around on the James River. Local native fish need to move through the stream system to complete their life cycles as well. Young mussel larvae hitch rides on native fish to move through the stream network. Maintaining genetic connectivity for fish and mussels relies on maintaining stream connectivity. (Numerous poorly functioning road culverts and low flow crossings create similar connectivity problems on small and large streams alike.)

Flow regimes, particularly in the low flow spectrum, are altered by reservoirs and ponds. Fish and other aquatic organisms are adapted to natural flow cycles. Alteration of flow can alter stream communities. Impoundments also alter water chemistry and temperature, both of which can alter stream communities. Examples of particular concerns include threats to the endangered James Spinymussel (*Pleurobema collina*) that spawns during the summer low-flow period, native Brook Trout (*Salvelinus fontinalis*) that requires water temperatures below 70° F (21° C), and keystone minnow species that build gravel mound nests in the current in the spring and summer. While the impact of each impoundment may be limited, cumulative impacts generally are not addressed through existing permitting programs.

GLOBAL AND NATIONAL THREATS TO THE CONSERVATION AND RESTORATION OF BIODIVERSITY

Airborne Pollutants

The negative of effects of "acid rain" have been known for many years. Acid precipitation occurs when acidic compounds in the atmosphere, present due to human activities, are washed to earth by precipitation events. The increased acidity in streams and other water bodies negatively impact aquatic species, especially when the underlying bedrock is not sufficiently basic (e.g., a limestone or other calcareous substrate) to buffer the effects of the increased acidity. The effects of acid precipitation on terrestrial systems are less clear, but contribute to the decline in health of much vegetation. High elevation conifer forests of the Appalachian Mountains are particularly affected.

A recent study of air quality in Shenandoah National Park (NPS 2003) reveals that the park's visibility and most sensitive aquatic ecosystems have been degraded by human-caused air pollution. In addition to presenting results of long-term air quality and other environmental monitoring, the study modeled the effects of acid precipitation on aquatic fauna. Results suggest that park streams occurring on siliciclastic bedrock (which covers approximately one third of the park) have generally lost one or two species, with some streams losing up to four species. Park streams with low acid neutralizing capacity (ANC) have several troubling characteristics, including lower fish species richness and population density. Young brook trout inhabiting these streams are sometimes killed as a result of acidic events. Higher ANC streams generally have greater numbers of families and individuals of three important benthic insect orders - mayflies, stoneflies, and caddisflies – than lower ANC streams. The presence or absence of these three insect orders in streams is often used as an indicator of water quality.

The same study illustrates the problem of protecting resources from distant sources of stress:

> "In descending order of importance, Ohio, Virginia, West Virginia, Pennsylvania, and Kentucky comprise the top five of thirteen key states causing sulfate air concentration and haze impacts at the park. West Virginia, Ohio, Virginia, Pennsylvania, and Kentucky comprise the top five states causing sulfur deposition impacts at the park. Virginia, West Virginia, Ohio, Pennsylvania, and North Carolina comprise the top five states causing oxidized nitrogen deposition impacts at the park."

These conclusions indicate that emissions from thirteen states significantly impact air quality and visibility in the park. Of the three pollutants analyzed, Virginia is the leading contributor to the park's problems in only one.

A 2002 report by the Virginia Department of Environmental Quality further illustrates that environmental threats can originate from distant locations. The report documents the deposition of airborne nitrogenous pollutants in the Chesapeake Bay Watershed. The key pollutants of concern are ammonia (NH_3), reactive nitrogen oxides (NO_x), nitric acid (HNO_3), and inorganic nitrates (NO_3).

The report concludes that atmospheric deposition accounts for approximately 32% of the nitrogen loading in the Chesapeake Bay. Emissions from the six states composing the Bay's watershed – Virginia, West Virginia, Maryland, Delaware, Pennsylvania, and New York – contribute only 49% of the total airshed deposition that ends up in the Bay. Model results of the transport and dispersion of emissions to the air indicate that emissions from as many as 36 states may end up in the Bay.

At a more local level, model results from the report estimate that only 19% of the atmospheric nitrate deposition in the James River watershed originates from sources within Virginia. Similarly, only 22% of atmospheric nitrate deposition in the York River watershed originates from sources within the state.

Climate Change

The average temperature of the Earth increased during the twentieth century by about 0.6 degrees Centigrade. Projections indicate a further increase of 1.4 to 5.8 degrees Centigrade during the twenty-first century (IPCC, 2002). Release of carbon dioxide into the atmosphere by burning of fossil fuels and land use changes are seen by scientists as primary causes of recent and projected warming (IPCC, 2002). Anticipated consequences of climate change include raised sea levels, altered geographic distributions of precipitation, more extreme weather events, changes in agricultural production, and extinctions of species (IPCC, 2002). One conservation biologist has described climate change as a “wicked twist” to the challenges faced by conservationists (Lawton, 2002).

Predicting the weather is notoriously difficult. Unsurprisingly, models of climate change sometimes make significantly different predictions about the changes in weather that will occur in particular locations. Two important models of climate change, one developed by the Canadian Climate Center and the other developed by the Hadley Center in U.K., both predict Virginia will increase in mean annual temperature by roughly 2 degrees Centigrade by the year 2100 (USGCRP, 2000). However, the Canadian model indicates Virginia will become much drier while the Hadley model predicts we will be wetter (USGCRP, 2000). Some scientists (Michaels, 2002) question the applicability of these models and the dire predictions derived from them.

The weather is always changing. Changes that do occur are hard to predict in detail and we know that the Earth’s life forms have survived “Ice Ages” and numerous other major climate changes in the past. Why should we be concerned about climate change, even if it is occurring?

Climate change should be considered in development of a biodiversity protection plan for Albemarle County because the prevalent view of climatological researchers is that a warming trend is already underway and that it will bring to us difficult new challenges. It would be imprudent to develop a county biodiversity protection plan that ignores potential impacts of climate change on conservation activities. Further, scientists believe the disturbed nature of our landscape works against the operation of adaptive processes to climate changes that have operated in populations in the past. Habitat fragmentation, which is discussed in the Comprehensive Plan and other sections of this report, seems particularly capable of interacting with climate changes in ways that threaten survival of many populations (IPCC, 2002; Thomas, 2002).

Biologists have long known that the distributions of many organisms are constrained by environmental conditions such as temperature or precipitation (Andrewartha and Birch, 1954). When climates change slowly, populations of organisms may gradually shift over the landscape, tracking the shifts in climates they are most suited to (Noss, 2001; Thomas, 2002). In the case of a long-term global warming trend, many species will be expected to gradually shift their distributions toward cooler higher latitudes or to higher elevations if there is substantial local altitudinal variation. Empirical studies indicate that such shifts in distributions of animals are underway (IPCC, 2002; Noss, 1991; Thomas, 2002).

Alternately, populations that cannot move with climate shifts (for example plants adapted to certain specialized soil types or terrestrial mammals living on islands) may undergo natural selection for increased frequency of genetic variations best suited to the changed local climate. Local extinction is possible when a population cannot shift its distribution with a climate change or when the population does not contain genetic variations that will allow it to adapt in place to new climate conditions.

Ecologically specialized populations and locally small populations appear particularly at risk for extinction due to climate change. Specialized organisms are less likely to survive migration over heterogeneous landscapes in response to shifting climate. Small populations generally contain lower levels of genetic variation than large populations. Small populations thus are less likely to contain genetic variations needed for adaptation to changed local conditions, if they are unable to move (IPCC, 2002). As noted elsewhere in this report, small populations always are at risk of becoming extinct through chance variations in birth and death rates.

Invasive exotic species may add to the stresses and losses precipitated in part by climate change. Remnant populations trapped on patches of habitat to which they are marginally suited after climate change may finally become extinct because of competition from introduced, better-adapted exotics. Some scientists believe that through a combination of climate change and exotic invasions, plant communities in many places will come to consist over the next century of assemblages of species that until recently had existed in very different parts of the world (Thomas, 2002).

Climate change will affect agriculture and forestry. Many forage species in Albemarle pastures are native to cool areas of Europe. Some of these species already struggle in the intense droughts common in our area. Local graziers may need to adopt new pasture species mixes if our climate warms. The USDA Forest Service has seen fit to project shifts in distributions of many common Eastern US tree species, based on different models of global warming (Iverson et al., 1999). Increases in the number of extreme weather events are expected to increase soil erosion from cropland and require new soil conservation strategies (SWCS, 2003). Biodiversity conservation efforts on parcels with commercial agricultural and forestal activities will be affected by changes in these activities forced by climate change.

Many strategies exist for dealing with potential climate change. Many of the world's governments have embarked on programs to reduce their country's' carbon dioxide releases. Much scientific research is underway on methods of capturing and storing carbon now released into the atmosphere.

Various methods of conserving biodiversity in the face of climate change have been proposed. Maintaining connectedness of habitats (or, reducing fragmentation) seems a fundamental approach (Noss, 2001). Some scientists suggest that boundaries of designated natural areas should include regions with environmental gradients (Noss, 2001, Thomas, 2002). Another approach proposes that in reforestation, planted trees should come from a variety of geographic locations and thus represent a variety of gene pools (Noss, 2001).

In Albemarle County, the mountains, their surrounding foothills and riparian areas may be particularly useful for conservation in the face of climate change. Many mountain areas still contain relatively unfragmented blocks of forest; they provide altitudinal gradients and north-south migration corridors. Riparian areas provide connectedness along with many other ecological values.

CONCLUSION

Looking back at the history of Albemarle County and the United States as a whole, the big picture relating landscapes, watersheds, and biodiversity is easy to see (in spite of many missing details). Major land alteration, most of it done to achieve very reasonable goals, reduced the ability of the land and waterways to support biodiversity. Declines in biodiversity were the result. The point is not to judge the past, but to learn from it. Much of what was occurring was not apparent as it was happening, not only because of differences in science and technology, but also because of perspective. The land was changed a little at a time, through a series of independent decisions. The now evident result was the cumulative effect of those isolated decisions.

In this way the present is no different from the past. Looking forward to the threats to biodiversity in Albemarle County and the barriers to restoration, the community is faced with a series of small decisions, most of them to be made by private landowners. This report largely is an effort to give context to those small decisions so that some estimate of the whole they represent can be considered in county scale planning. From this framework, large scale planning steps can be derived and education messages developed.

An integrating concept for understanding the landscape and watershed character on which biodiversity and other ecosystem services depend is ecosystem resilience. Ecosystem resilience is the ability of the ecosystem to "bounce back" from or somewhat smoothly adapt to blows to the system. Biodiversity both imparts ecosystem resilience and relies upon it. As an example of the first point, if global warming effects are severe, as many predict they will be, the genetic diversity implicit in biodiversity will dampen the potentially traumatic changes to the county's ecosystems. This resilience exists because diversity increases the chances that species tolerant of the new climate regime will replace those that are reduced or eliminated. On the second point, the severely altered, fragmented, and invaded (by exotic species) county and regional landscape reduces the ability of animals and plants to be resilient to the threats. Reestablishing connectivity can help restore resilience.

One can think of the history of Albemarle County land use change and legacy and rising threats to biodiversity as an accumulation of impacts to ecosystem resilience. Humans depend on that resilience for their survival. Other animals and plants that have lived here for millennia depend on that resilience. The lessons of the past reveal the question for the future: will the community use the growing, big-picture understanding of the landscape to protect and restore the resilience of the ecosystems that sustain biodiversity and human life, or will these natural systems and functions be lost to the “tyranny of small decisions?”

METHODS FOR ASSESSMENT AND MONITORING

This section introduces methods for assessing and monitoring the species, communities, and ecosystems that make up Albemarle County's biodiversity. It begins with a discussion of assessment methods, which forms the basis of the Group's recommendations regarding the ongoing assessment of species and communities. This is followed by information on assessing and monitoring ecosystems, and on classifying the County's vegetation communities.

BIODIVERSITY ASSESSMENT METHODS

Documenting the diversity of the flora and fauna of a region the size of Albemarle County, Virginia, approximately 726 square miles, is a daunting task that, done properly, would require person-hours and funding far beyond the capacity of most counties to consider. In localities facing this dilemma, less expensive and intensive efforts are often undertaken with the realization that accuracy and completeness are sacrificed. However, the expectation is that the most significant resources (as defined by those charged with Biodiversity responsibilities) are to be accurately identified in location, and their local, regional, state, and national status assessed and protection requirements outlined.

A preface to any such large-scale biological inventory must acknowledge that even the most thorough inventory efforts are never 100% complete because biological systems are usually very dynamic ones – especially animal communities which constantly undergo population changes and movements among seasons and years. No sooner would an inventory be completed than it would begin to be obsolete. Thus, an inventory of any type is a dynamic process requiring periodic (if not constant) updating as new information becomes available.

In the following sections, a number of approaches will be described briefly, ranging from the most basic and inexpensive assessments (usually the crudest) to the more elaborate ones focusing on particular groups of organisms with rigorous, statistically sophisticated designs. A fundamental distinction will appear in the approaches; one depends upon an inventory of particular taxa, e.g. birds, amphibians, conspicuous insects (e.g. butterflies or bees) identifying known locations for breeding, staging, or feeding. The other general approach uses physical or vegetation community attributes as a surrogate for biodiversity. That is, by maintaining combinations of soil types, elevations, slope and/or aspect, the full complement of habitats (i.e., herbaceous vegetation, shrubs, trees) will be maintained, and with them, the key associated microbial, plant, and animal communities. Where appropriate, we list the strengths and weaknesses of each approach:

Expert Systems

Often an excellent source of free information lies in the field notebooks, journals, published reports, articles, and books of local experts. In Albemarle County, Virginia, such known naturalists considered to be experts in plant and bird identification include Mr. Charles ("Mo") Stevens, Dr. Kenneth Lawless, Mr. Tom Dierauf, and Mr. Dan Bieker. These individuals have accumulated an extremely valuable number of county records over their lifetimes of rare or significant plant occurrences for the central Virginia region as well as unusual geologic formations; they have conducted many trips either alone, as part of a survey team, or with classes to document plant and bird locations. Their records have largely been translated from notebooks to electronic form as part of the County's Biodiversity Work Group effort (see section IV). The willingness of these individuals to share their knowledge and expertise is one of Albemarle's great human resources and one that appears to be rare in the state (Ludwig, 2000).

The obvious strength of the expert system is that it provides a large amount of free data for a given number of resources of interest, often rare and unusual assemblages of plants or animals. Often the locations known by the experts would never be found by conventional survey methods such as using topographic maps to identify unusual geological features or discontinuities. The weaknesses however are many. First, the data may often be dated, with visits having occurred as much as a decade or more in the past. This is especially problematic for animal species and/or where habitats are being altered by development at high rates. Second, and perhaps most severe, is that spatial sampling methods are, generally speaking, seldom followed in a rigorous manner. The preferred method of spatial sampling, such as stratified random sampling, often entails covering areas that are very difficult to access or on private lands. Another weakness found in such efforts is that detection differences of different species are usually not determined. Locating a singing male ovenbird in late May in a forested riparian zone is often fairly easy, but determining whether a singing Canada Warbler uses the same woodlot in migration requires perhaps 4-6 visits, since it is much less likely to be seen or heard on a visit.

Gap Analysis

A nationwide approach that has been endorsed by the U.S. Department of Interior uses maps and remote sensing of vegetation primarily to generate geographic information system (GIS) "overlays" representing predicted species distributions of terrestrial vertebrates (Scott et al. 1993). These are predicted, not known, occurrences of a large array of vertebrate species based on existing data, published records of habitat associations, and expert opinion. Because the spatial scale of interest is the state, the resolution is quite crude, usually on the order of a square kilometer. For widely dispersed species, this may be entirely appropriate. The approach was developed primarily to identify where important natural resources may not be adequately protected by public or private conservation lands and so is best applied at broad regional scales.

The strength in gap analysis is the broad application and the low expense involved in covering large areas using publicly available resources such as satellite imagery and digital orthoquadrangles, which are available from most state natural resource offices. The disadvantages are that:

(1) the information may be difficult to obtain from the state gap information center, or in a form that is readily usable (for example, in Virginia, individual species maps may be difficult to obtain and not readily downloaded from a PC; see http://fwie.fw.edu/WWW/vagap/frames.html),
(2) the imagery that forms the basis for the GIS may be quite dated, for example early 1990s for Virginia. A great deal of habitat change can occur in a decade, especially in a state undergoing rapid development, and

(3) getting accurate data on species with very specialized habitat needs or rare/endangered species is especially difficult using surrogate methods.

Community Composition and Species Richness Assessment

A rigorous statistical approach has been developed that allows investigators to sample in a systematic fashion to determine the identity and number of species of a given taxon. Basically, one uses repeated sampling using capture-recapture methods to gain "species accumulation data" to predict the number of species of a given taxon in an area, knowing that not all species can ever be fully enumerated (Nichols et al. 1998, Cam et al. 2002 as examples).

The advantages of these approaches are that they are statistically the most rigorous and they give an unbiased estimate of the number of species of a given community. The approach is also relatively inexpensive compared to more exhaustive species inventory methods. The disadvantages are that rare/endangered species may often go undetected by this method. It also requires involvement of statisticians familiar with the approaches.

Natural Heritage Approach

The Virginia Natural Heritage Program in Richmond uses a combination of methods to assess biodiversity at the scale of the county. A number of areas within Virginia have been inventoried to test methods. One such approach was reported in the second edition of *A Natural Heritage Inventory of the Dragon Run Watershed* (Ludwig, 2000). The work proceeds in a number of directions simultaneously and may be iterative. Information collection includes using aerial photographs, USGS topographic maps, museum collections, libraries, and naturalists' field data to begin with. Following this, plans for the field sampling are made, landowners are contacted, and surveys are undertaken. The natural-community focus addresses the many common or uncommon species, as well as ecosystem functions and processes, that are important for a more comprehensive biodiversity conservation approach. Accurate GPS locations are located on Natural Heritage map and data are entered into a Biological and Conservation Data system (BCD).

The advantages of this method are that a fairly thorough coverage of the county is performed, using expert opinion, known inventory information, and current field sampling. Disadvantages are that a rigorous sampling design is not used (as in # 3 above), and the costs can be fairly substantial, ranging from \$50 - \$300 K for a 2-3 year period. Making landowner contacts and getting permission can be very time intense and costly, as with any on-the-ground survey.

Physical Proxies for Biodiversity Measures

Similar to the approach taken by gap analysis, where broad habitat composition is used as a surrogate for species diversity, some suggest that physical proxies may be useful as indicators of biodiversity at broad scales (Franklin 1993, Nichols et al. 1998, Kintsch and Urban 2002). In this approach, categories of physical attributes such as elevation, aspect, slope, soil type, etc. are identified as GIS layers of information. These attributes are believed to strongly influence plant community composition (Poiani et al. 2000, Kintsch and Urban 2002) which in turn are expected to influence animal species diversity (Scott et al. 1993, Franklin 1993).

The advantages of this method are that most of the physical data are from readily accessible databases, at the county, regional, state, or federal levels. Thus, expenses are low. However, field validation is required at a sample of sites to demonstrate that the physical attributes translate to vegetation communities which in turn reveal particular animal community assemblages. The extent of this sampling will have a major effect on the ultimate costs; however, the sampling does not need to be conducted more often than one year. A major disadvantage is that rare or restricted species may not be readily identified by physical attributes alone. However, if representativeness is the highest value in protecting biodiversity, this approach may prove very useful.

Taxon-specific Approaches

Probably the most expensive in time and manpower are inventories that take a focal species approach (Lambeck 1997). A great deal of information has been published on those species that are deemed to be of highest public interest. In terms of hierarchy, public agencies generally have focused on rare and endangered species, those of high recreational interest (i.e. hunting and fishing interests), and those considered to be "charismatic," e.g. birds, mammals, amphibians, and a few "showy" insects such as butterflies and dragonflies. In general, any public effort, whether at the county or state level, will have to pay some tribute to at least a subset of these species to maintain public interest and enthusiasm (the "flagship" factor).

Examples of sources for specific inventory methods for these include the following:

- Birds – Ralph and Scott 1981, Ralph et al. 1990
- Mammals – Wilson et al. 1996 (Smithsonian series in monitoring methods)
- Amphibians – Heyer et al. 1994 (Smithsonian series)
- Butterflies – Pollard and Yates 1993
- Dragonflies – Clark and Samways 1996

The obvious weaknesses in these approaches are that they are narrow; very little of the rest of the entire biodiversity continuum is addressed if the focus is only on these "charismatic" groups. And there appears to be little support for the idea that any of these are effective "indicators" of diversity in general (e.g. Prendergast et al. 1993). Many of these published approaches however provide a very useful model for how to properly conduct broad scale surveys with good sampling rigor (e.g. see Nichols et al. 1998 or Cam et al. 1998).

Ecological Monitoring

Ecological monitoring is an essential ingredient for any attempt at biodiversity protection or environmental management. Predicting species depletion, or assessing their negative trends, can be difficult enough, but predicting responses to environmental stress at the scale of the ecosystem stands at the cutting edge of environmental science. Assessment is made extremely challenging by the "white noise" associated with environmental variability or cycles, by the lack of baseline data on which to make comparisons, and by the uncertainty of what key features to measure to indicate ecosystem "health". A serious impediment is that long-term cycles of decades, centuries, or longer are most often recorded only as anecdotal knowledge and are difficult to verify. Nevertheless, cycles of ecosystem states can have profound effects on biota. Therefore, it is essential to establish monitoring regimes very early in the conservation or management process, and to modify them as knowledge improves. The major goal is to understand how the variety of biological components of ecosystems is interrelated, how ecosystems respond, and how they may recover and adapt.

Undertaking monitoring forces recognition of the “shifting baseline syndrome.” An example is the depletion of species that once played major roles in ecosystems — so-called “ghosts of the past” such as large predators (e.g., wolves, cougars, hawks and owls, etc.) that played major roles in controlling species (e.g., deer that have serious impacts on forest growth; crows that are serious predators on bird eggs, snakes, lizards, etc.; feral house cats that can depress populations of ground-nesting birds and others)). Monitoring also recognizes that species loss may go unrecognized, during which time there may be a lag time in system readjustment. If the “ghost” is not recognized, any baseline against which change may be assessed may be insufficient for measuring the causes for change and its effects on sustainability or recovery. The "bottom line" is that acceptance of a present baseline of environmental condition, in the absence of historical information can lead to inappropriate conclusions and predictions about ecosystem health. An example would be to accept the present conditions of environmental fragmentation, young, even-aged forests, and a dramatically altered species community in Albemarle County as a standard for a sustainable environment.

The simplest measurement of ecosystem response to stress is to monitor direct effects on survival, growth rates, and reproduction of a suite of indicator species. Indirect "process" effects, such as productivity, precipitation, and changes in species diversity, are much more difficult to evaluate, as they may be mediated by effects on other components in the ecosystem, and/or caused by lags and cascading effects that are temporally or spatially dissociated from the initial stressor. Therefore, choice of appropriate scale for measurement and interpretation is essential. Various indicators (Table D below) may be used to track fluctuations, but an important factor concerns the fact that measurement of average equilibrium conditions can be misleading unless fluctuations under circumstances of high variability are considered and observed as a trend. An example is to assume that average rainfall among years is the major cause for environmental change, when the major changes may actually be brought about by the frequency and intensity of storms. Thus, the response of an ecosystem to stress becomes most apparent only after long term, large-scale observation of summed acute and chronic effects. It is also important to note that an ecosystem subject to repeated disturbance, or stress, tends to deteriorate in time because of loss of vigor and resiliency. Therefore, meaningful conclusion about change may be described by resiliency, that is, measurement in recovery rates of key indicators (often species) to reference conditions.

Table D. Indicators of ecosystem health. The top part of the table lists four general goals of indicators and the objectives towards which indicators are directed. The bottom part lists criteria for choice of indicators and their attributes; the first four criteria are general for any indicator that may be chosen and the fifth is species-specific. Ray and McCormick-Ray (2004); modified from Kelly & Harwell (1989), Hilty & Merenlender (2000).

Goal	Objective
Intrinsic importance and ecosystem structure	Valued, depleted, or commercial/sport species; biodiversity; habitat condition
Early warning of stressor and stress conditions	Early exposure to stressor; response rate; lag times of response
Ecological process and function	Rates of production, cycling, feedbacks, decomposition; changes in food webs, biogeochemistry
Conservation relevance	Addresses the "So what" question; species, communities, ecosystems at risk; relevance to adaptive management, regulations, legislation, and agreements
Criteria	**Attributes**
Stress sensitivity	High signal-to-noise ratio; sensitivity to change; false positives minimized
Reliability	High specificity of response; low variability
Complementarity	Multiple indicators possible
Ease of use	Low sampling cost; efficient logistics; ease of laboratory identification; pre-existing data base (e.g. , fisheries, pollution data on hand)
Species -specific	Ecosystem role (e.g., key, foundation species); clear taxonomy; specialist; well known natural history; known tolerance levels and resilience; correlated to habitat; limited distribution and mobility at some life stage; easy to find; trends easy to measure

SELECTING A CLASSIFICATION SYSTEM FOR TERRESTRIAL COMMUNITIES

Some kind of classification system for terrestrial communities is essential to guide protection efforts for two reasons:

1. To indicate which kinds of plant communities and/or physical habitats are rarest or in greatest danger and which are still widespread and not under threat. This would facilitate attempting to protect the areas most in need of protection first.
2. To provide a way to "keep score" as tracts are protected by easements or other means, to insure that tracts covering the full spectrum of variation are being protected.

One approach to protecting biodiversity would be to protect areas representing the full variation in physical site factors present in the county: all possible combinations of such factors as geology, slope steepness, slope shape (convex to concave), aspect (southwest-facing slopes are hottest and driest while northeast-facing are coolest and moistest), soil fertility (largely determined by underlying rocks), and soil drainage (varies from excessive to poor depending on type and topographic position). If the county had never been settled, this approach alone would do a good job of protecting biological diversity, and a classification system based only on such physical site factors would suffice.

But the extensive human disturbance that has occurred greatly complicates the job. Plant communities of interest (for example, forests approaching maturity and species-rich coves, slopes, flood plains, swamps, and bogs) often don't occur where they might be expected based on physical site factors. This suggests that a classification system will be necessary that combines both physical site factors and present-day occurrence of various plant communities. Such classification systems can be constructed. Mo Stevens, the County's most experienced field naturalist, has constructed one that might be used (see Table E).

Table E: Basic Classification of Albemarle County Plant Communities	
	Piedmont
I)	**Upland Hardwoods**
	1) Mesic - mixed
	2) Oak - hickory
	3) Oak - pine - heath
II)	**Piedmont Mountains**
	1) Ridge and upper slope mixed-mesic forest
	2) Rich Cove or ravine forests
	3) Granitic open rock plant communities
III)	**North-facing river or stream bluffs**
	1) Hemlock - Kalmia
	2) Hemlock - White Pine - Kalmia
	3) Other bluffs
IV)	**Alluvial Forest**
	1) Well-drained
	2) With wet pools or seasonal depressions
V)	**River Shores**
	1) Sand - gravel - mud bars and edges
	2) Rocky banks
VI)	**Wetlands**
	1) Fens & shrub swamps
	2) Wet meadows
	3) Upland wet depressions (Pin Oak) (ex: Avon St.; extirpated)
VII)	**Loblolly plantations**
	1) Mixed ages
	2) Two - five year old clear cuts in thick mixed growth stage
	Blue Ridge
I)	**Basic (greenstone) open rock communities**
1)	**Cliffs**
2)	**Talus**
II)	**Ridge-crest oak - pine - heath fire climax (scrubby)**
III)	**Rich cove forests**
IV)	**Hemlock - White Pine - Hardwood communities (in ravines and along streams**
V)	**Acidic ridge top & slope forests**

The Virginia Division of Natural Heritage (DNH) has a system based primarily on plant community composition, but also correlated with fertility and moisture differences. This system covers the entire state, and is continually being updated. It might be advantageous to use their system, especially considering the present initiative of the Nature Conservancy to become more active in the Virginia Piedmont. About 25 of their Ecological Community Groups (out of about 100 for the entire state) may occur in Albemarle County (see Table F). This system considers only plant communities that are mature or nearing maturity, so the County's biodiversity assessment would have to add additional community classes to cover such things as recently abandoned fields, pine stands (including plantations), transitional pine-hardwood forests, and other immature forests. This system is more complicated and requires considerably more botanical expertise than a system like that shown in Table E that combines physical site factors and general forest types and plant communities. Detailed descriptions and photographs of each type can be found on the Department of Conservation and Recreation's web site at <http://www.dcr.virginia.gov/dnh>.

Table F: DNH Community Types found in Albemarle County

TERRESTRIAL COMMUNITY TYPE	DESCRIPTION
Rich Cove and Slope Forests	Mixed hardwood forests of fertile, mesic, mountain-slope habitats at elevations ranging from about 1500 to 3600 feet. Major tree species include Sugar Maple, basswoods, White Ash, Tulip-poplar, Yellow Buckeye, and Northern Red Oak. Associated with moist, sheltered landforms. These communities are common in the County.
Basic Mesic Forests	Mixed hardwood forests of fertile, mesic, low-elevation habitats in the Piedmont and major mountain valleys, typically in deep ravines, sheltered north- or east-facing slopes along major streams and rivers, and occasionally well-drained floodplain terraces. Major trees include those in "Rich Cove and Slope Forests," plus Chinkapin Oak, Black Maple, Southern Sugar Maple, American Beech, Bitternut Hickory, and Black Walnut. These communities are common in the County.
Mesic Mixed Hardwood Forests	Mixed hardwood forests of mesic to submesic infertile habitats of the Piedmont and low mountains, on acidic, relatively nutrient-poor soils. Typical canopy trees include American Beech, oak species, Tulip-poplar, and hickories, with a wide variety of others. These communities are common in the County.
Eastern Hemlock Forests	Forests dominated by Eastern Hemlock, occupying mesic, sheltered habitats in the mountains and on isolated, north-facing bluffs and ravines in the Piedmont. These communities are uncommon in the County and are becoming rare to extinct due to widespread die-off of hemlocks caused by the hemlock wooly adelgid, an introduced pest.
Basic Oak-Hickory Forests	Mixed hardwood forests of submesic to subxeric upland habitats over basic rocks. Typical canopy trees vary, but generally include White Oak, Northern Red Oak, Black Oak, Chestnut Oak, Post Oak, Pignut Hickory, Red Hickory, Shagbark Hickory, Mockernut Hickory, and White Ash. These communities are common in the County.
Acidic Oak-Hickory Forests	Mixed hardwood forests of submesic to subxeric upland habitats over subacidic rocks, widely but locally distributed in the Piedmont and mountains, up to about 2000 feet in elevation. Dominant oaks include White, Black, Scarlet, Southern Red, and White. Hickories are less abundant than in Basic Oak-Hickory Forests; often are understory trees. These communities are common in the County.
Montane Oak-Hickory Forests	Mixed hardwood forests of submesic to subxeric mountain slopes and crests up to highest elevations in County. Typical dominant trees include Northern Red Oak, White Oak, Chestnut Oak, Red Hickory, Shagbark Hickory, and Bitternut Hickory. These communities are common in the County.
Mixed Oak/Heath Forests	Oak-dominated forests of submesic to xeric, infertile upland sites. In some cases, these communities have replaced former mixed oak-American Chestnut forests following the eradication of chestnut canopy trees by an introduced fungal blight. Typically dominated by a variety of oaks (including White, Chestnut, Scarlet, Black, Northern Red, Southern Red, and Post), with Pitch Pine (mountains) or Shortleaf and Virginia pines (Piedmont) indicating past disturbance. These communities are common in the County.
Chestnut Oak Forests	Forests overwhelmingly dominated by Chestnut Oak on subxeric to xeric, usually rocky upland slopes. (American Chestnut was formerly co-dominant prior to the introduction of the chestnut blight.) Other tree species include Bear Oak, Pitch Pine, and Table Mountain Pine

	(mountains), or American Beech and American Holly (east of mountains). These communities are less common in the County.
Eastern White Pine - Hardwood Forests	Mixed forests characterized by co-dominance of eastern White Pine and hardwoods. These communities are uncommon in the County.
Piedmont/Mountain Basic Woodlands	Deciduous and mixed woodlands of usually somewhat stunted trees forming an open or sparse canopy in xeric, rocky habitats. Most often dominated by variable mixtures of White Ash and hickories, with Eastern Red Cedar or Virginia Pine as a major associate. These communities are less common in the County.
Ultramafic Woodlands	Mixed woodlands of xeric uplands over ultramafic rocks. These communities are rare in the County.
Piedmont Hardpan Forests	Deciduous and mixed forests on gentle to flat Piedmont uplands and ancient, never-flooded stream terraces with impermeable clay subsoil. Sites sometimes pond water after rain, but are very hard and dry for significant portions of the growing season. Typically dominated by Post Oak, in nearly pure stands or in variable mixtures with Blackjack Oak, White Oak, Virginia Pine, Pignut Hickory, and White Ash. Virginia Pine increases after cutting and may dominate on heavily disturbed, clear-cut sites. Uncommon. This Community Group occurs in Albemarle County on Orange soils overlying basic dikes and on Lignum soils overlying acidic slates. There is the possibility that imperfectly drained depressions, which are rare microsites, may occur on these soils.
Low-elevation Acidic Outcrop Barrens	Scrub and herbaceous vegetation of exposed sandstone, quartzite, and granitic outcrops up to about 3,200 feet elevation. Vegetation is usually a mosaic of shrub thickets, herbaceous patches, and lithophytic lichens. These communities are uncommon in the County.
Low-elevation Basic Outcrop Barrens	Scrub and herbaceous vegetation of exposed, base-rich outcrops. Vegetation is usually a mosaic of shrub thickets, herbaceous patches, and lithophytic lichens. More fertile and dominated by different species than acidic outcrop barrens, and more prone to invasion by exotic weeds. These communities are uncommon in the County.
Floodplain Ponds and Pools	Semipermanently to permanently flooded natural-depression wetlands within the floodplains of major Piedmont streams, typically in abandoned oxbows and cut-off meanders. Dominant vegetation ranges from shrublands in shallower, semipermanently flooded ponds to submerged or floating aquatics in deeper ponds.
Piedmont/Mountain Bottomland Forests	Temporarily and intermittently flooded forests, encompassing most river floodplain habitats of the Piedmont and major mountain valleys, except those dominated by swamp forests. Dominant vegetation depends on soil drainage. Many of these communities have been severely impacted by clearing, grazing, agricultural run-off, and invasive exotic weeds. Many have been destroyed and few if any remaining stands are in excellent or pristine condition. These communities are probably common in a limited area, along the Rivanna and Hardware Rivers.
Piedmont/Low Mountain Alluvial Forests	Temporarily flooded forests of smaller stream floodplains, where distinct alluvial landforms (e.g., levees, terraces, backswamps) occur at very small scales. Typical trees include Sycamore, Box Elder, American Elm, Green Ash, River Birch, Red Maple, Sweetgum, Yellow Buckeye, Black Walnut, Tulip-poplar, and Black Willow. Occupy smaller, more topographically heterogeneous floodplains than Piedmont/Mountain Bottomland Forests, and have less diverse vegetation. These communities are mostly in fair to poor condition due to extensive past clearing, grazing, catastrophic flooding, and invasive exotic weeds. Occur in the County along lower-gradient streams in the Piedmont and low mountains.
Montane Alluvial Forests	Temporarily flooded deciduous and mixed forests occurring along

	relatively high-gradient small river and large streams in the mountains, on narrow floodplains with coarse deposition and rocky streambeds. Common trees include Sycamore, Eastern Hemlock, Eastern White Pine, White Oak, birches, and Tulip-poplar. Many of these communities were destroyed during early settlement. Occur along steep-gradient streams in the mountains.
Piedmont/Mountain Semipermanent Impoundments	Aquatic and shoreline vegetation of both beaver ponds persistent man-made impoundments along Piedmont and mountain streams. Compared to Floodplain Ponds and Pools, these impoundments are more subject to unpredictable disturbances. Emergent marsh plants are typical in abandoned but persistent beaver ponds; floating and submerged aquatics are found in rarer deepwater impoundments, and a variety of shrubs and trees may occupy the marginal zones.
Sand/Gravel/Mud Bars and Shores	Seasonally flooded to intermittently exposed herbaceous and shrub vegetation occupying the drawdown shores, bars, and islands of rivers and large streams.
Rocky Bars and Shores	Seasonally flooded to intermittently exposed shrub and herbaceous vegetation of rock outcrops on the shores and islands of large, high-gradient streams.
Mountain/Piedmont Acidic Seepage Swamps	Saturated deciduous forests of gently-sloping headwaters, large spring seeps, and ravine bottoms underlain by sandstone, quartzite, or base-poor granite. Could also include certain basin wetlands that are saturated or seasonally saturated by perched groundwater. Typical trees include Red Maple, Black Gum, Tulip-poplar, and Pitch Pine. These communities are common along small, low-gradient streams.
Upland Depression Swamps	Forested, seasonally flooded depression wetlands of nearly level Piedmont uplands with clay hardpans or shallow bedrock. Typical trees include Willow Oak, Sweetgum, and Overcup Oak. These isolated wetlands are vulnerable to major disturbances and alterations from logging, draining, and development. The only known occurrence of this type in the County was lost to urban development; no others have been found.
	Source for above groups: Fleming, Gary P., Philip P. Coulling, Dean P. Walton, Kathleen M. McCoy, and Michelle R. Parrish, *The Natural Communities Of Virginia: Classification Of Ecological Community Groups (First Approximation, January 2001)*, Virginia Department of Conservation and Recreation Division of Natural Heritage Natural Heritage Technical Report 01-1. Information on Albemarle County occurrences from Tom Dierauf.
ADDITIONAL COMMUNITY TYPES -- DISTURBED SITES (Not included in DNH classification system)	
"Recently" Abandoned Old Fields	Former pastures and fields occupied by early successional vegetation including a mixture of native and non-native grasses, weeds, and shrubs, plus early successional trees, most commonly Virginia and Shortleaf pines and red cedar. These can occur anywhere, but are most common in the eastern and central parts of the county.
Old Field Pine Stands	Former pastures and fields in more advanced stages of succession, supporting young to mature forests dominated usually by Virginia and Shortleaf pines. Occurrence similar to above.
Loblolly Plantations on Cutover Forest Land	Pine plantations on sites originally occupied by other forest types or abandoned fields. Dominated by planted Loblolly Pine. These areas are not monocultures except in the canopy, although increasingly intensive management is tending to make them monocultures. They are very abundant on the infertile soils east of the Southwestern, Carters, and Green

	Mountains, but are also common on the gentler slopes through the central part of the county.
Recent Clearcuts (too immature to classify under DNH system)	Young, hardwood-dominated forests on recently clearcut sites, usually with some scattered, small or low-value trees remaining from the harvested stand. Sometimes on soils are eroded from previous agricultural use. These sites are widespread in the County.
Selectively-logged Forest Stands	"Selective cutting" prevents a forest from progressing or developing into a Community recognized by the DNH system. Sites under this form of management are also found throughout the County.
Abandoned Quarries	Unusual highly-disturbed sites that tend to provide some habitat for plants otherwise unusual in the County.

A classification system could be used just to evaluate and compare different tracts that are candidates for easement or other protection. Also, identifying ecosystem types, their priority for conservation, and sources for appropriate management measures in the Comprehensive Plan would provide the County guidance for appropriate land-use decision-making. The DNH system (if accompanied by an understanding of the conservation value and appropriate management of each community) would probably be fine for this limited use. But if the intent is to classify the entire county, the DNH system might take too much time and money. A hybrid system (Table E) would be easier, but would still be a formidable undertaking. It may be possible to use GIS to map out significant combinations of physical site factors; such as differences in slope, aspect, elevation, geology, and soils; and later correlate these with plant communities. The GIS mapping might be relatively rapid, but correlating with plant communities might be difficult. See Section VI for more detailed recommendations on ecosystem classification and other data-collection issues.

Note: For a discussion of classifying aquatic ecosystem types, see Table H in Section V.

ASSESSING THE CURRENT STATE OF ECOSYSTEMS

The discussions of ecosystem classification above are a first step toward a larger goal--assessing the current state of ecosystems in the County. In order for land planning to effectively include biodiversity conservation, it will be necessary to know how any particular site fits into large-scale landscape patterns, and how comprehensive planning should be guided by those patterns. As in most other counties, however, there are no available assessments of the structure, connectivity, or habitat quality of the County's fields, forests, and streams (see Section II for the importance of these issues). This is a major information gap that needs to be filled. Without the context provided by a large-scale assessment, conservation efforts will continue to be less effective than they might be. The assessment will need to build on the known history of the County's landscapes (see section III), and expand on the limited "snapshot" data that is now available to provide a sense of the trends in land-use and land-cover change.

The extent of such an assessment could range widely. As with other aspects of the County's biodiversity assessment, a balance will need to be struck between the amount of information needed and the resources available to carry out a landscape or ecosystem analysis. The Work Group has not had the resources to carry out this task. Instead, it is recommended that the standing Biodiversity Committee select a method for the analysis and determine who is best able to carry it out. The Recommendations section of this report includes detailed information on various approaches to biodiversity assessment.

The Division of Natural Heritage of the Department of Conservation and Recreation is developing the Virginia Conservation Lands Needs Assessment (VCLNA), a project that could add to the County's assessment and priority-setting efforts for conservation. VLCNA is working toward "identifying and prioritizing natural lands and the habitat corridors necessary to support and enhance them." This GIS project is intended to:

- direct land protection/acquisition - for conservation, historic/cultural resources, recreation
- prioritize other resource management actions - e.g. invasive species control
- identify priority potential restoration sites
- facilitate planning by local governments

Once a large-scale assessment is carried out, the results could be used to amend the Comprehensive Plan to recognize the existing and potential states of ecosystems in the County, with the goal of providing more specific direction for land use decisions.

CURRENT STATE OF BIODIVERSITY IN ALBEMARLE COUNTY

This section is a guide to terrestrial and aquatic biodiversity of the County. This information forms the basis of a county-wide Biodiversity Assessment, which will be augmented, improved, and updated over the years. Ecosystems and communities are presented first, followed by information on animal and plant species.

COMMUNITY AND ECOSYSTEM TYPES

Terrestrial Habitats and Plant Communities of Albemarle County

The forests and plant communities of the County are extremely variable. There are two factors that account for this variability. The first is the variation in physical site factors that affect plant growth and the second is the disruption and complete elimination of original plant communities that started when the county was first settled by Europeans and continues up to the present day.

Variation in physical site factors is caused by differences in geology, topography, elevation, and soils. These factors are all interrelated. For example, the kind of soil that occurs at a specific location in the county is determined by the nature of the underlying rocks (or sediment derived from the rocks), the topographic position on the landscape (ridge top, steep or gentle slope, flood plain, etc.), and the elevation (different kinds of soils occur at high and low elevations in the county even on similar rock types). The variation and interaction of these physical site factors is reflected in the different kinds of forests and plant communities that occur.

The human disturbance history of the county has completely altered the original, natural forests and plant communities that occurred here. There are no intact old-growth forests remaining. Much of the county was cleared of forest and cultivated or grazed, especially in the Piedmont areas of the county. Grazing was by hogs as well as cattle and horses; hogs are especially destructive. In the Piedmont (below about 700 feet in elevation), the only areas never used for agriculture were small areas that were too steep and rocky, which means that practically all of the forest in the Piedmont portion of the county is growing on land once cleared for agriculture and later abandoned. Much land was also cleared for agriculture in the Mountains, and what wasn't cleared was heavily logged.

Cultivation and heavy grazing have significantly reduced plant diversity, and the least disturbed areas tend to have the highest diversity. In the highly disturbed Piedmont portion of the county, the steep and rocky bluffs that were too steep to cultivate, and that occur in places along some of our rivers, are the only places that have preserved fragments of the original, native vegetation. The situation is much better in the mountainous portion of the county, because there has been less human disturbance. Logging has been the only disturbance on much of the steeper and rougher mountain land, and logging has a much less drastic effect on natural plant communities than cultivation or heavy grazing.

See section IV for a discussion of classifying terrestrial habitat types.

Aquatic Ecosystems and Habitats of Albemarle County

The dominant aquatic feature of Albemarle County is the network of streams and rivers. Wetlands, though not as common in Albemarle County as they are in other areas, are important elements of the aquatic system. There are no natural "lake" environments in Albemarle County, but there are many ponds and reservoirs that have been established by the impoundment of moving waters. Floodplains and riparian zones are critical to the aquatic systems and provide a transition to the terrestrial landscape. However, aquatic systems are ultimately connected to the entire watershed ecosystem from which they flow.

The local hydrologic cycle starts with rainfall, which is abundant relative to much of the continental United States. On average, the County receives 46 inches of rain per year though the number can be quite variable (Table G, VA State Climatologist 2003). The area is also characterized by a large amount of evaporation and plant transpiration amounting to a general potential of 31 inches per year returned to the sky (VA State Climatologist 2003). The water that is not evaporated or transpired leaves the watershed via streamflow. A key issue is how long the water stays in the watershed. Some rain water leaves almost immediately as stormflow; some water spends a modest amount of time (days to weeks to months) in the shallow groundwater before reaching a stream; and some water spends years or decades in the deeper groundwater. Along the way water is accessed by people, used, shifted around, and chemically altered by human use.

Table G. Estimated annual water balance for the Mechums River Watershed above Garth Road in Albemarle County, VA. The balance would be different in other watersheds with different characteristics. This table is based on data from the USGS (2003) and Virginia State Climatology Office (2003) analyzed by Albemarle water resources staff.

Source/Destination	*Inches*	*Percentage (%)*
Rainfall	46.6	100
Evaporation and transpiration	31	66.5
Stormflow	8	17.2
Shallow groundwater to stream	6.3	13.5
Deep groundwater and other	1.3	2.8

The climate is relatively consistent across Albemarle County, meaning that the major variables defining stream character are watershed size, stream slope, geology and soils, and land cover. These factors influence the amount of water that evaporates or transpires, leaves the watershed quickly as stormflow, or spends time as shallow or deep groundwater. They also influence the quality of the water.

Stream Ecosystems

Albemarle County's moving-water systems range from the smallest spring seeps and ephemeral swales to the James River. In general these streams support warm water fish communities (bass, large and small minnows, suckers, and sunfish). Some small streams coming off the Blue Ridge (particularly in the headwaters of the Moormans River) support marginal cold water fisheries (including native brook trout). Albemarle County streams support a diverse community of invertebrates including insects, mollusks, crayfish, and others. The mollusk community includes the endangered James Spinymussel (*Pleurobema collina*). Both the fish and invertebrate communities are discussed elsewhere in this report.

Many streams, such as the Rivanna, Mechums, and North Fork Rivanna rivers are characterized by silty streambeds and high sediment loads. They are deeply incised, creating a "green tunnel" effect during the growing season. Other streams, such as the Moormans River, still carry large sediment loads, but are characterized by large cobble and boulder substrate and somewhat more gently sloping stream banks. Some of the tributaries to the James River are very slow moving and almost tannic, similar to Tidewater streams. The James River, with its watershed of 4584 square miles at Scottsville (more than six times the size of Albemarle County) stretching all the way to the Appalachian Mountains, is in a league of its own among Albemarle waters.

While the entire watersheds function as ecosystems, stream reaches within a watershed can be divided into relatively homogenous ecosystem units. The Nature Conservancy has undertaken this exercise to support conservation planning (Table H). The Nature Conservancy analysis looks at rivers and large streams in a Southeast regional context. The method used by TNC is based on the physical underpinnings of the ecosystem units (Smith et. al. 2002). Presumably the physical setting is a determinant of the habitat conditions and community character. Of course, the actual habitat and biological condition is also impacted by tremendous historical and present human disturbance (discussed elsewhere).

Table H. Physical ecosystem unit classification of Albemarle County streams carried out by The Nature Conservancy (Smith et. al. 2002). Note that each of these streams and river types has a network of smaller perennial, intermittent, and ephemeral streams that feed them.

Class Description	***Stream(s) in Class***	***Geology***	***Watershed Gradient***	***Stream Gradient***	***Habitat observations (not from TNC effort)***
Medium Piedmont rivers originating in the Blue Ridge / Central Appalachians	James R.	Granite/gneiss, sandstone/metasandstone, schist/phyllite			Large warm water river
Small Piedmont rivers, originating in the Blue Ridge	Rivanna R., Rockfish R.	Granite/gneiss, sandstone/metasandstone, schist/phyllite			Small warm water river
Transitional streams, Blue Ridge to Piedmont	Mechums R., Stockton Cr., Lickinghole Cr., Powell Cr., NF and SF Hardware R.	Granite/gneiss	Low	Low, very low	Classic Piedmont warm water streams. Some important mussel habitat.
	NF Rivanna R., Swift Run, Lynch R., Moormans R., Doyles R., Buck Mt. Cr.	Mafic hardrock	Moderate, high	Low	Diverse group of warm water streams with important mussel habitat Cool water tributaries.

Piedmont streams	Hardware R., NF Cunningham Cr., Mechunk Cr.	Sandstone/metasandstone	Low	Low, very low	
	Ballinger Cr.	Schist/phyllite, mudstone/shale	Low, moderate	Low	
	Totier Cr.	Schist/phyllite, mudstone/shale	Low	Low	Slow moving, small, dark, warm water stream
Piedmont streams on small isolated mountains	Buck Island Cr.	Schist/phyllite, mudstone/shale	Moderate, some high	Low	
	Moores Cr., Ragged Mt. Cr.	Mafic hardrock	Moderate, some high	Low, very low	Small warm water streams highly affected by current human impacts

Wetlands

In spite of a large amount of rain in the area, sloping land and high rates of evaporation and transpiration preclude conditions that would support the vast wetlands found in Coastal Plain areas or in northern North America. Still, there are important, interesting wetlands scattered across the County, and their relative rarity makes them all the more precious as habitat for plants, frogs, toads, salamanders, and aquatic insects.

As of the early 1980s, the National Wetlands Inventory (NWI) reported 2,169 acres of non-impoundment wetlands in Albemarle County and the City of Charlottesville totaling about 0.5% of the land area (Table I, USDOI 1988). Site scale surveys indicate that there probably are more wetlands than the NWI reported. Many of Albemarle County's wetlands are small, vernal pools or topographic dips in hill slopes that aren't catalogued in large-scale wetland surveys. Wetlands in Albemarle tend to come in the form of:

- Back swamps (wet areas at the base of the hill slope at the back edge of a floodplain)
- Complexes of abandoned stream channels in floodplains
- Occasionally flooded floodplains
- Temporary perched water tables on soils with low percolation
- High water tables near stream channels and impoundments
- Fringes of impoundments
- Topographic depressions that dip into the water table on hill slopes
- Spring seeps

Table I. Non-impoundment wetlands by type in Albemarle County, VA and the City of Charlottesville.

Wetland Type	Acres in County and City	Percentage of County & City
Emergent	436	0.1
Forested	1,410	0.3
Scrub/Shrub	278	0.1
Shoreline	45	<0.05
Total	2,169	0.5

Many wetland plants, both common and rare, are found on these sites. These plants and plant communities are referred to elsewhere in this document. Dominant tree species include Sycamore (*Platinus occidentalis*), Red Maple (*Acer rubrum*), Box Elder *(Acer negundo*), and Green Ash (*Fraxinus pennsylvanica*). Dominant shrubs/small trees are Speckled Alder (*Alnus serrulata*), Common Elderberry (*Sambucus canadensis*), Black Willow (*Salix nigra*), and Spice Bush (*Lindera benzoin*). Dominant herbaceous and grass-like plants include soft rush (*Juncus effusus*) and Wool Grass (*Scirpus cyperinus*) in emergent wetlands and New York Ironweed (*Vernonia noveboracensis*), Wingstem (*Verbesina alternifolia*), and Joe Pye Weed (*Eupatoriadelphus fistulosus*) in areas of frequently saturated soils.

Though the only naturally still water in Albemarle County is in beaver ponds, larger ponds and reservoirs have become fixtures in the landscape. Using the NWI estimates from the early 1980s, there are more than 3,441 acres of impounded water in the County and City covering nearly one percent of the land area (USDOI 1988). The presence of these human-made impoundments has vastly increased habitat for lake and pond fish species, such as sunfish and bass (family Centrarchidae). These impoundments create wetlands of different types. Small, shallow ponds may fill a niche once filled by beaver ponds, particularly if native vegetation is allowed to grow along the shoreline (though not on the dam, which must be kept clear). In spite of their advantages as wetlands, still water fish habitats, water supplies, and sediment traps, ponds and reservoirs have several negative impacts on aquatic ecosystems as well.

Riparian Areas / Floodplains

Even when they technically are not wetlands, riparian (or "stream-side") areas have tremendous value to both aquatic and terrestrial systems (Wenger 1999). Riparian areas are defined by their functional connection to and influence over the stream. By definition the water table near the stream usually is close to the land surface. During storms the water table rises, preventing infiltration. Much of the initial storm flow comes from areas adjacent to the stream. The roughness of the vegetation near streams slows and delays floodwaters and traps sediment and other pollutants. Over years, deposits from flooding streams produce floodplains and create complex topography resulting in habitat diversity. Because the water table is close to the surface, the likelihood is higher that the roots of plants near a stream will tap the water table, contributing to groundwater cleaning. Microbial activity in this zone is a major factor in nutrient removal as well. Vegetation near streams holds stream banks and riparian sediment in place. Branches and leaves from near-stream vegetation provide structural habitat and food to stream organisms. Shade from streamside plants helps keep streams cool. Riparian areas often have much greater species diversity that surrounding landscapes (Wenger 1999). Buffers can help people connect to streams and find refuge in a natural setting serving as corridors for private or public pathways.

Table J. Estimated area and length of stream, stream buffer, and floodplain in Albemarle County, VA and the City of Charlottesville (USGS 1990s, FEMA 1980).

Feature	*Amount County and City*	*Percentage of County & City*
Streams	2,013 miles	NA
Land Within 100 Feet of Streams	48,794 acres	10
Floodplain	28,931 acres	6

IMPORTANT SITES

Rare and unusual habitats, with their associated plant/wildlife records, are found scattered throughout Albemarle County, and area naturalists have long thought it would be beneficial to have a listing of these "special places." With the formation of the County Biodiversity Work Group, this effort was undertaken early in 2002, and the initial results are contained herein.

The knowledge accumulated by longtime County residents with a lifetime passion for natural history is invaluable. This list is an attempt to *begin* a database for such input. It is meant to serve as an outline, a "starting point" to which data can be added or amended. Once this database is created, these sites can be identified in the Comprehensive Plan as important sites to be considered in policy development, land-use planning, and application reviews. Because of the variety of site types and sizes, they could be grouped in the Plan to clarify the values represented or protected at each site.

This initial list is heavily biased toward plant occurrences and habitats; much overlap will naturally occur with notable wildlife habitats and species records, and more wildlife-related data will be forthcoming. In addition, the list can be expanded beyond individual habitats or species occurrences to include areas that are of particular importance for providing major habitat blocks and connectivity. (Note: the map included below is intended only to show the general location of these areas and sites, and not to set precise boundaries.)

The list (included in Appendix A) is the result of two meetings in February and March of 2002. Those providing input were: Ralph Bartholomew, Dan Bieker, Tom Dierauf, Ruth Douglas, Ken Lawless, Bess Murray, Jim Murray, and Mo Stevens. No specific standards for inclusion of any of the sites are implied or to be assumed; they are simply those places agreed to by the group as being foremost in their uniqueness, based on their expertise and years of field experience. It should be noted that 95% of this initial data is credited to Mo Stevens, one of the top field botanists in Virginia and a life-long Charlottesville resident.

SPECIES

Vertebrates

This section contains data for the vertebrate species of Albemarle County. In the attached lists (see Appendices B through F), species that are known or likely to occur in the County are listed by common and scientific name; global, national and state ranking; county occurrence; as well as habitat preferences and other county-specific notations. Given the extensive gaps in research and secretive nature of many species, it should be understood that rankings are often a "best informed guess", and should not be taken as the definitive status of many of these animals. Also, Natural Heritage rankings are subject to update; they can and do change.

A note on the county status of species: extremely little published data specific to Albemarle County exists on the status of most species. Information contained herein is the best that could be gleaned by the author using the references stated (listed in each section), personal records and experience, reports from students and field classes conducted since 1984 at Piedmont VA Community College, and anecdotal reports filtered through the Ivy Creek Foundation since 1983. The Ivy Creek Foundation serves to a large degree as a community clearinghouse for nature-related information and is served by many area scientists, professional and amateur naturalists, and nature clubs.

Albemarle County, with both Blue Ridge Mountain and Piedmont habitats, has traditionally supported a wide diversity of native fauna.

Trends

Reliable, long term data on population trends for Albemarle County vertebrates (other than humans) exists for only one class--birds. This information has been compiled through the Audubon-sponsored Christmas bird counts, and extends back to the 1920s. While some species have certainly prospered from human-induced change to the environment, the overall conclusions from eight decades of this data are undeniable: diminished diversity, dramatic declines, and outright extirpation of many species. It takes no great leap to extend these conclusions to all our native fauna--as wetlands are destroyed, forests fragmented, and more areas are mowed, paved and otherwise manipulated, diversity of species in all taxa is diminished. Declines and extirpations are unavoidable in the county if human settlement patterns and density continue along current trends--as has already occurred with Gray Wolf, Elk, Porcupine and others that need extensive, undisturbed wilderness. Other species, such as Henslow's Sparrow and Bewick's Wren, have also been extirpated from the County. Other declines are avoidable or can be diminished if a commitment is made to habitat preservation--and wise farming, logging, and county planning practices are adopted.

Albemarle County is fortunate to be the home of several experienced and expert field naturalists. Their field notes and publications can provide information on trends where more formal studies are not available. For example, John Grey and Charles E. "Mo" Stevens, Jr.'s 1949 article on "The Birds of Albemarle County" (published in the November/December issue of the Virginia Society of Ornithology's journal "The Raven") provides both a useful history of local field studies and an assessment of bird occurrences and populations from over a half-century ago.

Policy and Management Needs

While specific management practices can be employed to benefit certain species, and the case can be made that any action will be to the benefit of some and the detriment of others, some overall practices come to obvious light as beneficial to a healthy biodiversity. In general:

Highest priority should be given to the preservation of wetland habitats. They are often the most productive areas and a vital element in the overall ecosystem, and the most vulnerable. Albemarle is not especially well-endowed with wetland habitats, which makes those that exist all the more precious. Undisturbed streambanks and river corridors with extensive naturally-vegetated buffers are critical to many species, as well as to water quality.

Forest fragmentation is a slow, often indiscernible process, but a serious factor in the decline of many plant and animal species. Not only is habitat directly lost, but that which remains is far more susceptible to roaming predators who don't venture very far into extensively wooded areas. A ground-nesting bird such as an Ovenbird or Wild Turkey which finds safety in the deep woods is far more vulnerable to edge-roaming predators such as skunks, Virginia Opossums, Brown-headed Cowbirds, or house cats if once-contiguous forests become scattered woodlots. In fragmented tracts, the loss of just one or two breeding pairs of native fauna can precipitate a loss over an extensive area. Retaining and restoring large, unbroken tracts of mature woodland should be a priority in land planning.

Farming practices that encourage brushy fencerows, field dividers in large pastures, and limited use of pesticides and chemical fertilizers can benefit biodiversity. Impacts can also be limited where livestock is limited to pastures and well-defined forage/holding areas; allowing them access to streams and woodlots causes serious erosion, water quality decline, and loss of habitat.

Logging operations in the spring and early summer cause obvious peril to nesting fauna. Most vertebrates are actively involved in reproduction at this time. Roadside and railway spraying should also not occur during these months.

Mammals

Fifty-one mammal species (excluding humans and domestic animals) occur in Albemarle, plus 6 possible (though unlikely), and 4 species extirpated in the past 200 years (Porcupine, Gray Wolf, Elk, and American Bison). While some species thrive with current land use practices—such as Gray Squirrel, Woodchuck, White-tailed Deer, and Opossum—many are suffering declines. Principal factors in the declines include residential and commercial development, soil disturbance, forest fragmentation, pollution, increased vehicle traffic, and increased conversion in recent decades of farmland to short grass pasture. Loss of native trees to introduced insects and diseases is detrimental to the abundance and diversity of mammals also, especially in the case of the ongoing loss of the Eastern Hemlock. (The species most affected by Hemlock loss include Smoky Shrew, Hoary Bat, and Southern Red-backed Vole.) Historic loss of large predators such as Gray Wolf and Mountain Lion and the creation of large amounts of edge habitat have led to artificially high levels of deer and some rodents. County trends in mammal populations mimic those throughout the region —species that tolerate human activity, mixed habitats, and land disturbance are stable or increasing; those that require cool/moist situations, undisturbed forest, or isolation from human activity are in decline or extirpated.

See Appendix B for the "Annotated List of the Mammals of Albemarle County."

Amphibians

Twenty species of frogs, toads and salamanders are found in Albemarle County; eight more are possible. The status of many species is poorly or completely unknown due to lack of study and the secretive/hidden nature of many subjects. Many, including Spring Peeper, Red-backed

Salamander, and American Toad are quite common, while others are only very rarely encountered. The County seems to support a wide diversity of species (although not overwhelming numbers of individuals), due to the presence of both mountain and piedmont habitats. Most amphibians are sensitive to pollution and habitat disturbance, and can be good indicators of troubled ecosystems—although most populations remain difficult to track. One alarming trend of the past few decades has been the apparent decline of the Upland Chorus Frog, a once common species now rarely heard in the County.

See Appendix E for the "Annotated List of the Amphibians of Albemarle County."

Reptiles

Turtles, lizards and snakes are represented by 30 species in Albemarle County; 7 more are possible. As with amphibians, many of these animals are not easily detected or studied, thus their status remains unclear. Many reptiles, especially turtles, are hardy animals and can be long-lived. While well-suited to life on dry land, most reptiles depend heavily on, and are most often found in, wetland situations—and are thus particularly susceptible to loss of this habitat type. Loss of habitat and human persecution is responsible for declines (some dramatic) of many species in Albemarle, including Milk, Brown and Corn snakes, Kingsnakes, Snapping Turtles, and Timber Rattlesnakes. Forest-dwelling snakes as well as Eastern Box Turtles are vulnerable to forest fragmentation, and have suffered declines. Few animals are more beneficial in controlling rodents than snakes, yet untold numbers continue to be killed out of ignorance and fear.

See Appendix F for the "Annotated List of the Reptiles of Albemarle County."

Birds

Due to their relatively high visibility and vocal abilities, birds are the most readily accessible form of wildlife to most people, and are consequently the most studied. 284 species have been documented in Albemarle County since 1950, including 111 breeders, 14 accidental species, and 2 former breeders now extirpated (Bewick's Wren and Henslow's Sparrow). The diversity of species present in the county and their varying habitat requirements ensure that loss of any habitat will have negative effects on one species or another.

However, notable trends in the County exist, supported by decades of Audubon Christmas Bird Count data, observations/records of long-time County residents, Breeding Bird Surveys held each May in the County, and corroborating regional scientific studies. Of greatest concern is the significant decline of neotropical migrants, including many warblers, tanagers, vireos, and flycatchers. See table K for an analysis of bird population trends in Virginia, as found in Breeding Bird Survey data--data specific to Albemarle County is not currently available from this Survey.

Although causes are many, the primary factor is the decline in quality of breeding habitat - areas for which we are responsible. Forest fragmentation is a principal culprit—in direct loss of nesting sites, but more insidiously in the increased ratio of edge to forest interior, which facilitates predation by more open-land predators such as skunks, foxes, Virginia Opossums, Blue Jays, Brown-headed Cowbirds, and feral/domestic cats. Kentucky Warbler, Ovenbird, and Cerulean Warbler are examples of species suffering dramatic declines in the past three decades.

Table K. Population trends of resident bird species versus neotropical migrant species in Virginia during the recent (1980-2002) and complete (1966-2002) time periods included in the Breeding Bird Survey[1]. The number of statistically significant (P< 0.05) trends is shown in parentheses. A + indicates an increasing trend, whereas a – indications a decreasing trend (a few species had 0.0 trends and are not shown here).

Group	1966 – 2002		1980 - 2002	
	+	-	+	-
Neotropical migrants (n = 52 species)	23 (6)	28 (11)	21 (6)	30 (9)
Resident species (n = 48 species)	26 (11)	21 (10)	24 (8)	23 (10)

Another trend which has precipitated the decline of many species is the steady conversion of mixed use farmland to pasture over the past 30 to 40 years, and (since the ready availability of brush-killing herbicides) the increased loss of brushy fencerows, roadsides, and woodland edges. Bobwhite Quail, Upland Sandpiper, Bachman's Sparrow, Bewick's Wren, and Loggerhead Shrike have all been seriously affected.

Conversely, the past decade has seen the increase of some species in the County as they recover from past pesticide poisoning, and experience range expansion (Bald Eagle, Osprey, Double-crested Cormorant, Tree Swallow). Insect and fungal diseases of native trees, most notably Eastern Hemlock (wooly adelgid), and Sycamore (a fungal disease is killing many trees) are bound to translate to loss of breeding opportunities for species dependent on these trees—especially Northern Parula and Yellow-throated Warbler, respectively.

The quantity of data available on bird populations has made it possible for several organizations to identify the species most in need of conservation efforts. The U.S. Fish and Wildlife Service has identified seven "species of concern" (not yet listed as endangered or threatened, but showing significant negative population trends) for Virginia; six of those species occur in Albemarle County (see Table C-3 in Appendix C).

Partners in Flight, a cooperative land-bird conservation effort linking conservation organizations and government agencies, has developed a Landbird Conservation Plan for the Mid-Atlantic Piedmont, a region that includes all of Albemarle County. The eleven priority species from that plan, all of which occur or have occurred in Albemarle County, are shown in Table C-4 in

[1] The Breeding Bird Survey (BBS) is a large (> 2000 volunteers) international breeding bird survey conducted in June each year across Canada, the U.S., and Mexico. It is supported by the U.S. Geological Survey and data are maintained at the USGS Patuxent Wildlife Research Center, Laurel MD. For more details, visit: http://www.pwrc.usgs.gov and visit the BBS under the Monitoring Programs page for trend summaries by species at scales ranging from individual states to regions to the entire country.

Appendix C.

The National Audubon Society maintains a "watch list" of bird species "facing population declines and/or threats such as habitat loss on their breeding and wintering grounds, or with limited geographic ranges" (from www.audubon.org). Twenty-five of those species occur in Albemarle County, and are listed in Table C-5 in Appendix C. This table includes species listed with a status of "red" or "yellow" (see below for explanation); "green" species are not under threat.

- RED: species in this category are declining rapidly, have very small populations or limited ranges, and face major conservation threats. These typically are species of global conservation concern.
- YELLOW: this category includes those species that are also declining but at a slower rate than those in the red category. These typically are species of national conservation concern.

(from www.audubon.org)

As stated above, observation data from the annual Christmas Bird Count provides some information on population trends for wintering birds in the County. Each count consists of a one-day group effort in early winter, in which observers travel assigned routes within a fixed 15-mile-diameter circle and record every individual bird seen or heard. There are two count circles in the County--the "Charlottesville" circle, centered on Ivy, and the "Warren" circle, centered on Keene.

Graphs of this data included in Appendix C show number of birds found per observer hour (a measure that corrects the rate of observation for the time spent searching, which varies from year to year) for both circles. The species in these particular graphs were selected from the total list of species occurring in the County by finding all the wintering species that are included on the FWS species of concern list, the Audubon watch list, and/or the PIF priority list mentioned above. (Short-eared Owl and Dickcissel were not graphed; while these species occur in the County, they have not been observed during the CBC within the Charlottesville count circle.) Other graphs could be created for other species of interest. (Note that some species have changed names during the count period, and the data for both names has been combined; for example, “woodcock” was changed to “American Woodcock.”)

While some species (such as Rusty Blackbird and Grasshopper Sparrow) have only appeared intermittently during the counts, and thus are difficult to analyze, other species show visible trends in these graphs. Northern Bobwhite, Loggerhead Shrike, and Field Sparrow, for example, show quite pronounced declines.

A similar citizen monitoring effort, the Breeding Bird Survey (see description above), has generated data for trends of breeding species, many of which would not be monitored by the Christmas Bird Count as they are not found in the area during winter. Tables C-6 and C-7 in Appendix C show species found to have statistically significant negative or positive trends in the Breeding Bird Survey Data. The data on trends is not solely from Albemarle County, as county-level data is not available; in this report, we have used data from the Southern Piedmont ecoregion (which includes Albemarle). State-by-state data is also available, but the Southern Piedmont is generally more similar to Albemarle than is the entirety of Virginia. (Comparisons to Blue Ridge/Appalachian regions would also be useful.)

A valuable task for the County's ongoing biodiversity assessment would be to determine the habitat-change trends implied by the patterns of increasing and decreasing species, and to attempt to compare those trends to past landscape states, including both pre- and post-Colonial periods.

See Appendix C for the "List of the Birds of Albemarle County." *Note: Information in this list is based on* <u>The Birds of Albemarle County, VA</u>*, by Charles E. (Mo) Stevens, Jr., and Bill Minor, 1997. It has been updated with the addition of two species, Painted Bunting and Swallow-tailed Kite.*

<u>Fish</u>

Fish are probably the most thoroughly studied and best understood aquatic taxa group in Albemarle County. Still, the fish communities of the county could use a more comprehensive and systematic analysis. Fifty-nine species of fish have been collected in Albemarle County (Jenkins and Burkhead 1993, VDGIF 2002, Chappell and Woodward 1998; see Appendix D). Twelve more species are likely to be present based on their reported ranges or records of introduction (Rohde et. al. 1994, DGIF 2003). Of the 59 reported collected species, 11 were introduced to the watershed by humans. Of the 71 species believed to include Albemarle in their range, 17 were introduced. Historic trends in fish populations and species diversity are not available, but there is no reason to think that the Albemarle County trends are any better than the rest of the United States. In the U.S., 37% of recorded freshwater fish species are now rare, imperiled, or extinct. (Master 1998). In Virginia 20% of fish species are similarly at risk.

With the exception of a few cold water (or trout) streams on the eastern slope of the Blue Ridge Mountains, most of the county streams are occupied by warm water fish communities. Many of the most familiar fish are introduced game species such as Bluegills (*Lepomis macrochirus*), Largemouth Bass (*Micropterus salmoides*), and Smallmouth Bass (*Micropterus dolomieu*). However, the greater diversity comes from less well known, non-game fish, particularly from the minnow family (Cyprinidae). Some of these minnow species are identified as keystone species. Nature Conservancy planning documents report that "chub species including Bluehead Chub (*Nocomis leptocephalus*), Bull Chub (*Nocomis raneyi*), River Chub (*Nocomis micropogon*), and Fallfish (*Semotilus corporalis*)…are considered keystone species because they build large nests in which many species spawn" (TNC 2002, RRBR 1998). Only one species known to occur in the county has a special federal status. The Appalachia Darter (*Percina gymnocephala)* is listed as a Federal Species of Concern. Certainly some of the species are locally rare.

By Virginia standards, Albemarle County's fish community is moderately diverse. The 59 collected species in Albemarle represent almost 60% of the 99 freshwater species reported in the 10,000 square mile James River Watershed to which almost all of Albemarle County drains (Jenkins and Burkhead 1993). Twenty six of the species in the James River Watershed are believed to be introduced. For context, the diversity of the James is high relative to the 49 freshwater species of the Virginia's portion of the Delmarva Peninsula or even the 91 species of the larger Potomac River Watershed, but it is moderate compared to the 247 species of the Tennessee drainage (among the most diverse freshwater systems in the world). Moderate diversity in the United States translates to high diversity in a worldwide context.

Jenkins and Burkhead (1993) provide an outstanding resource on the Freshwater Fishes of Virginia that includes maps of historical observations. Rohde et. al. (1994) provide a more portable guide to fish of the region including range maps. The Virginia Department of Game and Inland Fisheries keeps records of fish observations made by their staff and those to whom they grant collecting permits. A discussion of fish, particularly nest-building minnows, as indicator species is available in Rivanna Basin Roundtable's Rivanna River Basin Project State of the Basin 1998.

Invertebrates

Terrestrial Invertebrates

Relatively little information is available on the diversity of terrestrial invertebrates in Albemarle County. Certainly there is a great diversity. The NatureServe (2004) database lists 1676 species of invertebrates in Virginia (including aquatic invertebrates).

Nuisance species and charismatic species receive the most attention as can be seen in the Department of Game and Inland Fisheries records which highlights ticks, butterflies and moths (Lepidoptera), and only a few species from other groups (DGIF 2004, Appendix G). The Ivy Creek Foundation has a list of butterflies of the Ivy Creek Natural Area (Appendix G). In spite of the modest level of attention they receive, invertebrates are a huge influence on terrestrial ecosystems through their roles in a host of functions including pollination, breaking down materials, serving as food, killing trees, influencing soil characteristics, acting as pests, controlling pests, etc.

A project related to terrestrial invertebrates that may not have taken shape without the presence of the Biodiversity Work Group has been a volunteer survey of bee diversity in Albemarle County. This effort has been supported and supervised by the U.S. Geological Survey and a professor at UVA. Bees are critical to ecosystems as pollinators. The introduced western or European honeybee (*Apis mellifera*), which had naturalized in North America, has been viewed as a primary pollinator for centuries. Mite infestations practically have eliminated wild honeybee populations and have created great difficulties and substantial costs for beekeepers. The decline of the honeybee has revived interest in native bees as pollinators and has reemphasized the importance of maintaining biodiversity to serve unforeseeable societal and ecosystem needs.

The "Albeemarle" survey started in the spring of 2003 and continued through the fall. In that sampling season nine volunteers collected and mounted approximately 3200 bee specimens that are now being identified by the USGS staff (Droege 2004). Though there has been almost no previous study of Albemarle bees, USGS staff expect, based on the scientific literature that as many as 250 bee species could be present in the county (Droege 2003).

Aquatic Invertebrates

The aquatic invertebrates (animals without backbones) make up a fascinating and important but spottily understood taxa group. There is limited information on the aquatic macroinvertebrates (which are visible to the naked eye), particularly within a few taxa groups. The aquatic macroinvertebrates include flatworms (Phylum *Platyhelminthes*), leeches and earthworms (*Annelida*), mollusks (*Mollusca*—snails, mussels, and clams), mites (*Hydracarina*), and crustaceans (*Crustacea*—crayfish, scuds, and sow bugs), and a large variety of insects (*Insecta*, Voshell 2002). In some cases, particularly for the insects, the species level taxonomy has not been characterized fully. (There is almost no information on microscopic organisms.) While it is unrealistic to expect that all aquatic invertebrate identification and taxonomy will be resolved any time soon, there is much opportunity for student projects and state and local efforts to improve the knowledge in this area.

A few of the taxa groups are better understood than others. The mussel community (class *Bivalvia*) has received significant attention because of species of concern (see below). Dragonflies and damselflies (order *Odonata*) are better understood, for cultural reasons and because of their relatively long adult stage and the associated ease of identification. There is limited information on crayfish species. The mussels and dragonflies and damselflies serve as examples of the non-insect and insect diversity of Albemarle's aquatic ecosystems, but they represent only a small part of the picture.

Twelve species of native freshwater mussels (family *Unionidae*) have been observed or are believed likely to occur in Albemarle (Appendix G). One, the James Spinymussel (*Pleurobema collina*) is a federally listed endangered species. The Green Floater (*Lasmigona subviridis*) is a federal species of concern. The Atlantic Pigtoe (*Fusconaia masoni*) is listed as threatened by the state of Virginia. There are nine species of known or likely gastropods (mainly snails).

As Albemarle's only resident federally listed endangered animal species (of any variety), the James spinymussel receives a great deal of attention. (Other species may have been extirpated already.) The James spinymussel was originally believed to be limited to the James River drainage but has recently been discovered in the Roanoke River drainage (Neves 1991 and 2003, NatureServe Explorer 2003). In any case, Albemarle is a hot spot for this rare mussel. The James spiny mussel is an example of the roughly 67% of freshwater mussels that are vulnerable, imperiled, or extinct in the United States (Master et. al. 1998). (See table G-1 in Appendix G for a list of mollusks known to occur in the County.)

Approximately 80 species or dragonflies (suborder *Anisoptera*) and more than 20 species of damselflies (suborder *Zygoptera*) are likely to occur in Albemarle (Appendix G). Like many aquatic insects, the dragonflies and damselflies develop as nymphs or juveniles in the water and emerge to the terrestrial environment for breeding. The diversity among the *Odonata* serves as an example of the diversity across aquatic insect orders including beetles (*Coleoptera*), flies (*Diptera*), mayflies (*Ephemeroptera*), caddisflies (*Trichoptera*), stoneflies (*Plecoptera*), and more. The *Odonata* group also serves as an example of the imperiled state of freshwater aquatic insects. Approximately 18% of *Odonata* are vulnerable, imperiled, or extinct (Master et. al. 1998). The *Odonata* are unusual among aquatic insects in having their taxonomy well defined to the species level. The taxonomy of some aquatic insect groups is not definitive. The *Odonata* are predators and are most common in wetlands, ponds, and slow moving water habitats though a few occupy fast water and riffles. The many other aquatic insects use a range of habitats and feeding strategies (including scraping algae, shredding leaves, and collecting or filtering particles). See Table G-2 in Appendix G for a list of the County's known or potential *Odonata*.

Six species of crayfish appear as known, likely, or observed in Albemarle County in VDGIF databases (VDGIF 2002, VDGIF 2003, Watson 2003). Virginia is credited with at least 23 species (NatureServe Explorer 2003). Of the 322 species of crayfish identified in the United States, 52% are now extinct, imperiled, or rare (Master et. al. 1998). The threats are similar to those faced by other freshwater taxa. See Table G-3 in Appendix G for a list of crayfish.

Aquatic macroinvertebrate community composition is frequently used as a measure of stream water and habitat quality. Two such monitoring efforts take place in Albemarle County. First, the Virginia Department of Environmental Quality (VDEQ) uses aquatic invertebrate identification to the family level to estimate water quality. Thirty-seven families of insects and 12 families of non-insects have been collected (in riffle habitat only) by DEQ in Albemarle County (Appendix G, VDEQ 2002). (In many cases multiple species within the same family probably were collected.) More families probably will appear over time. Second, the protocols of Virginia Save Our Streams have been applied recently by a local program called StreamWatch. This method uses a mixture of order and family level identification to allow citizens to monitor stream health. A similar, previous effort was carried out as part of the Rivanna River Basin Project (1998). In this study, the data were difficult to interpret but indicated particularly poor water quality in Meadow Creek, particularly good water quality in Buck Mountain Creek, and relatively good water quality elsewhere in the Rivanna Watershed. The StreamWatch program (www.streamwatch.org) uses an updated methodology that may shed more light on the situation. See Table G-4 in Appendix G for more information on aquatic invertebrate families in Albemarle County.

There are a variety of good sources of information on aquatic macroinvertebrates. Family level identification and life history information and excellent illustrations are available in McCafferty 1983 and Voshell 2002. The standard book for identification of aquatic insects to the genus level is Merritt and Cummins 1996. Adult dragonflies are identified to species and described in Dunkle 2000. On the web, information on aquatic macroinvertebrates is available at NatureServe.org and www.npwrc.usgs.gov and at other sites that can be found through Internet search engines. The Virginia Museum of Natural History sells a series of booklets on "The Insects of Virginia." The series covers several aquatic taxa groups.

Table G-5 in Appendix G includes a list of observed invertebrate species from Albemarle County (both terrestrial and aquatic).

Plants

Albemarle County currently has a considerable diversity of plants--about 1336 species as of

2003. Of these, some 1066 are natives that were probably present before the arrival of European settlers in the County. There is no information available to tell us how many species may have been present in pre-settlement time which have now been extirpated by the destruction of habitat through farming, mining or other developments of civilization. Meanwhile settlers brought with them many aliens, some intentionally and others unintentionally, and more continue to arrive or are discovered each year. A list of the Albemarle Flora can be obtained from the Third Edition, "Atlas of the Virginia Flora (1992)". A copy of this list, which was extracted from the electronic database "Virginia Flora Display Program rev. 2.1" by Tim Williams, will be on file in the Albemarle County Planning Department.

Despite the obvious interest of Thomas Jefferson in the trees, shrubs, and plants of Albemarle County, very little in the way of formal studies of the flora of the county took place before the early 1950s. The gardens at Monticello, although very extensive, had many more alien herbaceous plants than natives, and detailed records of native plants are scarce or non-existent. Jefferson did keep extensive records of a multitude of fruit trees, shrubs and vines, many of which were native to Albemarle County. These are discussed in "The Fruits and Fruit Trees of Monticello" by Peter J. Hatch.

The first extensive studies of the flora of Albemarle County were started by C. E. (Mo) Stevens in the early fifties and are still ongoing. Most of our current knowledge of the flora of this county is due to his dedication. A few others—Tom Wieboldt, Bruce Davenport, Kenneth R. Lawless, Tom Dierauf, Bill Minor, and Tim Williams—have made, and continue to make, contributions to the Flora of the County.

About 100 of the vascular plants of Albemarle County are classified as Rare or Very Scarce; see Table I-1 in Appendix I. Most of these rarities are found either on steep bluffs along rivers or creeks, or in wet areas where lumbering or farming was difficult or impossible. Information on several such sites is included in Appendix A, "Important Sites." The difficulty of building housing in such areas has also been an important factor in the survival of these plants, although with modern building techniques, these areas are more and more threatened. Over the past 50 years, the construction of houses along formerly almost-deserted county roads has caused major changes in the population of many native plants once seen as common, and likewise has brought about an increase in alien plants, many of which have a drastic harmful effect on our natives, as discussed elsewhere in this report.

Observation Mapping

Charles E. "Mo" Stevens, a resident of Charlottesville, has long been recognized as one of Virginia's outstanding naturalists. For decades he has recorded observations on occurrences plants in Virginia, including Albemarle County. These observations are recorded on field maps and notebooks and extend back to the early 1960's. Mr. Stevens agreed to digitization of his observations on notable plant occurrences in Albemarle County and to the use of these data in efforts to protect local biodiversity.

Field observations from Albemarle County were recorded on twenty USGS quad maps. Shape files of the locations of Stevens' observations were created using photocopies of these field maps and ArcGIS software with georeferenced images of the same USGS maps. Over five hundred observations from field maps are recorded, along with taxonomic, observation date and other information. Most of these records are of plant species that are locally uncommon. Some refer to invasive exotics and a few refer to animal observations. All observations from each map containing Albemarle County data were digitized, so some of these observations from these maps occur in adjoining localities.

While reviewing the initial digitizations, Mr. Stevens provided comments on the significance of many of the locations. Auxiliary databases for these significance comments have been created. Their entry is nearly complete.

Current Management Activities

Across the County, various programs are in place that have benefits for biodiversity. This section briefly reviews the current state of those efforts:

- Donated Conservation Easements: These voluntary private agreements between a landowner and a land-conservation organization usually limit the development potential of a property and/or prescribe management activities. These easements can be used as a tool to protect habitats. Easement holders active in the County include the Virginia Outdoors Foundation, the Thomas Jefferson Soil & Water Conservation District (TJSWCD), Albemarle County and its Public Recreational Facilities Authority, and the Nature Conservancy.
- Purchased Conservation Easements: The County's Acquisition of Conservation Easements program (ACE) gives landowners the opportunity to sell development potential while keeping their land intact.
- Funding Programs: Several state and federal programs are available to provide funding to landowners for conservation management activities on their land. The TJSWCD can provide assistance with these programs.
- Technical Assistance: The TJSWCD is also available to provide advice and assistance to landowners who are planning conservation work on their land.
- Tracking Conservation Lands: The Virginia Department of Conservation and Recreation maintains an up-to-date online map and database of conservation lands in Virginia. The information can be viewed and downloaded at http://www.dcr.state.va.us/dnh.

BIODIVERSITY EDUCATION

INTRODUCTION

The citizens of Albemarle County value the natural landscape and the plants and animals living therein, and have demonstrated that they support the goal of protecting biodiversity. The County has formalized this shared value in the Comprehensive Plan and citizens have confirmed it in public surveys. However, evidence suggests (from various forums, comprehensive plan documents, surveys, etc.) that public support for the general goal of protecting biodiversity is ahead of people's understanding of the steps required to achieve that goal. Thus, there is a need for a public education program that contributes to both understanding and positive action in support of biodiversity.

There are several existing and successful education efforts that address biodiversity to varying degrees. However, there is no overall framework for biodiversity education. A local biodiversity education framework could place these program-by-program efforts in a county- and ecosystem-wide context to help the county achieve its biodiversity goals.

There are also many needs in biodiversity education that are not served adequately. A biodiversity education framework could help in the identification of these gaps. The County could look for opportunities to provide or encourage the biodiversity education efforts that would help it achieve its goals. The Biodiversity Work Group can begin the process of establishing this framework. Most of the work will need to be further developed and continued by the Biodiversity Committee.

GOALS FOR A BIODIVERSITY EDUCATION FRAMEWORK

A biodiversity education program should strive to achieve the following goals:

- To establish a comprehensive framework for biodiversity education that is linked to the achievement of biodiversity protection goals.
- To conduct and support a variety of education programs that develop understanding of biodiversity, ecosystem services (services like pollination and clean water that healthy natural systems can provide) and the importance of their preservation for individuals and the community.
- To develop citizen understanding of biodiversity protection issues.
- To explain county policy on biodiversity.
- To convey stewardship techniques to owners and managers of private and public lands to enable them to manage for biodiversity on their lands.

Biodiversity Education Topics

There are many specific topics that relate to biodiversity. Some of the major topics include:

- Defining biodiversity and explaining its importance
- Essential steps in protecting and restoring biodiversity, connections with ecosystem concepts, and conservation of ecosystems and watersheds
- Species, community, and natural history information and experiences
- County (and other) government roles in biodiversity protection and restoration
- What people in a rural setting can do to protect and restore biodiversity
- What people in a neighborhood setting can do to protect and restore biodiversity

Biodiversity Education Audiences*

There are also several potential audiences for biodiversity outreach and education efforts. Some of these audiences include:

- Elected and appointed county leaders
- County staff
- Neighborhood residents / small lot owners
- Rural area residents / large lot owners
- Public land managers (Parks and Recreation, Schools, Rivanna Water and Sewer Authority, University of Virginia)
- Farmland preservation advocates
- Open-space easement holders and promoters
- Developers, contractors, builders, and realtors
- Pre-school youth
- Primary school youth
- Secondary school youth
- College students

* Many of these groups can be reached through several venues, both formal and informal and via teachers, clergy, scoutmasters and other community leaders.

Existing Biodiversity Efforts

There are several entities providing biodiversity-related education in the community. Some of these providers include:

- <u>K-12 Schools</u>- The K-12 system has standards of learning (SOL) for each subject and grade that are intended to provide a coherent system of education in all subjects covered by the school system. There are a number of SOLs that provide information to students about issues in biodiversity across a variety of subjects. There should be strong curricular and structural linkages between the K-12 curriculum and the county's biodiversity program. Private schools have biodiversity related education efforts as well.

- Piedmont Virginia Community College (PVCC)- PVCC provides course work focusing on a great variety of aspects of biodiversity education, including general interest courses such as Natural History, Spring and Fall Wildflowers, Astronomy, Forestry, Horticulture, and Ornithology. These courses provide community members with information about biodiversity and actions needed to protect our biodiversity. There are also opportunities for other courses to be offered in the broad area of biodiversity.
- The University of Virginia (UVA) - UVA provides numerous opportunities for study in Environmental Science, both at the undergraduate and graduate level, although its focus is primarily national and international in scope. These programs are generally provided for students matriculated at the university; however, there are opportunities for community members to take some courses under approved conditions. There is also an Environmental Planning curriculum. For local residents, the School of Continuing and Professional Studies sometimes has relevant courses. The university has the potential of being a very valuable biodiversity education resource for our community.
- The Virginia Museum of Natural History at the University of Virginia (VMNH-UVA) - The VMNH at UVA provides programs for all ages, but primarily elementary and pre-school children. Programs are offered both at the museum's facility on the UVA campus and through an outreach effort. The "natural history" mission is closely related to the biodiversity mission.
- Ivy Creek Foundation (ICF) - The ICF, through partnerships with Albemarle County and the City of Charlottesville, maintains two natural area trail systems in the Charlottesville area (the Ivy Creek and Ragged Mountain Natural Areas). The organization provides guided tours of the Ivy Creek Natural Area to elementary-age children. ICF also hosts guest speakers, nature walks, and meetings of local organizations that provide many natural history education opportunities to both adults and youth. ICF is called out from the broader list of NGOs because of its unique partnership with the county and city and its roles in managing public land and education.
- Virginia Discovery Museum- The Discovery Museum provides exhibits and education opportunities for pre-school and school-aged children. Some of these exhibits cover biodiversity-related topics.
- Non-Governmental Organizations That Contribute to Biodiversity Education as Part of Their Missions- There are several organizations that provide biodiversity education, scientific work, advocacy, or access. Among these groups are the Monticello Bird Club, Virginia Native Plant Society, Environmental Education Center, Rivanna Conservation Society, Citizens for Albemarle, Rivanna Trails Foundation, Piedmont Environmental Council, Tree Stewards, Piedmont Landscape Association, numerous garden clubs, and StreamWatch. A particularly large group in this realm is The Nature Conservancy, which is an international, non-partisan conservation group with a staff of conservation scientists and planners. Based on a study of the Southeast, TNC has identified the Rivanna River and its watershed as a particularly important target for biodiversity conservation as an example of a southern Piedmont river and forest habitat.
- Local Naturalists- A number of individual local naturalists have collected incredible amounts of information on biodiversity in Albemarle County. They have shared their knowledge both in educational settings and by providing data to county officials.

- The Albemarle Unit of Virginia Cooperative Extension- Extension has staff and programs that address biodiversity. In particular Extension operates 4-H and trains Master Gardeners. Extension is a conduit and developer of educational material on topics such as wildlife and water friendly yard care.
- Thomas Jefferson Soil and Water Conservation District and Natural Resources Conservation Service- The TJSWCD is a state entity and NRCS is a federal agency. Both provide conservation information to landowners (particularly farmers) and develop educational materials. Both agencies help landowners access government cost-share funding for conservation practices. The Thomas Jefferson Planning District Commission could be a contributor as well.
- Department of Game and Inland Fisheries, Department of Conservation and Recreation Division of Natural Heritage, and U.S. Fish and Wildlife Service- These state and federal agencies take a special interest in biodiversity, particularly rare and threatened and non-game species. They, along with other government agencies, are resources for biodiversity education materials and support.
- Albemarle County Staff- County staff provide education and outreach on water resource protection topics some of which relate to ecosystem and biodiversity conservation. Audiences include school youth, college students, and water resource professionals.

A few topics and audiences have received more attention than others. Natural history, species, and community information and experiences for young children and adults have been provided through the VMNH-UVA, ICF, K-12 Schools, and PVCC. County staff and NGOs have worked to educate public officials about the importance of biodiversity and to educate residents about what they can do. TJSWCD and NRCS have promoted federal and state cost-share programs that conserve natural resources and, in some cases, biodiversity. While some areas are addressed, probably no area is thoroughly covered.

On the other hand, relatively little has been done to reach out to the development community. Many opportunities may exist with secondary school youth and college students. The county role, still being defined, needs to be promoted. There appears to be a significant need to explain and connect the somewhat complex topics of biodiversity, ecosystems, and watersheds.

CONCLUSION

Public biodiversity education should be based upon an overall plan to provide citizens with opportunities to educate themselves on biodiversity issues, with a focus on both understanding issues and taking action to support biodiversity. The creation of such a plan should be under the auspices of the Biodiversity Committee. A key step is framing an overall approach; an initial framework is included as the table in Appendix J. Achieving the goal of long-term preservation of Albemarle's biological resources requires a commitment to landscape states that support biodiversity. This fact should drive the creation, conduct, and evaluation of education programs.

A Biodiversity Education Subcommittee or advisory group to the Biodiversity Committee could build on the table in Appendix J and, in partnership with representatives of organizations currently offering such educational opportunities, develop a broad framework of biodiversity concepts important for public understanding of biodiversity issues and actions. It could also help each organization to develop their education programs within this framework, so that a coherent master plan for biodiversity education exists and is used in the development of courses and presentations on biodiversity issues. By using a more detailed version of the table, the Biodiversity Committee could simultaneously track the total Albemarle biodiversity effort, associated educational needs, the committee's and county's direct biodiversity effort, and efforts of outside parties.

The Biodiversity Committee and its education sub committee/advisory group can document and create targeted education programs that support the completion of specific tasks. For example, the task of managing one's backyard is very different from participating in the development and execution of public policy, but both tasks can be informed by an educational effort. In addition, biodiversity-related studies already underway in county schools can be documented and enhanced through a direct link to the work of the Committee, and the Committee can work with these initiatives to identify additional needs and opportunities for the school curriculum to address community biodiversity initiatives. The result will be a complete educational structure that addresses every component of our community's effort to preserve and enhance our biological resources.

RECOMMENDATIONS

Biodiversity Planning Goal

The Work Group recommends adoption of the following overall goal to guide development and implementation of the County's biodiversity policies:

GOAL: The County should develop a biodiversity action plan and subsequent implementation measures that provide means for sustaining the landscape states and ecological integrity required for important ecological services and healthy populations of native plants and animals.

The strategies recommended below in the section on the Biodiversity Action Plan are intended to help the Biodiversity Committee determine those necessary landscape states and set policies for achieving them. The Work Group has, in some cases, submitted examples of implementation measures for these strategies.

Recommendations to the Board of Supervisors

The Standing Biodiversity Committee

Given the redefinition of the Work Group's tasks and the threats and needs identified elsewhere in this report, the Work Group recommends that the following items be the responsibility of the standing committee:

Table L: Recommended Tasks for Standing Biodiversity Committee
Development of policy recommendations to the Board in response to biodiversity issues and information gathered from the Biodiversity Assessment. The Committee should be consulted on programs, regulations, and Comprehensive Plan changes that may affect biodiversity protection.
Development of educational materials and programs on biodiversity.
Input on and oversight of the maintenance, expansion, updating, and evaluation of the ongoing Biodiversity Assessment begun by the Biodiversity Work Group, and development of a protocol for assessing changes in the state of biodiversity (with reference to planning goals).
Assistance in staff development of an action plan that specifies detailed steps for achieving protection of Biodiversity as outlined in the Comprehensive Plan; and
Provision of periodic reports to the Board of Supervisors on the state of biodiversity in the County.
Review of the biodiversity impacts of selected development proposals, and comment to the Planning Commission and Board regarding the impacts and potential mitigation measures or alternative approaches.

These tasks are largely technical in nature, requiring experience and expertise in natural history, environmental sciences, conservation planning, and education. The Work Group therefore feels that the Committee would function most effectively if constituted as a technical advisory body that reports to the Planning Commission and Board of Supervisors, rather than as a "stakeholder" group charged with balancing biodiversity and many other interests. (However, some representation of landowners, concerned citizens, farmers, foresters, and/or persons interested in conservation-oriented urban and rural development would be appropriate, as the committee would benefit from their perspective.) With clear advice from such a technical group, the County's normal policy-development and project-review processes could balance biodiversity and other issues of concern.

The Work Group has made the following recommendations regarding the makeup of the standing Committee:

Table M: Recommendations for Membership of Standing Biodiversity Committee
1) The process of establishing the standing Biodiversity Committee should begin upon completion of the Biodiversity Work Group's work and acceptance of this report by the Board of Supervisors.
2) The Biodiversity Committee should consist of 8 to 12 members; the Work Group feels that this is a good compromise between the wide experience base of a larger committee and the more efficient interaction and decision-making of a smaller group. The group agrees that a larger group would be cumbersome and slow to act. When additional expertise is needed, the Committee should invite experts to attend meetings and provide input that the Committee needs.
3) The Committee needs to include a range of expertise in fields applicable to its tasks (see below). As with the Biodiversity Work Group, membership should include individuals with experience in:
a) natural history (including those with detailed knowledge of local wildlife, plants, and other resources);
b) terrestrial, aquatic, and landscape ecology;
c) biological conservation and conservation planning;
d) population genetics; forestry; geology and soils;
e) geographic information systems for conservation;
f) and science education (adult and youth).
g) The group should also include local landowners and citizens with interests in biodiversity conservation, farming and forestry, and conservation-oriented rural and urban development.
4) All members of the Committee, no matter what their background or area of expertise, should be supportive of the biodiversity-protection goals that the County has adopted into its Comprehensive Plan. The Work Group feels strongly that the Committee's role should be to support, expand on, and implement that policy. As part of the application process for the Committee, potential members should be asked to confirm their support for biodiversity protection in the County, and their answers should be considered in the Board's selection of the most suitable candidates.
5) The membership of the Committee should reflect the diversity of the community. The Work Group recommends that the process of announcing the Committee's formation and accepting applications be expanded to ensure that persons of both genders and any ethnic, racial, and/or socioeconomic group are well aware of the opportunity and have an equal opportunity to be involved.

6) The Committee should be known as the "Natural Heritage Committee."

Immediate Measures Needed to Protect Biodiversity

While the County will need to carefully select its biodiversity policies, much can be lost during the time needed for committee creation and later deliberation, policy and program development, regulation amendment, etc. Valuable habitat sites, especially those under threat from construction, clearing, or pressures from adjacent land uses, should be protected as soon as possible. Others should be protected as a precautionary measure. The sites that are selected as Important Sites, and valuable examples of various ecosystem types**,** for example, should be protected wherever possible. Protection methods might include conservation easements (donated or purchased), land purchase (and subsequent management by the County for conservation purposes), donation of land to non-profit organizations, or management agreements. Action to protect important sites should not be limited by the incomplete or changing nature of the Biodiversity Assessment. Opportunities for effective conservation must be acted upon even when information is incomplete, to ensure that the opportunities are not missed. Expert assistance is available to make the best judgments possible in the time available.

RECOMMENDATIONS TO THE STANDING COMMITTEE

Data Collection, Analysis and Application

Strategy: Continually add to, improve, and update the Biodiversity Assessment begun by the Biodiversity Work Group.

Recommendations

The Biodiversity Working Group recommends the following approaches to the permanent Biodiversity Committee in Albemarle County:

1. We recommend using a combination of the methods listed in section IV under "Biodiversity Assessment Methods," as each has certain strengths and limitations. We suggest that both a habitat/landscape approach be used in conjunction with inventories of specific taxa of interest. The annual variation in funding support that the County experiences may allow more intensive inventory work in some years, and less in others.
2. We suggest the Committee use, as a starting point, protection of the known Important Sites and occurrences of rare, unusual, or sensitive species of plants or animals (the BWG GIS files), with a commitment to expand the sampling to other parts of the County to try to supplement the current GIS coverage. In concert with this effort needs to be a landowner educational program to inform the pertinent landowners of the natural resources on their lands, their values, and some tips on stewardship to sustain these resources.
3. In addition to #2, we suggest using a modified GAP approach to identify larger-scale

landscape features that are currently intact and of high biodiversity value for protection, such as wetlands (all sizes), stream corridors, large intact forest tracts (especially those > 500 acres), native grassland and early-successional habitats, cliffsides.

4. We recommend the Committee carefully determine which taxa are of sufficient interest and importance to consider for the County, and to pursue opportunities to scientifically inventory these using best contemporary methods. In many other areas, volunteer networks have taken the responsibility of data collection while the overall coordination, data management, analysis and report writing is handled by a public agency (e.g. the national Breeding Bird Survey operated by the U.S. Geological Survey's Biological Resources Discipline) or a non-governmental organization.
5. Investigate feasibility and establishment of an early detection system for invasive species, as well as an inventory and management system for invasives.

Strategy: Increase the County's capacity for effectively using information on biodiversity in its decision-making processes.

Possible Implementation Measures Include:

- Provide training in conservation principles, County biodiversity policies, and the character of local biodiversity for staff involved in planning, policy development, and development review. Ensure that review processes provide effective biodiversity protection.
- Hire staff with conservation biology experience, and/or contract with consulting conservation scientists to address data analysis and appropriate decision-making
- Providing GIS and database tools as necessary to provide staff and the public with necessary information for effective biodiversity protection.

Policy Development

Strategy: Use information gathered in the Biodiversity Assessment to set directions for land-use policy development.

Strategy: Work to connect biodiversity policy development to Rural Area and Development Area land-use policies.

Possible Implementation Measures Include:

- Presenting maps recognizing important sites, examples of ecological community types, and large-scale landscape structures to the Board for adoption into the Comprehensive Plan with the intention that they guide policy decisions and project-review processes. (focus on large blocks/fragmentation, connectivity)
- Adopting a list of priority site and landscape-feature types into the Comprehensive Plan, for the purpose of identifying important resources to be protected. This list, which should be amended as necessary based on results of the ongoing Biodiversity Assessment, should initially include:

Table N: Critical Site & Landscape Feature Types for Comprehensive Plan Recognition
1) **Wetlands**. All non-impoundment wetlands should be considered high-priority areas. However, as stated in section IV, many of Albemarle County's wetlands are small sites that aren't catalogued in large-scale wetland surveys, and therefore need further assessment.
2) **Large areas of unfragmented forests** (with breaks of 200 meters or more considered to be boundaries), and contiguous areas where reforestation efforts can reconnect forest areas and re-create larger blocks.
3) **Steep bluffs** (native vegetation hotspots)
4) **Lengthy, connected stream/river ecosystems,** representing all the native ecosystem types.
5) **Riparian corridors** including all vegetation (both existing forests and potential reforestation sites) and steep slopes, out to 100 ft from the stream edge or the limit of adjacent slopes.
6) **Known breeding and roosting areas** (for example, the eagle nest and heron rookery listed in Table A-1 in Appendix A.)
7) **Migration/movement routes,** including corridors connecting habitats and local routes for seasonal amphibian movements, etc. Forested ridgetops (without antenna towers and other collision-death threats) in this region are critical migration routes for birds migrating on regional to intercontinental scales.
8) **Rock outcrops and barrens** with characteristic flora
9) Sites with **known occurrences of rare/out-of-range species**, and good examples of **intact native community types**
10) **Potential native grassland restoration areas** of 25 acres or more. Many grassland species have declined dramatically.

- Tying biodiversity policies to Rural Area and Development Area land-use policies by participating in a comprehensive landscape-futures scenario process that establishes a vision for achieving biodiversity protection, rural preservation, and other land-use goals on a shared landscape. Use the outcomes of this process to guide policy and regulation changes.
- Adopting a set of indicators to measure progress toward explicitly biodiversity planning goals and to evaluate the success of biodiversity protection efforts.
- Engaging adjoining localities in a regional biodiversity planning process that recognizes the role of multiple jurisdictions in protecting the habitat values of large-scale landscape structures.

Structure of the Biodiversity Action Plan

The Natural Resources and Cultural Assets Plan states that the Biodiversity Action Plan should (at a minimum) include details on:

- How the information obtained from the biological inventory will be incorporated into the land-use planning process. Procedures to protect biological resources may be similar to the implementation procedures for significant resources outlined in the Open Space Plan.
- Establishing education programs

- Procedures for the establishment/maintenance of a biological resource database.
- Voluntary measures that could possibly be utilized by the County, such as use-value assessments of rural lands, agricultural/forestal districts, conservation easements, etc. to protect areas identified as significant biological resources.
- Whether there is a need for hiring a County staff member with expertise in conservation biology, and/or training existing County staff in principles of conservation biology.

Building on this outline, the Work Group proposes the following structure and strategies for the Action Plan. The strategies included in this outline are intended to focus directly on on-the-ground physical goals for biodiversity protection and restoration. They should be used to direct policies and programs for both the Rural Areas and the Development Areas.

Each strategy below also includes recommended implementation measures for the standing Committee's consideration. These measures are included as examples to suggest effective directions toward achieving the Biodiversity Planning Goal, rather than as a complete list of actions to be taken.

Strategy: Protect and restore large blocks of contiguous terrestrial ecosystems (especially forests) and extensive aquatic ecosystems.

It is important to implement this strategy effectively and quickly. However, implementation will be improved by identifying these ecosystems as part of the Biodiversity Assessment and gaining an understanding of how the County’s ecosystems function and interrelate.

<u>Possible Implementation Measures Include:</u>

- Adopt Comprehensive Plan policies that identify these ecosystems as priority protection areas.
- Require protection of large-scale landscape structures in special-use permit, rezoning, and CPA approvals.
- Design and adopt programs to assist landowner and land managers to identify, maintain, and restore areas that are central to extensive ecosystems.
- Revise standards for the ACE program, use-value taxation, and other County programs to support maintenance of large habitat blocks.

Strategy: Protect and restore the connectivity of terrestrial and aquatic habitats.

<u>Possible Implementation Measures Include:</u>

- Design and adopt programs to identify existing and potential habitat linkages and pursue their protection and restoration.
- Establish regulations and programs to achieve protection and restoration of stream buffers that serve both to protect water quality and to provide habitat connectivity. Possible approaches include funding and assistance programs for landowners to protect or re-establish buffers (and provide alternative watering sources for livestock), protection requirements for permitted land uses, and a riparian-zone overlay zoning district (either creating a new district

or adding standards and protection measures to the existing Flood Hazard Overlay district and Water Protection Ordinance).
- Add conditions aimed at connectivity protection to the County's list of standard conditions for special use permit reviews.
- Require protection of habitat connectivity in special-use permit, rezoning, and comprehensive-plan amendment approvals.

Strategy: Maintain and reestablish multiple representative examples of native ecological community types and sites with the physical characteristics necessary for those communities to exist.

Possible Implementation Measures Include:
- Adopt programs, regulations, and voluntary measures that implement protection and restoration, including:
  - Terrestrial Ecosystems
    - Encourage landowners to allow hardwood forests on significant areas of their land to ages much greater than typical harvest rotation in an attempt to add to our limited amount of "old growth forest" in the County.
    - Provide incentives to landowners to attempt to control invasive exotic tree, vine, and other plant species in upland forest settings.
    - Encouraging landowners to minimize soil compaction by keeping machinery to established paths and roadways, and out of woodlands.
    - Encouraging forestry plans that maintain large, contiguous forest blocks, restrict clear cutting and high-grading of timber, and low-impact alternatives such as draft horses.
    - Minimizing use of pesticides and fertilizers.
    - Encouraging landowners to restrict livestock from woodlands and perennially moist areas.
    - Minimizing any disturbing activities in breeding areas during spring breeding season.
  - Stream Ecosystems
    - Work cooperatively with other agencies to set and maintain minimum in-stream flows in rivers and streams whose flows are affected by impoundments.
    - Restore as many miles of riparian stream buffers as possible to a forested condition.
    - Encourage reforestation of watersheds through land use planning, incentives, and education.
    - Identify and repair stream blockages such as road culverts and utility lines functioning as blockages.
    - Develop, promote, and enforce designs for stream crossings that allow aquatic organisms to pass through.
    - Minimize the need for new impoundments through conservation and creative water resource development for public water supply, and through education and careful consideration regarding smaller ponds. Develop tools to analyze

cumulative impacts of potential impoundments.
    - Build fish ladders on dams on major streams where feasible (e.g. NF Rivanna water intake, Mechums pump station). Breach or remove dams that are not in use (e.g. Woolen Mills, Advance Mills).
    - Develop a mitigation/restoration fund tied to the stormwater program to fund buffer and stream projects.
    - Develop instream flow goals for major dams.
    - Use streambank repair methods that create rather than eliminate stream habitat.
    - Upgrade sewage treatment as funds become available.
    - Implement methods to restrict livestock from streams and impoundments.
  - <u>Wetlands</u>
    - Locate former wetlands and restore them where possible. Former bottomland wetlands present significant opportunities.
    - Encourage people to let beavers build dams on small streams.
    - Encourage pond owners to allow native vegetation to grow on the edge of ponds (except on the dam).
  - <u>Riparian Areas / Floodplains</u>
    - Restore as many miles of riparian stream buffers as possible.
    - Include the entire floodplain in the buffer wherever possible.
- Pursue conservation easements and land purchases that protect intact habitats. The County should cooperate with other agencies and organizations to increase the scale and effectiveness of this effort.
- Require protection of native ecological community types in special-use permit, rezoning, and CPA approvals.
- Include restoration of terrestrial and aquatic habitats in conditions of approval or proffers for development projects and other approvals as part of the mitigation of the impacts of those proposals. However, these restoration efforts should not be used to justify destruction of existing habitats.
- Add conditions aimed at protection of native community types to the County's list of standard conditions for special use permit reviews.

Strategy: Protect and buffer ecologically valuable areas and known occurrences of rare species and community types.

<u>Possible Implementation Measures Include:</u>

- Require protection of ecologically valuable areas in special-use permit, rezoning, and CPA approvals.
- Require conditions of approval for special use permits and rezonings (and altering regulations for by-right uses and land development) to ensure protection of important habitat sites. If the site in question has not been surveyed for its importance, requiring such a survey would be necessary. This survey would be used to determine potential impacts to biodiversity, and to suggest alternative approaches to use of the land in question that would avoid those impacts and/or improve habitat value of the land
- Purchase land (outright or acquiring development rights) to protect known important sites,

especially those with high development potential or in imminent danger of loss.

- Actively pursue the donation of conservation easements with terms oriented toward biodiversity protection, to be held by the County or other holders.
- Develop conservation easement templates with standards for biodiversity protection, and include those standards (or others tailored for specific sites) in easements held by the County.
- Implement monitoring and management standards for biodiversity on lands under conservation easements.
- Set standards for prioritizing protection of important sites.
- Review existing land-conservation programs and revising their standards to better achieve the Biodiversity Planning Goal, or developing new conservation programs where necessary.
- Offer tax incentives for conservation, including promoting the provisions in the tax code that qualify habitat protection and restoration for the open-space category of use-value taxation.
- Raise awareness among landowners of the available conservation programs.
- Provide support for private protection and land-management efforts.
- Work with landowners and other entities to promote sound conservation practices and, where appropriate, to establish cooperative management plans
- Provide connections to conservation-oriented land-management assistance, funding, and protection programs, whether state, federal, or private.
- Develop lists of management procedures that will benefit multiple species of concern and apply those procedures to programs and regulations.
- Revise building-site definitions and subdivision regulations for rural residential development to require protection of and avoidance of impacts to habitats.

Strategy: Recognize and convey the importance of biodiversity and ecosystem services. Provide community education and foster awareness of biodiversity and understanding of its importance.

Possible Implementation Measures Include:

- Create a biodiversity education subcommittee/advisory group to the Biodiversity Committee or partner with an existing effort like the "Natural History Roundtable."
- Establish a community-wide framework for biodiversity education.
- Further develop the understanding of existing efforts and needs regarding biodiversity education. Consider a survey to improve this understanding.
- Connect course curricula in the community to the educational initiatives of organizations. Specifically produce and provide a summary brochure to provide a unified biodiversity message with a listing of resources and things people can do. This could be done immediately.
- Inventory biodiversity-related SOLs across the K-12 curriculum. Work with the schools to help them use local information and examples in meeting SOL requirements.
- Consider such ideas as a speaker's bureau, a video, a 6th grade outdoor school, and more to achieve biodiversity education.
- Tailor education approaches to different audiences, including those beyond those traditionally engaged (the choir). Outreach through rotary clubs, garden clubs, religious congregations, and scout groups might be effective.

Strategy: Manage protected areas.

Possible Implementation Measures Include:

- Develop and implement long-term management plans for existing protected areas, and cooperating with other owners and holders of protected areas to ensure effective management.
- Permanently protect habitats on publicly-owned lands and ensure management of key portions of those lands for biodiversity protection. This would require a survey of the existing or potential habitat value of public lands and an effort to put conservation easements and natural area preserve deeds of dedications in place, with and management plans.
- Revise conservation easement templates to include more effective management standards for biodiversity protection, and pursuing voluntary changes to existing County-held easements that put these improved management standards in place.

Strategy: Identify opportunities and act on them, or facilitate action by others.

Possible Implementation Measures Include:

- Use the methods identified in this report, including a modified gap-analysis process, to identify conservation opportunities.
- Establish research needs and carry out research to improve and/or augment existing conservation programs (for example, by developing methods to select indicator species or “health performance measures).
- Actively facilitate the donation of conservation easements with terms oriented toward biodiversity protection, to be held by the County or other holders.
- Assist landowners with funding programs that support land protection and management efforts that protect biodiversity.
- Offer land-use tax incentives to support dedication and management of land for biodiversity protection.

Strategy: Anticipate and address threats.

Possible Implementation Measures Include:

- Ensure that the County has and uses the capacity to remain well informed about new and anticipated threats to biodiversity and act to prevent the impacts of those threats.
- Anticipate and manage development patterns to avoid impacts to biodiversity and to facilitate protection and restoration of populations, habitats, and ecosystems.
- Cooperate with other jurisdictions and levels of government to manage and reduce impacts of air pollution on biodiversity in the County.
- Consider and implement measures to allow for habitat and range shifts due to climate change as part of land-use planning.
- Eliminate or minimize the impacts of invasive exotic species. Educate residents in the recognition and management of invasive exotic species.
- Encourage the use of native plants in landscaping plans approved by the County, and prevent the use of known non-native, invasive species.

- Regulate the use of known non-native, invasive species in the County.
- Find and cooperate with any federal, state, or private invasive-species control programs.

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