A Joint Publication of the Watershed Science & Wetland Science Institutes of the Natural Resources Conservation Service,
The University of North Carolina at Greensboro, and Pilot View Resource Conservation & Development, Inc.

The Restoration & Management of Small Wetlands of the Mountains & Piedmont in the Southeast:

A Manual Emphasizing Endangered & Threatened Species Habitat with a Focus on Bog Turtles

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On the cover
*Upper left: Bog turtle (*Clemmys muhlenbergii*) by Dennis Herman; bottom left: Meadow Bog by Dennis Herman: upper right: weir by Ken Bridle; lower right: Gray's lily (*Lilium grayi*) and Canada lily (*Lilium canadense editorum*) hybrid by Jennifer Mansfield-Jones.*

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Gray's Lily (Lilium grayi)

The significant problems we face cannot be solved at the same level of thinking we were at when we created them.

—Albert Einstein

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Preface

In 1993, bog turtles (Clemmys muhlenbergii) were found in a wet meadow of the northwest Piedmont region of North Carolina during a Natural Heritage Inventory. Although the site appeared degraded and grazing pressure was heavy, there seemed to be enough remaining habitat to support a healthy population of this rare species, now protected by both state and federal law. Interest grew in the site and we began a population study which soon revealed that there were fewer turtles in the site than had been initially anticipated.

We began to talk about restoration. The US Fish and Wildlife Service saw potential for habitat improvement and provided funds through the Partners for Fish and Wildlife Program; the landowners provided the opportunity; and local conservationists provided the energy. However, hopes of success diminished as a review of the literature revealed very little on restoring, enhancing, or managing similar wetlands. But as the old adage suggests, "hope floats," and before long, enthusiasm defeated pessimism. Instead of giving up, we expanded the scope of the project from a single-site project to one that focused on conducting basic research in techniques that could lead to the development of management guidelines for similar sites. As a number of state, federal, and private agencies were promoting restoration, the need for such information became progressively more apparent. The Wetland Science Institute of the Natural Resources Conservation Service responded to this need with additional funding.

Consequently, what started out as a small part of a local Natural Heritage Inventory became a project that inspired the development of this manual. Although the outcome of that particular project was especially interesting, it need not be unusual. Conservation projects in general can have great power to pull together disparate special interests to achieve many common goals related to wetlands and the surrounding habitat, including game species management, stabilization of plant and animal populations in decline, flood control, and groundwater recharge. Restored wild areas benefit humans in many non-tangible ways also; many people not only enjoy observing wildlife, but are enriched by having intact pieces of the natural world in their surroundings.

There is no attempt here to make the readers of this handbook into soils, hydrology, wildlife, or legal experts. The assessment of soils, hydrology, biology, and topography generally require the technical assistance of natural resource conservation professionals. Alterations that change the hydrology of the land may require construction permits and evidence of design, engineering, and zoning compliance. These checks and balances are necessary to ensure that the landowner and community both benefit from correctly implemented projects, and that neither is burdened with the consequences of a failed project. Poor planning can lead to unsuccessful projects that sour the willingness of other landowners to restore wetlands. It is also important to note that until recently, and in the memory of most landowners, wetland management recommendations were usually "ditch, drain, and fill." It may take time to convince landowners and their neighbors to give up current land uses in favor of restoration. Perhaps this manual will help.

Preservation and management of wetlands for the benefit of native wild plants and animals are the major foci of this manual, but the bog turtle is highlighted because

it is considered a flagship species. Flagship species are usually charismatic animals that have the ability to generate interest in a special habitat or a conservation project, and indeed the bog turtle does just that. Nevertheless, many other plant and animal species, rare and common, depend on wetland habitats found in the Mountains and Piedmont [here considered proper names] of the Southeast. The five states in the Southeast that currently have populations of bog turtles are Georgia, North Carolina, South Carolina, Tennessee, and Virginia. While the information in this handbook was specifically developed for these five states, it may also apply to similar types of wetlands found in other states.

Finally, our intent is to help increase awareness of the value of these sites, not only to their inhabitants, but also to the other native species living in the network of wetlands and other natural communities. Any small wetland can drastically affect life beyond its edges. Besides providing refuge to the many species not found in surrounding dry, terrestrial communities, they also improve the ecology for all the wild species in the region. Wetlands may benefit some terrestrial and avian species by providing additional nesting sites, drinking water, sources of nectar, vegetation for cover, or perhaps by increasing the numbers of prey species available for consumption. We hope to assist landowners and land managers in understanding the importance of each small wetland patch and the role each plays in preservation of species and their ecosystems. Increased understanding of the values of wetland restoration will both motivate more restoration and educate the public about the vital need for this type of activity. In these days of global environmental decline and climate change, it is this type of restorative activity, to which each landowner can contribute, that will help to reverse some of the declines.

Ideally, the management strategies recommended here would be based on techniques that have been developed over years of sound scientific investigation in a variety of related fields. These fields would include hydrology, vegetational succession, population dynamics of native species, and biological and chemical limitations of alien plants. Although additional studies are underway, present knowledge of the dynamics of these systems is far from ideal. Management techniques recommended here are based on the best information available at the present time and the research and field experience of the authors. We make no pretenses that sufficient study has been conducted. To the contrary, this document is in part, a plea for more and better information that will allow small wetland management to proceed on a firm scientific foundation.

This document is only a beginning, and hopefully one that will grow and be modified as new information becomes available. We encourage you, the users of this manual (field personnel, farmers, researchers, landowners, conservationists, and critics), to respond with comments that might improve future editions.

1

Introduction

Nora A. Murdock

Green pitcher plant (Sarracenia oreophila).

Introduction

In the past this continent was lush with wetlands and full of the related benefits. The features of rich biodiversity and clean water attracted human settlers to shores and wetland rich areas. The tribal peoples on this continent shared an intimate bond with the natural world that is evident in their song, dance, stories, and ceremonies. Their impact on the landscape, although not entirely benign, was within the ability of the natural communities to adapt, allowing both to flourish. European settlers, guided by a different ethic, initiated a series of transformations that would change the land forever.

During the last 400 years agriculture, urbanization, transportation, and industrialization have resulted in large modifications in the landscape (Table 1.1). The importance of wetland ecosystems (Table 1.2) were not understood or appreciated. When wetlands were considered at all, it was often in a derogatory fashion resulting from the perceived infestation of these "swamps" with pestilence, disease, and loathsome creatures. Wetlands were equated with wastelands. Farmers were not considered industrious unless they "reclaimed" these areas through ditching, draining, or filling for the higher use of agriculture or development.

The technology and persistence applied to wetland draining has resulted in large wetland losses in most areas of North America. In North Carolina alone, about 90% of the bog and fen habitats have been lost. Federal, state, and local programs provided assistance and incentives for destruction of wetlands as early as the mid-1800s (e.g., Swamp Lands Acts of 1849, 1850, 1860). Today, as human populations in most watersheds grow, stress accumulates in the integrated natural systems. This stress is manifested in a decline in the health and resilience of the ecosystem.

The negative impacts of wetland destruction were becoming apparent by the early to mid-1900s with noticeable declines in fish and waterfowl populations. Yet destruction of wetlands continued to be the accepted and encouraged practice in the United States until the late 1960s. As a result some types of wetlands have become very rare, along with the biodiversity that depends on them, and the benefits of wetlands have been lost to the surrounding human community.

Through a number of educational programs initiated by public agencies such as the Natural Resources Conservation Service (NRCS), US Fish and Wildlife Service (FWS), and non-governmental organizations (NGOs) like Ducks Unlimited and the World Wildlife Fund, the public now has a new awareness of the importance of wetland ecosystems. The Clean Water Act of 1972 initiated the use of regulation to protect wetlands under Section 404. However, wetlands are still being lost at an astonishing rate. Earlier in our nation's history wetland losses were due primarily to draining for agriculture. Today many more are being destroyed for road construction, housing developments, and shopping centers. Economic prosperity and an increasing human population often mean tremendous losses for wildlife and natural areas.

Manual Focus

In the past two decades a new appreciation for wetlands and the benefits they provide has begun to develop throughout the nation. A large body of evidence continues to suggest the importance of preservation and restoration of wetlands for the benefit of natural systems and the human populations that depend on them. This manual will focus

Table 1.1 Methods of Altering Wetlands

Physical

a) **Filling** - adding any material to change the bottom level of a wetland or to replace the wetland with dry land.

b) **Draining** - removing water from a wetland by ditching, tiling,or pumping.

c) **Excavating** or **dredging water away** - preventing the flow of water into a wetland by removing water upstream or lowering groundwater tables.

Ann Berry Somers

Ditching of wetlands is still a common practice.

d) **Flooding** - raising water levels either behind dams, by pumping, or otherwise channeling water into a wetland, often done for the purpose of creating livestock watering ponds, irrigation ponds, detention ponds, or water hazards on golf courses.

e) **Fragmenting** - bisecting wetlands with roads that create barriers to normal flow of water and normal activity of wildlife, also creating a source of mortality for wetland animals migrating from one portion of the wetland to another.

f) **Shading** - placing pile-supported platforms or bridges over wetlands, causing vegetation to die.

g) **Conducting activities in adjacent areas** - disrupting the interconnectedness between wetlands and adjacent land areas, or incidentally impacting wetlands through activities at adjoining sites.

Chemical

a) **Changing levels of nutrients** - increasing or decreasing levels of nutrients within the local water and/or soil system, forcing changes in the wetland plant community

b) **Introducing toxins** - adding toxic compounds to a wetland either intentionally (e.g., herbicides and/or pesticides) or unintentionally (e.g., storm water runoff from nearby roads containing oils, asbestos, heavy metals, and others), which adversely affect wetland communities.

Biological

a) **Grazing** - consumption and compaction of vegetation by large numbers of domestic livestock.

b) **Disrupting natural populations** - altering the number or abundance of existing species, introducing exotic or domestic species, or otherwise disturbing resident organisms.

Modified with permission from World Wildlife Fund and The Conservation Foundation, 1988.

on a particular group of wetlands called freshwater bogs, fens, wet meadows, marshes, or seeps. In particular, these wetlands are found in the headwaters of the Mountain and Piedmont geomorphic provinces of the eastern states from New York to Georgia. Of particular interest in these freshwater wetlands is the high level of biodiversity of rare plants and animals, including federally listed species like the Mountain sweet pitcher plant (Sarracenia rubra ssp. jonesii) and the bog turtle (Clemmys muhlenbergii).

The goal of this manual is to provide landowners and land managers with an easy-to-read guide based on the best available scientific and technical information available as they work in and around small wetlands of the Mountains and Piedmont of the Southeast. It is an attempt to develop a framework for decision making, which includes information about wetland functions, human values, ecology, and restoration techniques. Hopefully, this guide will provide a foundation to begin restoration and management of these small wetland communities.

What is a Wetland?

Wetlands can be described as lands where the water table is usually at or near the surface, or the land is covered by shallow water (also see Glossary). These lands are saturated with water or covered with water all year, or for long periods of time during the year. Wetlands have hydric soils (the type that form under flooded or saturated conditions) and are inhabited by water-loving plants. Southern Appalachian wetlands are significant ecological communities and include many different types such as bogs, fens, pools, and seeps (Appendix A). Some wetlands, like ephemeral pools, are ecologically important because they dry seasonally, and allow a fish-free environment necessary for the development of several species of amphibians. Other types of wetlands are important because they usually stay wet throughout the year.

Benefits of Wetlands: Functions and Values

Small wetlands perform environmental services that benefit larger ecosystems in numerous ways: They function to purify water, provide habitat for plants and wildlife, help recharge groundwater, and abate damage from floods (Table 1.2). Additionally, shallow aquatic habitats are important for many forms of life and over 90 species of rare plants and animals are associated with these ecosystems in the Mountains and Piedmont of the

Table 1.2 Importance of Wetlands

a) **Floodwater storage** - wetlands may store water during floods and slowly release it to downstream areas, lowering flood peaks.
b) **Habitat for wildlife** - wetlands provide essential breeding, nesting, feeding, and predator-escape habitats for many amphibians, reptiles, mammals, birds, and insects.
c) **Home of many rare and endangered species** - over 90 rare and endangered species are found in small wetlands of the Mountains and Piedmont in the Southeast.
d) **Water supply** - some wetlands are important in maintaining groundwater levels.
e) **Education and research** - wetlands provide unique opportunities for nature education, observation, and scientific study.
f) **Open space** - wetlands provide undeveloped space for ecological processes to continue.
g) **Aesthetic values** - wetlands are areas of great diversity and beauty.
h) **Water quality** - wetlands contribute to improving water quality by removing excess nutrients and many chemical contaminants.

Modified with permission from Kusler, 1983 and National Research Council, 1992.

Introduction

Hank Henry

Small, spring-fed wetlands are important habitats for many species.

Southeast (Appendix B). In areas where wet spots are scarce, populations of many types of plants, amphibians, insects, crustaceans, and mollusks depend upon small wetlands for survival. Some are wetland obligates, that is, they are unable to live in other types of aquatic environments such as nearby streams, creeks, and ponds.

Several animals, abundant in earlier years, are becoming increasingly less common due to wetland losses. Examples are: spotted salamanders (Ambystoma maculatum), marbled salamanders (Ambystoma opacum), southern bog lemmings (Synaptomys cooperi), wood frogs (Rana sylvatica), red salamanders (Pseudotriton ruber), mountain chorus frogs (Pseudacris brachyphona), and the American woodcock (Scolopax minor). Even the call of the spring peeper (Pseudacris crucifer), a once familiar sound piercing the night in late winter and early spring, has become a strange and unusual sound to many children. The musical trill of the American toad (Bufo americanus) has never been heard by a whole host of citizens, and many students, when asked by their teachers to describe an experience with a toad or turtle, report they have never had one.

On the landscape level, discrete patches of wetlands may occur within reach of nearby wet areas, forming a web or mosaic of suitable habitats (Figure 1.1). Whether or not streams connect the wet areas, the close proximity of suitable wetlands permits animals to move between them. There is also significant movement of plant species between small adjacent wetlands. The individual plants don't move, but their seeds can be blown by the wind into adjacent areas or transported by wetland animals migrating from one patch to another.

A population in one wetland may occasionally exchange individuals with a nearby population through migration. Such sub-populations form a larger unit called a metapopulation (Box 2.1). Sub-populations are often small and if they become isolated, are vulnerable to extinction caused by chance demographic fluctuations, inbreeding, or disease. Isolation can be caused by changes in the use of the land separating them, such as new roads, subdivisions, and shopping areas that disallow plant and animal populations the opportunity to move safely to an adjacent wetland. Severe weather events or succession of woody vegetation are also serious threats to small, isolated populations. Thus, long-term survival of some wetland organisms is dependent upon the persistence and connectedness of the many small wetlands that form a mosaic in the landscape.

Many of the above functions, long understood by biologists, have only recently entered into public awareness. The values we now place on wetlands are derived from a greater understanding of the importance these functions have for the quality of our lives. In previous times, we never thought of ourselves as capable of doing harm on a grand scale; we did not recognize that altering small patches of wetlands could have detrimental cumulative effects. Now we know of our power to impact the environment. There is a new reverence, not just for wetlands, but for all of nature. It is no longer acceptable to view natural systems, such as wetlands, as blemishes that must be dealt with. We have come to appreciate wetlands, not only for the water quality benefits, but also for their aesthetic qualities. The negative views of wetlands, such as mosquito-infested wastelands, are changing to a broader understanding that such systems should be preserved and restored.

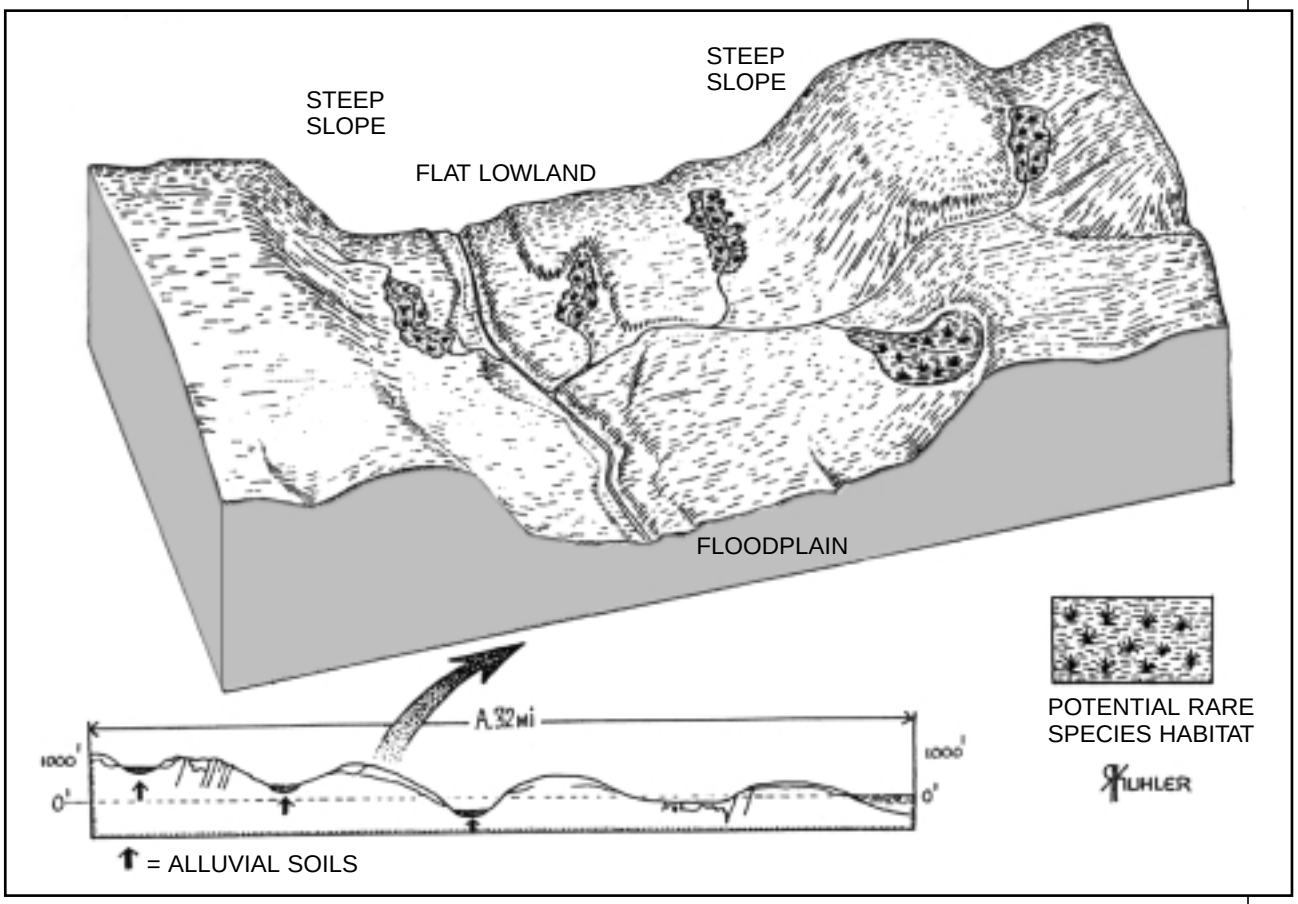

Figure 1.1 *Generalized view of a western Piedmont landscape showing topographic and hydrologic units prior to alteration by draining and fragmentation by roads. Note patchy occurrence of small wetlands.*
Modified with permission from Lee and Norden, 1996.

Can Wetlands Be Restored?

Restoration can be defined as a recovery of ecological function. Although few believe that full restoration of damaged wetlands is possible, this manual is based on the conviction that at least partial restoration is feasible and beneficial, and should be a high priority for land managers.

Many wetland definitions and descriptions have official connotations depending on the context. **Wetland preservation** is the most obvious and basically means that impact to an existing wetland should be avoided, and the wetland be allowed to continue to develop and function unaltered. **Wetland restoration** is defined as active rehabilitation of a degraded wetland or hydric soil area to recover its natural attributes, ecological functions and values. **Wetland enhancement** is defined as improvement, maintenance, and management of existing wetlands for a particular function or value, possibly at the expense of others. **Wetland creation** is defined as the conversion of a non-wetland area into a wetland where one has never existed. **Wetland mitigation banking** is a term that denotes the trade-off of "unavoidable" wetland destruction with wetland preservation, restoration, enhancement, and creation with the objective to avoid a net loss of wetlands.

In order for people to make wise decisions about the management of freshwater wetlands, reliable information is a key component. Data must be collected before and after modifications in order to determine the effects of treatments (before-after sampling design). The quality and effectiveness of restoration projects is often proportional to the amount of knowledge available about the system. The ultimate success of one's efforts

Ann Berry Somers

*Wetlands benefit rare species as well as familiar ones like this American toad (*Bufo americanus*).*

may depend on the level of preparation that occurs prior to manipulation. The National Research Council Committee on Restoration of Aquatic Ecosystems recommends that a wetland be monitored for a minimum of 10 years after restoration is attempted, and landowners and managers are advised to follow this practice whenever possible.

Wetlands restored in regulatory contexts (mitigation) often include little monitoring after initial enhancement or creation. Since the law does not require it, funding for monitoring is usually not available and long-term scientific data about the success or failure of these projects has not been generated. Since it has not been scientifically demonstrated that replacement wetlands function as well as natural wetlands, creation and restoration are not recommended to mitigate avoidable destruction of wetlands. It should also be noted that United States law requires consultation with the US Fish and Wildlife Service when modifications are undertaken in any area that could negatively impact threatened or endangered species.

When working in wetlands along creek and stream channels or in other significant natural resource areas, it is often best to enlist the assistance of local experts who can bring resources and partners to aid in the success of the project. The advice of local conservation professionals and officials can be helpful beyond the legal and regulatory aspects of the project including technical support, design, contacts, and financial assistance. Since three-quarters of national wetlands are privately owned, many agencies and programs have been developed to help landowners design and implement voluntary conservation plans. For current information that applies to any local situation, consult current and local resources such as those listed in Appendix D.

Importance of Landowners

Three-quarters of the remaining wetlands in the United States are privately owned. Millions of wild birds, mammals, and other creatures depend on wetlands for food, breeding, and nursery areas. Nearly one-third of America's endangered and threatened plants and animals need wetlands to survive. Wetlands also benefit people by providing natural floodwater storage, affording recreational opportunities, recharging groundwater supplies, filtering pollutants, and providing irrigation water.

Landowners are of critical importance in the identification, restoration, and management of wetlands. Protected, preserved, and restored wetland areas become the local biodiversity banks. These banks will be increasingly important during periods of environmental stress such as droughts, storms, and disease. Careful land-use planning and conservation of exemplary wetland communities and rare species populations are two important ways that this natural heritage can be retained. Since the vast majority of wetlands are on private property, conservation of these valuable systems cannot be achieved without the efforts, support, and protection of good citizens. Private landowners are the key to conservation in the Southeast, and the programs available to help them are continually improving.

"We need to recognize the landowner as the custodian of public game on all private land... compensate him...with either cash, service, or protection, for the use of his land and for his labor...on the condition that he...safeguards the public interest."

— Aldo Leopold

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2

Ecology of Bog Turtles

Dennis W. Herman

Bog turtle eggs (Clemmys muhlenbergii).

Ecology of Bog Turtles

Scientifically known as Clemmys muhlenbergii and formerly called the "Muhlenberg's" turtle, the bog turtle is North America's smallest turtle species. Bog turtles are characterized by their small size, dark coloration, and large yellow to orange blotches on both sides of the head. Shell lengths of bog turtles average between 3 and 4 inches, and the largest bog turtle ever recorded was 4.5 inches.

The main identifying character of bog turtles is the brightly colored blotch located behind the eye on each side of the head. These blotches vary in coloration from yellow, yellow-orange, orange, and orange-red from population to population. Turtles with yellow or orange blotches may be found within the same population and in some sites the turtles' head blotches may be only yellow or orange. The size and shape of the blotches also vary from population to population and are dependent on the turtle's age. Juvenile and newly hatched bog turtles possess large blotches that are light in coloration, whereas older adults have brighter and more intensely colored blotches that are usually diffused with darker pigment and are often broken up and incomplete.

The upper shell or carapace is usually black to mahogany-brown and may be marked with lighter whitish to yellowish sunburst rays of color in the individual scutes. The lower shell, or plastron, is usually black with varying amounts of white or pale yellow patches. The neck, limbs, and tail are very dark brown or black, with or without streaks of red or orange. The top of the head is usually speckled with black and the lower jaw may be spotted with red or orange. The upper jaw is notched, creating two sharp points on the beak. Along the back is found a mid-dorsal keel or ridge and pronounced sculptured growth rings around the scutes are present on the carapace in juveniles and middle-aged adults. Older adults usually possess smooth worn shells and lack mid-dorsal keels and distinct growth rings due to years of digging or burrowing in mucky soils and vegetation.

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The large blotch on each side of the head is characteristic of the species. The shape and color of the blotches may vary from region to region.

Sexual dimorphism is pronounced in this species. Unlike many other turtles the males are larger than females and possess larger, more robust heads. Carapace lengths average 3.5 to 4 inches in males, while females are slightly smaller with an average of 3 to 3.75 inches in length. Females have greater carapace width to length ratios and shell heights than males. The rear marginal scutes are usually flared in males giving them a more streamlined appearance from above, while female bog turtles appear more circular. The plastron is dished out or concave in males and is flat in females. Male bog turtles have long, thick tails with the anal (cloacal) opening extending past the edge of the plastron, and females have short tails with the cloacal opening inside the plastron edge.

Protected Status

Bog turtles have been variously protected by every state in which they occur. The bog turtle is listed as "Threatened" in Georgia, North Carolina, South Carolina, and Tennessee, and "Endangered" in Virginia. Because of inconsistent state protection throughout the turtle's range, the U.S. Fish and Wildlife Service placed the bog turtle on the Endangered Species list in November 1997. The bog turtle is listed as "Threatened" for the northern population (CT, DE, MA, MD, NJ, NY, and PA) and "threatened due to similarity of appearance" for the southern population (GA, NC, SC, TN, and VA); this designation is based on the naturally occurring 250-mile gap between the population in southern Virginia and that of Maryland. The southern bog turtle population is not fully protected under the Endangered Species Act (ESA), but may not be possessed, sold, traded, or collected. Landowners in the southern states can continue to develop bog turtle habitat by any legal means available to them, as long as the proper permits are obtained beforehand. In the northern states, bog turtles are fully protected under the ESA. A summary of the ESA is included in the Example Handout in Appendix C.

Population Dynamics

Little is known about the dispersal or movement patterns of bog turtles. Individual bog turtles have been found crossing roads more than a mile from their wetland home or other suitable habitats. These migratory movements take them into forested uplands, distant ridges, lowland valleys, and cultivated areas. Summer and early fall movements are sometimes long, bringing them into areas where their occurrence is unexpected. Males tend to move more frequently and over greater distances than females. Bog turtles may exist in moderate to high densities in suitable habitats. Mark-and-recapture studies in the southern part of the bog turtle's range indicate that suitable habitats have densities of 15 to 20 turtles per acre. Home ranges for bog turtles are estimated to be less than 0.5 acre (.23 ha) in area and are slightly larger for males than for females. Sex ratios in the bog turtle's southern range average 1 male to 1.3 females per site.

The bog turtle is an ectothermic reptile (cold-blooded), and undergoes a definite annual cycle related to seasonal changes of temperatures in its environment. Bog turtles alternate seasonal warm-weather activity with cold-weather inactivity. Winter survival requires that bog turtles undergo a period of cold-weather dormancy through the winter. Winter dormancy is probably longer at higher elevations than in the Piedmont. Depending on the weather, bog turtles sometimes begin surface activity during mid-March in the South. The greatest bog turtle activities occur from mid-April through September. Elevation affects the timing and length of the major phases of the activity cycle. In the Piedmont, bog turtles have a longer active season than turtles in the higher Mountain sites.

The bog turtle's life span is estimated to be in excess of 40 years based on recapture studies. Female bog turtles reach sexual maturity at approximately 3 inches in carapace length or from 5 to 7 years of age. The secondary sexual dimorphic characters of males (longer tail and concave plastron) begin to appear at around 2 1/2 inches in carapace length. Bog turtles in the wild are capable of reproducing between 5-7 years of age under the most ideal conditions, but the actual age of first egg deposition is closer to 10 years. Reproduction may take place annually, but most likely occurs every second or third year. Female bog turtles may reproduce from 10 to 15 times over a 40 to 50 year life span. Egg clutch sizes range from 1-6 eggs with an average of 3 eggs per clutch.

Distribution

Bog turtles are known from Georgia, North Carolina, South Carolina, Tennessee, and Virginia in the southern part of their range (Figure 2.1). The majority of records are known from the Blue Ridge Intermountain Plateau, but many have been found in the upper Piedmont along the base of the Blue Ridge Escarpment. Elevations of bog turtle sites range from 710 to 4500 feet, with the majority known from 2000 to 3000 feet elevation. Bog turtle populations

Figure 2.1 *Range of bog turtles (*Clemmys muhlenbergii*) in the Southeast.*

have been found along ten river basins in the Southeast in both the Mississippi-Ohio and Atlantic drainages.

Habitat Dynamics

Wetlands preferred by bog turtles are spring-fed with saturated soils and modest amounts of running water. The sites do not have standing water of significant depth. Viable bog turtle populations occur in seepage slopes or terraces along headwaters of small to moderate size streams. Sites occupied by bog turtles are infrequently flooded, so they are not found on large, flat floodplains of major rivers or streams. Bog turtle habitat is characterized by being sedge-dominated, wet meadows with little or no canopy and are referred to as sedge meadows or Meadow Bogs.

Bog turtles are not found in true "bogs" in the Southeast. True bogs are typically composed of vegetation mats that grow over small depressions, ponds, or small lakes. They are fed primarily by rain and water runoff. Peat moss (Sphagnum sp.) and other bog building plants along the shore grow out into water-filled depressions, eventually filling them with decomposed vegetation.

The common denominator of all bog turtle habitats in the South is that they are spring-fed. Technically speaking, the wetlands preferred by bog turtles are known as fens. To most ecologists a fen is a spring-fed wetland located over calcareous or mafic rock and enriched by nutrients, creating a wetland with great plant diversity. Only one such wetland has been described from the southern Mountains, although fens are common further north. Bog turtle habitats are, in fact, "poor or acidic" fens located over granite or metamorphic gneisses. These spring-fed wetlands are acidic with

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Bog turtles are often found in grazed wetlands.

many floral components common to both true bogs and nutrient rich fens. Sphagnum, usually associated with acidic bogs, can be the dominant ground cover in many bog turtle habitats. Because of the acidic nature of these nutrient-poor fens and plant assemblages linked to true bogs, some ecologists refer to them as bogs. In fact, one rare natural community, the Southern Appalachian Bog, is so named because of these characteristics. Sedge meadows (also known as Meadow Bogs) are a major component of these natural communities, and wetlands that have little or no sedge meadow habitat are inhabited by small populations of bog turtles or no turtles at all. The open nature of meadow bogs allows maximum sunlight to warm the herbaceous layer providing bog turtles with basking and nesting sites. One of the bog turtle's ultimate limitations is a closed canopy, which cuts off surface light and warmth.

Habitats in the upper Piedmont may or may not have floral components similar to those along the Blue Ridge. Most Mountain sites have peat moss (Sphagnum sp.) as ground cover; some exhibiting extensive mats, while others have only a few patchy areas.

Piedmont sites, on the other hand, vary greatly in the amount of peat moss growth with many having no peat moss at all. Needle rushes (Juncus sp.) appear to be more prevalent in Piedmont sites, while sedges dominate Mountain sites.

Meadow Bogs are defined as "impacted" natural areas, usually grazed by livestock or located adjacent to pastures and are created and maintained by agriculture, livestock, beaver, and possibly fire. Today livestock have replaced the large herds of herbivores (bison, elk, and earlier the larger Pleistocene megafauna) that once seasonally migrated through and lived in the wetlands, grazing and browsing on low shrubs and sedges, maintaining the open wet meadows preferred by bog turtles and other species. The majority of bog turtle populations in the Southeast occur in sites that are currently grazed or formerly grazed by livestock. The turtle's dependence on livestock grazing and browsing has been well documented.

Beavers were once a major creator of ponds (see Wetland Management by Beavers, Chapter 6). These ponds filled in over time to become open wet meadows used by bog turtles. Today beavers have rebounded from near extinction and these industrious rodents may create short-term negative impacts to existing bog turtle habitats by flooding them. The beaver's importance in creating and maintaining bog turtle habitat may not be as evident today as it was in the past. As bog turtle sites are protected along common stream corridors, beavers may once again be beneficial to the bog turtle's long-term survival.

Threats to Bog Turtles and Their Habitat

Wetlands inhabited by bog turtles are under constant threats from agricultural use, development, and natural succession. The illegal collecting of bog turtles for the pet trade, both domestic and international, directly threatens the turtle itself. These threats are having an adverse effect on bog turtle populations in the South, as well as throughout the turtle's range. Habitat loss has accelerated over the past 20 years from fragmentation due to human encroachment and natural succession. The decline in bog turtle populations can be attributed directly to these threats.

Prior to European colonization in the 1700s, the dynamic wetlands used by bog turtles were a complex of habitat units and potential habitats interconnected by a mosaic of dispersal routes. The long-term dynamic ecosystem could

Box 2.1 A Bog Turtle Metapopulation in North Carolina

By Dennis W. Herman

The best known metapopulation in North Carolina, currently under study, is comprised of at least 20 wetlands ranging from 0.5 to 6 acres in size along a small stream with several tributaries. Bog turtles have been captured in six of these wetlands and found on roads at three locations within the drainage (see Figure 2.2). The first bog turtle site in this metapopulation was discovered in 1990. This site, which is located on a secondary tributary, has 35 marked turtles and is currently the largest turtle colony known in the metapopulation. Bog turtles were captured and marked in three other wetlands along the stream drainage during the early 1990s, the largest population with seven turtles recorded. Additional turtle captures have been made since the initial discovery of these wetlands. Searches in nine other wetlands have yet to produce bog turtles, for reasons yet unknown. This is a classic metapopulation with intact habitat units along the main corridor and four secondary tributaries, some with turtles and others without. The average distance between habitat units is roughly one mile, and the greatest distance between bog turtle sites is two miles. Currently, there are no impediments to dispersal, although a road does parallel the stream in some places and pasture is common in many areas. The entire stream drainage is under private ownership, with the exception of three small wetlands owned by the National Park Service (Blue Ridge Parkway). Protection of the entire corridor and habitat units would preserve one of the best metapopulations known in North Carolina, but multiple ownership along the drainage makes it very difficult to do so using conventional purchase methods.

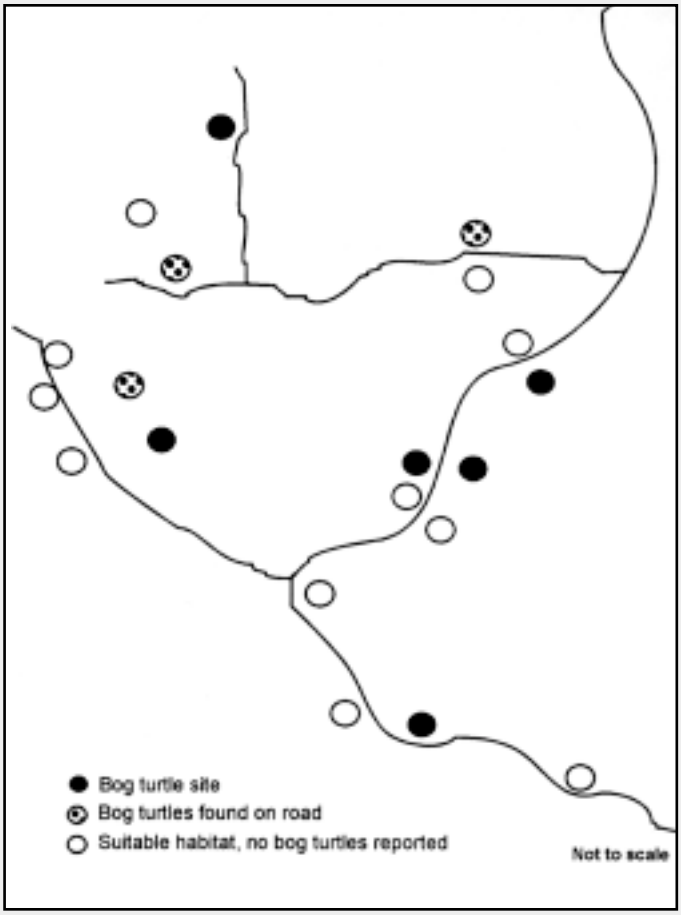

Figure 2.2 *Bog turtle metapopulation showing subpopulations. Roads not shown.*

withstand the loss of a single habitat unit while providing bog turtles with other usable habitats. The biological need for individual bog turtles to disperse takes them out of their wetlands to explore and locate new sites to colonize. Individual turtles could move freely up or down the corridor, enriching the gene pool and helping to maintain genetically healthy population units. Bog turtle habitat units or single population sites interconnected along a common stream corridor are referred to as metapopulations (Box 2.1). Only a handful of these metapopulations remain today because of habitat fragmentation. The most common types of fragmentation occur when streams are impounded to form lakes, highways are built across inhabited wetlands, and wetland habitat units are drained for agricultural use or development. Roads that bisect bog turtle wetlands are the single most detrimental threat to turtle populations. Highway mortality is high in areas where bog turtles must cross roads to get from one wetland to another. There is no doubt that roads and highways can

be managed more effectively to reduce road mortality and some of these measures are discussed in Chapter 6 in the section on Managing Roadways.

Most of the metapopulations known today are fragmented, with great distances separating one population unit from the next. Bog turtles encounter impediments that make it difficult for dispersal to occur successfully. Some bog turtles have been found crossing ridges to locate wetlands in an adjacent valley. Overland dispersal may be more common than was previously thought, but it may also be a result of habitat unit losses along the stream corridor that turtles used historically. As mentioned previously, very few metapopulations remain in the South today. Bog turtle populations are dynamic, fluctuating and shifting over long time periods. The survival of the bog turtle depends on connected habitat units along riparian corridors or habitat patches in adjacent valleys where dispersal into them is not impeded. A case study of the best metapopulation presently under investigation in North Carolina is presented in Box 2.1.

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3

Identifying Important Small Wetlands and Potential Sites for Rare Species in the Southeast

Ken Taylor © NC Wildlife Resources Commission

Gray's lily (Lilium grayi).

Identifying Important Small Wetlands and Potential Sites for Rare Species in the Southeast

The term "wetland" can have different meanings in different contexts. For official regulatory purposes, a wetland is defined as "those areas that are inundated or saturated by surface or groundwater for a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil condition." In most areas of the Piedmont and Blue Ridge Mountains, wetlands are commonly referred to as swamps, marshes, bogs, wet flats, or bottomland hardwood forests.

The source of water (groundwater, rainwater, surface runoff, snowmelt) is the most important factor in the development of any wetland. The amount of water in an area and the amount of time flooded conditions persist determine the kind of wetland that develops in an area. Hopefully, you will find examples of the types of wetlands that occur naturally in your region. These can then be used as reference for restoration and management (Appendix A).

The various wetland types located in the Piedmont and Blue Ridge Mountain regions of the Southeast harbor many rare plant and animal species. Of the habitats mentioned in Appendix B (rare plants and animals), Southern Appalachian Bogs support more rare species than all other types of wetlands combined. The bog turtle, Clemmys muhlenbergii, is found in 3 of the 6 wetland types, and has been chosen as the prime example to illustrate the need to identify potential sites. It is a federally protected species and there is great interest in its status, distribution, and natural history. Many agencies and organizations use the bog turtle as the flagship species for wetland protection. If a site has potential as bog turtle habitat, then it is most likely potential habitat for other rare species.

Dennis W. Herman

*The bog turtle (*Clemmys muhlenbergii*) is often used as the flagship species for wetland protection throughout its range.*

The following guidelines can easily be modified to identify potential habitat for many species found on the rare plant and animal list. There are many similarities between bog turtle habitat in the northern and southern parts of the turtle's range. However, most research used to produce this document took place in the turtle's southern range, so the emphasis has been placed on wetlands in the Southeast.

If the possibility exists that protected species might be found in a wetland, it is suggested that landowners be informed by the investigators. A simple handout can be developed to ease legal concerns of landowners; a sample document summarizing the laws for one region is provided in Appendix C.

Guidelines for Identifying a Potential Bog Turtle Wetland in the Southeast

A. Contact the appropriate state wildlife agency where the potential site is located or Project Bog Turtle (see Appendix D) to find out if the wetland is known to support bog turtles.

B. If it is not a known bog turtle wetland but has an emergent and/or shrub wetland component, then it should be surveyed to determine if it is potential bog turtle habitat.

Conditions for the determination of potential habitat:

1. Visual assessment can be performed in any month of the year.
2. Potential bog turtle habitat is recognized by 3 criteria or the 3-S system (**S**pring-fed, **S**oggy, and **S**unny):

a) Suitable hydrology (**S**pring-fed) - spring-fed with shallow surface water or saturated soils present year-round, though in summer wet area may be restricted to spring head areas. These wetlands are typically interspersed with wet and dry pockets. Water flow is often subsurface. However, if you do not need boots to walk into the wettest portions of the site, it probably is not suitable habitat for bog turtles.

b) Suitable soils (**S**oggy) - a bottom substrate of soft muck, though in summers of dry years this may be limited to near spring heads. The saturated soils in bog turtle habitats in the Southeast have been classified as Chewacla, Codorus, Hatboro, Nikwasi, Toxaway, Wehadkee, and alluvial soils.

c) Suitable vegetation (**S**unny) - open, sunny areas dominated with vegetation of grasses, sedges, and rushes (emergent wetland), often with a shrub component. Common herbaceous vegetation of Piedmont wetlands includes sedges (Carex sp.), lamp rushes (Juncus sp.), bog rushes (Scirpus sp.), rice cut grass (Leersia oryzoides), tearthumb (Polygonum sagittatum), spotted jewelweed (Impatiens capensis), skunk cabbage (Symplocarpus foetidus), and arrowheads (Sagittaria sp.). Upland and Blue Ridge Mountain wetlands include these plants with the addition of panic grasses (Panicum sp.), sensitive fern (Onoclea sensibilis), cinnamon fern (Osmunda cinnamomea), and peat moss (Sphagnum sp.), which are found more commonly in the Mountains than in the Piedmont. Common shrub subcanopy species in wetlands of both regions include tag alder (Alnus serrulata), red maple (Acer rubrum), deciduous hollies (Ilex sp.), and elderberry (Sambucus canadensis), and in disturbed sites, multiflora rose (Rosa multiflora).

3. The appropriate state wildlife agency or Project Bog Turtle should be sent a copy of survey results including a site map, surveyor's name, date of visit, opinion on potential/not potential habitat, and a description of the hydrology, soils, and vegetation. If rare plant species are found during the survey, then the appropriate state plant specialists or heritage programs should be contacted and sent the above survey results. (See Appendix D for directory). A sample data sheet is provided in Appendix E for making reports.
4. If the wetland is identified as potential bog turtle habitat, then it should be surveyed to determine the presence of bog turtles. This survey is not to estimate population size, just presence or absence of turtles. A special, long-term mark-and-recapture study would be required to determine population size.

Potential sites may be surveyed using visual techniques and hand capture, or turtles may be trapped (see Guidelines below). Most bog turtle sites are identified using visual searches. However, recent evidence clearly demonstrates that some sites containing bog turtles may be overlooked using visual-only surveys.

If a potential site is threatened with destruction and is being surveyed to fulfill a regulatory obligation, it is imperative that the site be trapped by a recognized and qualified turtle trapper, according to guidelines

presented in this chapter, before survey results can be considered conclusive.

Guidelines for Visual Surveys:

1. Surveys should only be performed April 15 - June 15. This coincides with the period of greatest annual turtle activity (spring emergence and breeding) and before vegetation gets too dense to accurately survey. Surveys after June 15 should be avoided by inexperienced persons because of the potential of disruption of breeding or destruction of nests or neonates.
2. Air and water temperatures should be a minimum of 50°F.
3. Cloud cover should be no more than 50%, and surveys should not be conducted during electrical storms. However, a good time to survey for bog turtles is immediately after a rain.
4. A minimum of 3 people should survey each wetland together. At least one of these should be a qualified bog turtle surveyor recognized by the appropriate state agency or Project Bog Turtle, who will instruct the other surveyors in survey techniques.
5. A minimum of 3 surveys per wetland site, separated by 5 or more days, are needed to accurately assess the site for presence of bog turtles. At least 2 of these surveys must be performed in May. For best results, spread the surveys over a long period. If turtles are found on the first or second visit, the site does not need to be revisited.
6. Survey time should be a minimum of 2 hours per site visit or 1 hour per acre of wetland unless a turtle is found before the time has elapsed.
7. The appropriate state wildlife agency or Project Bog Turtle should be sent a copy of survey results including a site map, size of wetland surveyed (acres, hectares, or square meters), dates of site visits, time spent per site, surveyors' names per visit, weather per visit (air temperature, water temperature, % cloud cover, wind, precipitation), presence or absence of bog turtles found, and date, age/sex of turtles found (see Data Sheet, Appendix E).

Ann Berry Somers

Bog turtles and many other animals use open muddy runs.

Guidelines for Trapping Surveys:

1. Potential sites that do not yield bog turtles using visual-only surveys should be trapped by experienced personnel.
2. Trapping is a serious matter because animals are vulnerable while in the traps. Only qualified personnel of the state wildlife agency, Project Bog Turtle, or an appropriate federal agency should use this type of survey. All individuals involved in the effort must have the appropriate permits.
3. Prime areas of the site should be saturated with traps. At least 20 traps per acre of habitat should be set. Traps must be covered to shade captives and must be checked a minimum of every 48 hours.
4. A minimum of 9,000 trap hours should be required per site if the site is one hectare (2.2 acres) or less. This is approximately equal to setting 20 traps for 20 days and is called the "20-20 Rule." Only one turtle is needed to confirm a site as bog turtle habitat. Traps should be removed after 1 capture unless there is interest in population assessment or long-term data collection.

5. Surveys should only be performed May 1 - June 15. This coincides with the period of greatest annual turtle activity (spring emergence and breeding) and before vegetation gets too dense. While turtles may be trapped outside of this time period, a result of no turtles would be considered inconclusive. Surveys after June 15 should be avoided by inexperienced persons because of the likelihood of disruption or destruction of nests or neonates.
6. The minimum number of traps or trap hours should be increased if:
    a) it is a dry year.
    b) novice trappers are setting traps.
    c) the site is larger than 1 hectare (about 2.5 acres).
    d) trapping is done at any time other than May or June.

Bog turtles may be encountered outside of a wetland site as they disperse or move between wetland habitat units. Although it may seem strange to find a bog turtle some distance from a wetland, it is a common occurrence and many observations have been reported in recent years.

What Should One Do if a Bog Turtle is Found?

A bog turtle, or any rare species listed in Appendix B, should be photographed and reported to the appropriate state or federal agency in the region and to Project Bog Turtle. A map of the locality and exact location description with mileage from the nearest intersection should be included in the report.

If a bog turtle is found on the road, move it to the side of the road to which it was heading, lest it get crushed by a vehicle. If dead, it should be kept on ice or frozen. Notify your local wildlife officer immediately and don't forget the photograph! Dead bog turtles are very important specimens and are only legally housed in a state natural history museum or the Smithsonian Institution. **Do not** keep a live bog turtle unless you have an endangered species permit issued by the state agency. It is a serious offense to illegally possess a federally protected species.

See Appendix D for directory of state and federal agencies, universities, museums, and independent organizations to contact if you find rare plant species or rare animals (bog turtles).

See Appendix F for informative handouts that address landowner concerns if bog turtles are found.

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4

Planning for Success

Kenneth A. Bridle

Channelized flow of water in a site where cattle have been excluded.

Planning for Success

Restoring damaged wetlands should be a high priority now that the public generally understands their functions and values. However, restoration of any ecological function is a long-term commitment and should be considered carefully prior to habitat or hydrologic manipulations. Planning may be the most important step in the process. Evaluating existing site conditions is an important part of decision making; likewise, documenting pre-existing conditions is an important part of evaluating the outcome.

Ann Berry Somers

*Spotted salamander eggs (*Ambystoma maculatum*).*

Documenting Site Conditions

One of the most important constraints on achieving success in restoration is the degree of disturbance to the sites. Almost all small wetlands in the Mountains and Piedmont of the Southeast have been cleared for pasture, filled, or drained by ditches or subsurface tiles (see Table 1.1). Some alterations have been more successful than others, and the degree of damage to the wetland varies. Very small wetlands in urban settings that have been severely ditched and are isolated from other similar wetlands have less potential for reaching restoration goals than wetlands in sites where the surrounding landscape is relatively intact and within reach of other similar areas (Figure 4.1).

Site character and restoration potential can be determined by examining the site size, history, hydrology, soils, natural plant and animal communities, landscape ecology, conservation potential, and management objectives. This is a complex matrix of features, which interact with each other to result in the character and potential of the wetland. Some wetlands are special because of their size, biodiversity, flood control, water purification, groundwater recharge, wildlife habitat, erosion control, or simply location. Most wetlands include a combination of many of these traits and are valued accordingly. A detailed assessment of wetland features may require the technical assistance of natural resource conservation professionals. However, many characteristics of the site can be recorded by anyone using the data sheet in Appendix E or something comparable. These data can then be used to assist field personnel

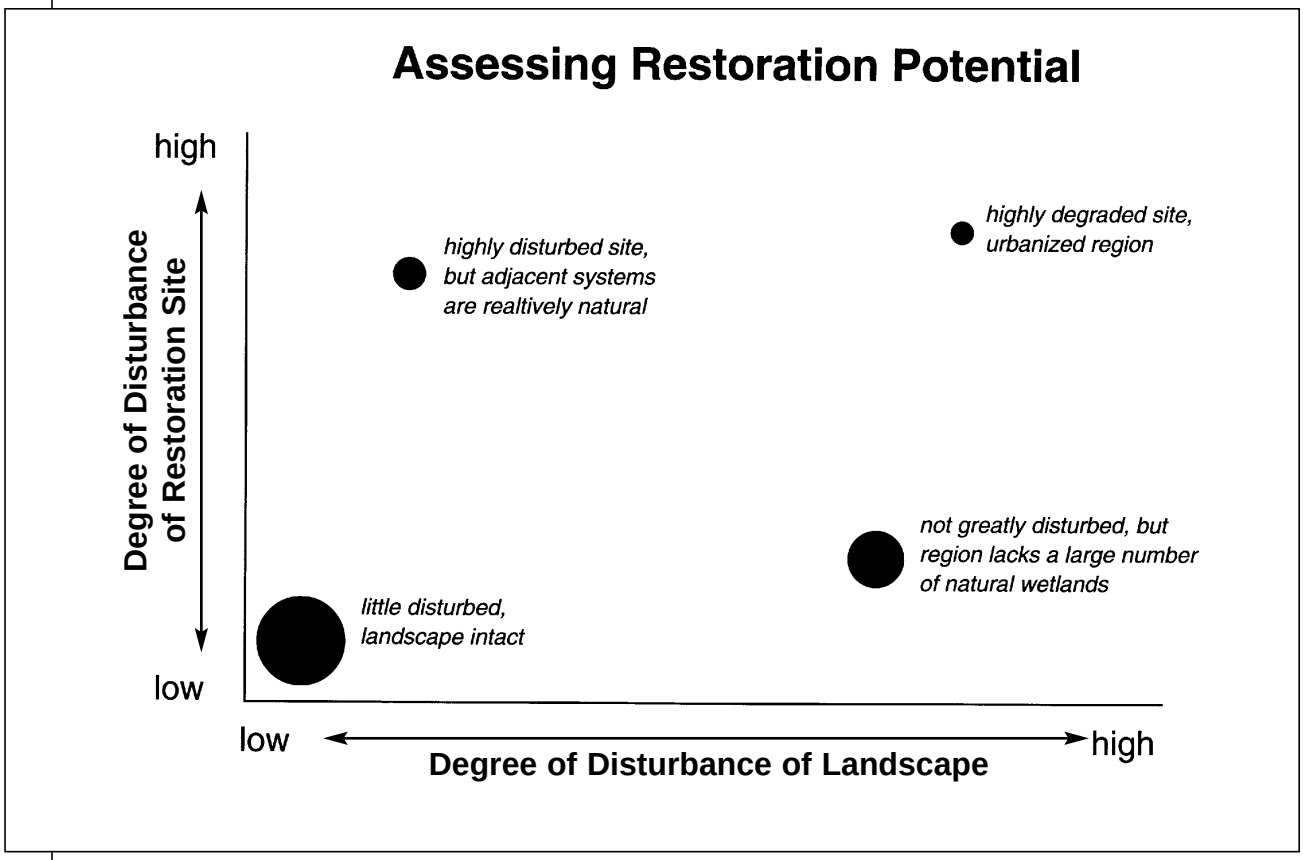

Figure 4.1 *Assessing restoration potential by using an hypothesized model for wetlands differing in degree of disturbance and landscape condition. Large dot indicates high potential for successful restoration; smaller dots indicate comparatively lower potential.* Used with permission from National Research Council, 1992.

and land managers when they evaluate the potential for restoration and expected outcome.

Site Hydrology

A key component for identification of a wetland type and its restoration potential is the water system on the site. The source of the water (groundwater, rainwater, surface runoff, snowmelt, etc.) is an important factor in the development of any wetland. The amount of water in an area and the duration of flooded conditions determine the kind of wetland that develops in any wet location. Under conditions of long duration of flooding, the soil chemistry is altered and produces soils known as hydric soils. Hydric soils form under saturated, anaerobic conditions and are recognizable by their gray-black colors and high organic contents. The 1987 Army Corp of Engineers Wetlands Delineation Manual, the standard for wetland delineation, focuses on three factors which must be met for a regulatory "wetland" to be defined: wetland plants, hydric soils, and hydrology. A site exhibits wetland hydrology if ponding over the soil surface is less than 2m deep and the soil is saturated to the surface during the growing season. Therefore a wetland is defined as "those areas that are inundated or saturated by surface or groundwater for a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."

Management of a fresh water wetland generally requires that the hydrology of the site be maintained or enhanced by protecting the source quantity and quality. In most cases, past alterations that drain off water or drop the water level should be reversed, if possible, so that more water is resident in the site. However, it must be understood that efforts which increase the level and/or duration of

saturation for the benefit of one species, may have detrimental effects on other species. An accurate assessment of the hydrology of the site is essential if a restoration or enlargement of the wetland is desired. Measurement of groundwater levels in a series of test wells over the course of a year or two will provide valuable data.

Considering the importance of hydrology in your restoration plan, it is recommended that you:

- Delineate current and proposed hydric soil areas.
- Include plans for maintaining and protecting water quantity and quality.
- Analyze the water budget.

Wetland Size

The local topography, hydrology, and climate determine the potential of an area to host large wetlands. Places like the eastern Coastal Plain or along broad river systems, large wetlands are common. In other locations large wetlands are not a significant part of the landscape; smaller wetlands (a few acres or less) are more common in these areas. In the Piedmont and Mountains of the Southeast, the topography and local relief restrict water-collecting slopes to a small percentage of the total watershed. With the exception of large river valleys, largely converted to agriculture, most wetlands in these areas are, or were, small.

It is very important to consider and accurately define the size of the wetland under management consideration. Include a primary boundary around the core of the wetland and secondary boundaries around areas that buffer the core, which allows room for potential expansion of the wetland. Include this information in the form of a map of the local area and the watershed where the wetland occurs. Other information on the site map should include any ditches and drains, buried tiles or pipes, stream channels, trees and shrubs, rare plant and animal occurrences, and any other relevant information about the site. This forms the first step in baseline documentation of the site.

Dennis W. Herman

*Swamp Pink (*Helonias bullata*) is one of the rare species found in Mountain wetlands.*

Natural Communities

A natural community is "a distinct and recurring assemblage of populations of plants, animals, bacteria, and fungi naturally associated with each other and their physical environment." In most cases natural communities are at the heart of sites considered to be biologically significant. Although occasionally sites are recognized as significant simply because they contain populations of rare species, most contain examples of one to several community types ranging in quality from fair to excellent. The significance of such sites is often augmented by, but not dependent on, the presence of rare species. The condition and extent of natural community types within a site usually has a strong influence on its overall significance. Resource conservation professionals can help identify and rank the significance of natural communities and plan for their management.

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*Spermatophores, found on leaf litter in winter or early spring, are evidence of breeding activity by spotted salamanders (*Ambystoma maculatum*).*

To successfully address the management of natural communities, these steps are recommended:

- Identify, map, and photograph current natural communities in and around the subject site.
- Map the ideal future natural communities after the restoration.

Wetland Animals

Most wetland types serve as habitat for animals of all shapes and sizes. Wildlife professionals, recreational wildlife enthusiasts, and many landowners appreciate the wildlife quality and quantity found in wetlands. The management objectives of many wetlands focus heavily on the needs of wildlife, often the target of restoration activity. Understanding the multiple demands, uses, and functions of all the wetland species, including humans, is important to integrating a successful management plan. Comprehension of wetland diversity and the plant and animal components is important to understanding wetland function. Identification guides are essential and many guides and keys are available; some excellent works are listed in the bibliography of this chapter.

Of specific interest in this manual is the bog turtle (*Clemmys muhlenbergii*), a small, elusive and rare turtle that lives in habitats of wet meadows, bogs, and other freshwater wetlands in the southern Appalachians and adjacent Piedmont. The biology, ecology, and distribution of the bog turtle are discussed in Chapters 2 and 3.

Other animal species that inhabit wetlands associated with the bog turtle include frogs, salamanders, snakes, turtles, various mammals from small insectivores to beaver, white-tailed deer, and a host of birds resident throughout the year or as seasonal migrants. Many of these animals are considered obligate wetland species (dependent on wetlands) and others can survive in many different habitats.

Wetlands can provide a variety of breeding sites for amphibians, reptiles, small mammals, insects, and spiders. Potential amphibian breeding sites include partially submerged or saturated logs, small pools along the edges of streams and rivulets, moss clumps, and rocks in and around moving water. Wet logs, damp soil, and mossy hummocks also make good spots for reptile eggs. Small mammals, such as meadow voles, build nests from grasses along the margins of the wet areas and birds nest in the woody vegetation or shrubs. Insects and spiders use a variety of habitats within the wetlands for breeding. More studies are needed to learn about their important roles in small wetland ecosystem ecology.

Considering the importance of wildlife in your restoration plan, these procedures are recommended:

- Survey wetland animals.
- Note wildlife habitat factors.
- Identify potential breeding sites.
- Describe desired habitat improvements.
- Monitor wildlife after restoration.

Following is a list of examples of a few species found in small wetlands of the Mountains and Piedmont of the Southeast. It is by no means intended to be comprehensive.

Amphibians are abundant around any healthy wetland. Some species of interest are:

- **Mud salamander** (*Pseudotriton montanus*), whose entire life cycle takes place in the muddy wetland.
- **Spotted salamander** (*Ambystoma maculatum*), whose winter or early

spring breeding migrations take them from adjacent woodlands to the deeper pools for courtship and egg-laying.

- **Pickerel frog** (*Rana palustris*), whose escape route takes them into the meadow instead of the water.
- **Four-toed salamander** (*Hemidactylium scutatum*), where females lay eggs under moss and attend them until hatching; larvae spend about 6 weeks in the water before transforming for terrestrial life nearby.

Common reptile species often found in these wetlands include the following:

- **Queen snake** (*Regina septemvittata*) - this slender snake eats mostly crayfish and is found near streams, rivers, and wetlands. Yellow on the lips and along each lower side distinguishes this animal from the northern water snake.
- **Eastern kingsnake** (*Lampropeltis getulua*) - a beautiful snake that eats turtle eggs, small mammals, birds, and other snakes. Usually quite gentle when handled.
- **Northern water snake** (*Nerodia sipedon*) - this extremely variable species is often mistaken for the venomous cottonmouth because of its affinity for water. The undersurface has half-moon-shaped spots, often outlined with dark brown or black. They prefer to escape, but will readily bite if prodded by humans.
- **Eastern box turtle** (*Terrepene carolina*) - often found in the shallow areas of wetlands but also can be found far upland. The carapace is dome-shaped like a German army helmet and the hinged plastron allows the turtle to completely withdraw its soft parts into the shell, protecting them from wildlife predators. However successful in the past, this adaptation does not protect them from road mortality and people who desire them as pets. Although it is hard to believe, this familiar turtle is in serious decline in many places throughout its range.
- **Common snapping turtle** (*Chelydra serpentina*) - become large as adults and can found in most of the wetlands of the Southeast. An impressive creature, this turtle may be found moving from one body of water to another in springtime.
- **Eastern mud turtle** (*Kinosternon subrubrum*) - a small turtle more abundant in the Coastal Plain than Piedmont wetlands and almost absent from the Mountains. They may compete with bog turtles when found in the same sites.

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Children learn by doing. What better way to get them interested in conservation than by letting them help with restoration projects?

A few mammals of interest are these:

- **Meadow vole** (*Microtus pennsylvanicus*), a common yet important species that creates tunnels through the wetlands that bog turtles and other animals use, and whose presence can be identified by grass clippings in their runways and their dark gray to black droppings.
- **Southern bog lemming** (*Synaptomys cooperi*), a small rodent similar in appearance to the meadow vole, but it has an extremely short tail and its droppings are bright green.
- **Beaver** (*Castor canadensis*), a very important (at least in the past) species that helps create and maintain wetlands

and whose presence is identified by terraced pools backed up by dams and the ever present gnawed stumps around the wetland.

- **Star-nosed mole** (*Condylura cristata*), rarely observed but easily distinguished from other moles by the 22 fleshy appendages surrounding the nostrils. Important ecologically because they aerate the soil, consume insects, and serve as prey for a wide variety of other species.

Bird species are so numerous in these wetlands that it is difficult to list them. Just a few of interest are these:

- **Song Sparrow** (*Melospiza melodia*) - an abundant species with a lively song consisting of many short notes and a trill near the end.
- **Alder flycatcher** (*Empidonax alnorum*) - known to have nested in at least one Mountain Bog in North Carolina, this bird normally nests in alder wetlands of more northerly regions.
- **Chestnut-sided warbler** (*Dendroica pensylvanica*) - a small, colorful warbler of the higher mountain wetlands.
- **Common yellowthroat** (*Geothylpis trichas*) - a species heard more often than seen in the wetlands.
- **Ruby-throated hummingbird** (*Archilochus colubris*) - our smallest bird species and the chief pollinator of Gray's lily (*Lilium grayi*), a rare flower found in several mountain wetlands in the southern Appalachians.
- **Red-winged Blackbird** (*Agelaius phoeniceus*) - a common resident of open habitats. Nests are built of wetland grasses and attached to cattails or stems of bushes growing near water.

Wetland Plants

Wetland plant communities are often small, remote, and usually unnoticed by most people. There are important differences in fresh water wetlands that can be identified by the species composition of the plant community. Any remnant natural communities on a restoration site provide useful information to guide restoration.

One of the most interesting aspects of working in small wetlands of the Mountains and Piedmont of the Southeast is the opportunity to see unusual plants not found in the drier terrestrial communities nearby (Appendix B). Resources for the identification of wetland plants can be found in common keys and field guides of plants such as those listed in the bibliography section of this chapter. There are also specialty publications dealing with wetland plants. It is important to be sure that the guide or key being used to identify an unknown plant is intended for that use and covers the geographic area where the plant occurs. Some important indicator plants are listed in Chapter 3.

Landscape Ecology

The lay of the land and its natural and manipulated parts make up the local landscape ecology. As in other ecological systems, such as food webs, these parts interact with each other and merge into the characteristics of the familiar landscape. Common parts of our landscape include various forests, meadows, farms, roads, streams, hills, houses, shopping centers, and thousands of other land uses. All this taken together, gives a place its special unique features and values.

The Natural Resources Conservation Service has adopted a hydro-geomorphic (HGM) approach for developing objective models of wetland functions. This modeling process involves the classification of wetlands based on landscape position and hydrologic processes, use of reference wetlands to develop a reference domain, and collection of scientific data to verify the models. The NRCS state biologist can assist restoration planners in determining whether appropriate functional assessment tools are available.

Of interest for wetland restoration and management are features of the ecological landscape in the watershed, including the wetland. Hydrologic details of the watershed are part of the analysis needed to classify a wetland. Landscape ecology issues might also include the ability of the wetland to filter out

Table 4.1 Guidelines for Development of a Management Plan

1. **Document the Site** (see Appendix E)**.**
   This record forms the basis of your own "case study" which should capture enough information about the site to allow a person who has never been at the site to understand the basics of the situation. Document every phase of the project in writing and with photographs. Provide as much detail as possible. Photograph the site from several different positions and permanently stake the points where photos are taken. Date and keep on file.
2. **Assemble Pertinent Ecological Information.**
   Include publications, advice from experts, and new data that might be collected from the site. This targeted new information will help you understand the site. All this information should help you to develop an ecological vision of the natural systems at your site.
3. **Gather Human and Socioeconomic Information about the Site.**
   Answer questions regarding land use, economics, law and politics, constituencies, cultural attitudes, and general demographics. Identify stakeholders who would be affected by potential site changes. Identify partners that might help achieve targets and goals.
4. **Engage Partners.**
   People of many skills and interests will help. Specialists may be necessary to help analyze and interpret data and refine the goals and targets of the management plan.
5. **Identify Direction.**
   Some are short-term targets, others long-term goals. Define the targets and explain their importance. Proper targets insure good planning, avoid wasted time and resources, and are key to all other planning.
6. **Analyze Information.**
   List and rank the targets and their threats. Determine the level of support and resources needed to achieve goals.
7. **Develop Strategies and Zones.**
   Describe the different parts of the site and any buffer areas. What goals apply to which areas? Define the targets in each area. Where do the threats come from?
8. **Identify Actions.**
   What has to be done to implement the conservation strategy? Who will do them? When do they occur? What do they cost? Who will pay for it? Make a timeline of actions and budgets.
9. **Assess Feasibility.**
   It is a waste of time to work on projects that are unwise, unrealistic, and likely to drain resources from other projects. Is it reasonable to expect success? Are the necessary ecological processes in place? Do the resources exist to complete the project?
10. **Measure Progress in Mid-course.**
    Evaluate project success based on the results of monitoring. Are the actions having the desired effect? Is progress being made toward goals? Are changes needed in the management plan or monitoring program?
11. **Follow-up.**
    Write up your results. What lessons have you learned? Will maintenance be required or is the project self-sustaining? If the project was part of a mitigation agreement, provide reports with data. Good, bad, or ugly, your results are an important source of information for others and should be shared—so the same mistakes are not repeated or successful strategies overlooked. Publish if possible.

Modified with permission from National Research Council, 1992 and Poiani et al., 1998.

Ann Berry Somers

Well-placed tin can provide important cover for wildlife. A search of several toxicology databases revealed that elemental tin, like that used in sheet metal, is not toxic to humans or other animals. Plywood coverboards are also used by wildlife, but the glues are not environmentally friendly.

sediment or chemical contaminants; to function as a flood and flow control measure for the watershed; to provide wildlife habitat; and to recharge groundwater. All these functions have many benefits for the natural and human populations of the ecological systems in the watershed. Identification and description of all wetland features and neighboring areas is basic information needed for a successful management plan.

Management Planning

Preparation is important in successful restoration and management; developing a workable and adaptive plan is the key to restoration success. This plan should include a testable hypothesis, monitoring, and evaluation of results of the treatments (manipulation). The treatments should lead to some desired future condition, known and described in advance. Often small manipulations, correctly applied, can make dramatic changes in the wetland landscape. Frequently the ultimate impact of a manipulation may not be obvious until its effects can be separated from the natural dynamics of the system. To achieve the desired result, a plan must be in place. Guidelines for developing a management plan are given in Table 4.1.

Future site conditions will vary, depending upon management objectives formulated with the help of professionals. For example, if the objectives are to maximize favorable conditions for bog turtles, a large core wet area with deep, soft mud is desirable. Increasing the size and duration of shallow wet areas is likely to appear in every management plan. Water depths should not exceed a few centimeters (except during extremely wet

Table 4.2 Ways to Reduce Risk of Failure in Wetland Restoration Projects

a) Make detailed assessments of wetlands prior to manipulation.
b) Document existing site conditions in writing and with photographs.
c) Photograph the existing plant community from different positions for comparison with later conditions.
d) Allow time for careful planning, and clearly state goals.
e) Consult professionals and agency personnel.
f) Create large buffers.
g) Use methods that require little maintenance.
h) Use detailed and long-term surveillance and monitoring.
i) Minimize impact during monitoring and construction.
j) Require a biologist to be present at critical times during construction; some construction crew errors are uncorrectable.
k) Allow for midcourse correction based on monitoring results.

Modified with permission from National Research Council, 1992.

times) and some surface water should persist throughout the driest part of the year. A mosaic of vegetation types should be present and include some woody plants such as alders. Large areas of native herbaceous vegetation including sphagnum mosses, sedges, grasses, and ferns are desirable. Alien species such as multiflora rose and privet are not desired. A diverse assemblage of animals will improve general biodiversity, and some large grazing animals are considered a favorable addition under certain conditions. (See Chapter 2, Bog Turtle Habitat Dynamics for more details.)

Once documentation of hydrology, biology, and landscape ecology is completed, the project plan can be constructed and given a final evaluation to determine the feasibility of meeting the objectives of restoration and management. Data generated by the evaluation should support the intended restoration design and long-term management of the site. Complications or problems with the plan should be obvious at this point.

Once the project is underway, allowing for mid-course evaluation can reduce risk of unwanted results. Corrections can be made based on monitoring results. Other suggestions for avoiding failure are outlined in Table 4.2. Some wetlands will need periodic management in perpetuity, but all sites should be evaluated several years after project completion and compared with management objectives in order to evaluate results. Short-term evaluations resulting in claims of success may be premature. Plan on follow-up data collection to evaluate long-term outcome.

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5

Managing Wetland Vegetation

Ann Berry Somers

Round-leafed sundew (Drosera rotundifolia).

Managing Wetland Vegetation

The purpose of this manual is to assist land managers in becoming successful wetland managers. A land manager can be any person or agency aware of the special needs and benefits of wetlands who has the power to make the needed changes. The intent is to stop the decline of wetland plants and animals by producing more and better wetland habitats. Habitats are environments used by species to grow, live, hibernate, bask, forage, and reproduce. The management options for specific wetlands vary, based on site character and the objectives and motivations of the management plan. Discussed below are some techniques used to manage wetland vegetation. While the primary consideration should be to improve the function of a target wetland, the adage "first, do no harm" is also worth remembering.

Over time, freshwater wetlands in the Southeast succeed toward a closed forest canopy; the sunny microhabitats gradually disappear as the interior surface becomes shady. The time this takes can be relatively short. For example, the Southeast experienced very dry conditions in the mid-1980s and during this time extensive woody growth emerged in many wetland sites. Although it is difficult to predict how global climate change will impact the wetland hydrology and biota of the Southeast, clearly the succession to shaded conditions is an important consideration in the conservation and management of small wetlands.

Many plants and animals require open sunny habitats and are not found in heavily shaded areas. Appropriate treatments may be needed to manipulate the wetland communities to the desired mix of woody and non-woody plants. For example, the ecology of the bog turtle seems to indicate a preference for patchy habitat of wet shrubby and woody areas interspersed with open, sunlit, boggy, wet meadows with various herbaceous vegetation types (Box 5.1). This habitat type might have developed and been maintained by natural disturbances (high winds, storms, floods) and the actions of animal herbivores such as beaver (Castor canadensis), elk (Cervus elaphus), or bison (Bison bison). Of the types of animals that might have played an important role, the beaver is the most likely since it not only feeds on woody plants, but is also an accomplished wetland builder. In many cases, our management strategy might be guided by comparison with the actions of beavers on the native landscape (see Wetland Management by Beavers, Chapter 6).

Several options for managing woody wetland vegetation include cutting, grazing, chemical methods (herbicides), and the use of fire. Each site will present prospects and challenges for the use of any or all of these techniques. Also, new technology and greater experience will likely produce new techniques applicable to specific problems. This basic discussion of vegetation management considers the dynamics of wetlands, the ecology of wetland species, and the larger picture of the watershed. With so many wetland functions and values at risk, it is helpful to know that options exist for their restoration and management.

Mechanical Woody Vegetation Removal Techniques

As used here the term mechanical means cutting, sawing, clipping, mowing, uprooting, and related physical techniques that can be used directly on plants. A variety of tools and mechanical equipment may be used to cut back or pull out wetland woody plants, depending on the job required. The size of the wetland and the amount of management

Box 5.1 Removal of Hardwood Canopy is Beneficial to the Bog Turtle

By Dennis W. Herman

The bog turtle's ultimate enemy may be a closed canopy. The turtle's basking sites and nesting areas are located in open, sunny sedge meadows with emergent vegetation and a subcanopy of shrubs. Later stages of succession produce a closed canopy that blocks sunlight and eliminates surface warming and herbs. Bog turtles are long-lived, reaching ages in excess of 40 years. Mating and egg-laying can occur over the life of a bog turtle. Reproductive success declines as adequate nesting sites disappear and individual turtles can live to a ripe old age persisting in sub-optimum sites. If areas open up in the wetland by man-made or natural reasons, then reproduction can once again occur in the population. This case study illustrates how an aged population of bog turtles benefited from the removal of canopy species and actually began reproducing again after nearly two decades.

Dennis W. Herman

This view of a meadow bog shows how livestock grazing maintains the open, shrubless wetlands preferred by bog turtles.

Dennis W. Herman

A view of the same meadow bog showing the rapid shrub succession two years after livestock were removed. Habitat becomes less suitable for bog turtles as shade increases.

The bog turtle was discovered along a second order stream in a north Georgia county in 1979. The habitat where the first turtles were found was atypical, comprised of a rocky meandering stream with small seepages irregularly located along the stream. Some typical wetland species were observed in the seepages including sedges (*Carex* sp.), bog rushes (*Scirpus* sp. and *Juncus* sp.), and small amounts of peat moss (*Sphagnum* sp.). A hardwood canopy of oaks (*Quercus* sp.), maples (*Acer* sp.), and tuliptree (*Liriodendron tulipifera*) dominated the area preventing sunlight from reaching the forest floor.

A bog turtle survey began in 1979 by a US Forest Service biologist ended in 1982. Only one old adult female was found during this initial survey. Dr. Ken Fahey found additional adult bog turtles from 1983 to 1986, all of them very old. No evidence of reproduction was ever found at this site, and it was assumed that it was an old population, expected to persist only until the last turtle died out.

The upper slope above the site was logged in 1986, but provided no direct benefits to the population. The survey was discontinued from 1987 through 1990. In 1990, Dr. Fahey and the US Forest Service joined forces, renewed searches, and began a trapping campaign to locate new turtles. The survey was moderately successful, with the capture of additional specimens, yet reproduction and recruitment were not observed. The Forest Service, at the urging of Dr. Fahey, began to selectively remove some vegetation and girdled some large trees in 1993. Girdling of trees has continued from 1994 to the present. A bog turtle nest containing three eggs was found in the top of a rotting hardwood stump in July 1997 in one of the open areas created by tree and vegetation removal. This was the first reported case of bog turtles reproducing at the site and in Georgia.

required to implement the plan often determine the most effective and efficient method to use. Small wetlands, like the most common ephemeral pools, seeps, and bogs are amenable to skillful management by people using hand tools without the aid of large, heavy machines. On the other hand, large areas like floodplain forests may require large equipment like trucks, tractors, and earthmoving equipment to achieve the management goals. If heavy equipment was used to drain or otherwise alter the wetland, then it is likely that similar equipment will be required for restoration.

The amount of time required for different techniques also needs consideration. Can organized work crews of volunteers be used at the site? Is there sufficient skilled labor available from the landowner or other local groups to do the job? Can someone subcontract this work? Who has the knowledge and skills? The timing of the treatments and the frequency of repeated or subsequent treatments must be considered. Does the management plan outline any alternative treatment options as conditions change? How will the treatments and subse-quent responses be evaluated for effectiveness? A wetland management project where the goal is to keep conditions sunny will require more intensive management practices. Consideration must be given to the fact that management might also continue far into the future and plans should be made now to ensure that the best possible arrangements have been made for this commitment.

Choice of technique may depend on the season in which the work will take place. If a wetland has deep, soft mud, as required by bog turtles, this condition will limit the machinery used and may make it difficult to walk around the site even in high boots. The impact of entering a wetland, with either machinery or people intent on drastically modifying the vegetation, should not be considered a trivial part of the management project. In some cases the trampling, crushing, and breaking of the surface and the hummock forming vegetation can cause direct destruction of plants, eggs, nests, or animals who hide in these niches.

Matt Flint

*Turk's-cap lily (*Lilium superbum*) is found in moist conditions in the Mountains.*

This damage can affect reptiles, amphibians, mammals, and invertebrates that live and nest in the low vegetation at the open margins of wetlands. Excessive trampling may also harm the hydrology of the wetland by penetrating impervious soil layers.

Careful cutting of wetland woody trees and shrubs can be effective in opening a closed canopy to the point of producing a response in the plant community. Often it might be helpful to experiment on a small part of the wetland to determine both the logistics of the site and to gauge the response of the treatment before it is widely applied. Cutting with hand tools or hand-held power equipment is the most accurate method of trimming or removing woody plants. Removing individual plants to open the canopy and allow more light to reach the surface can benefit surface basking reptiles, amphibians, and insects. These openings in the canopy may also benefit wetland herbs requiring sunlight at the surface to germinate and grow.

There can also be drawbacks to sudden new openings in the canopy. In experiments to study the effects of canopy openings on populations of mountain sweet pitcher plant (Sarracenia rubra ssp. jonesii), it has been observed that grasses and even red maple seedlings aggres-sively colonize some new openings. In some cases the new plants

Box 5.2 A DOT Wetland Mitigation Site

By Kenneth A. Bridle, Ph.D. and Ann Berry Somers

Mitigation is a term used to describe actions to compensate for environmental damage. This essay describes the case of a small wetland restoration and preservation that resulted as part of a mitigation agreement. This site was chosen because it is considered to be a freshwater biodiversity site of local significance. The wetland is located in a larger floodplain and was purchased by the North Carolina Department of Transportation (NCDOT) as mitigation for wetland damage during the construction of a highway bypass. The construction project and this wetland are in the same USGS hydrologic unit.

This wetland, called a "marsh" by locals, consists of a rich and diverse biological community in the midst of an historic farming and grazing bottomland. Horses and cows have grazed the site as recently as 6-7 years ago. Historic photographs confirm that this wetland has been exposed to row crops and other agricultural activity since at least 1940.

Dennis W. Herman

Marsh prior to restoration. Note woody growth in background resulting from elimination of cattle and horses that once grazed the area.

Possibly the most significant natural area in the county, this wetland has been noted by local naturalists, birders, and herpetologists for over 30 years. An informal group of biologists has been studying the site with occasional visits since about 1971. An array of wildlife studies have been conducted and information about birds, reptiles, and plants all indicate the special biological nature of this wetland. Vegetational analysis and soil surveys were used to delineate the wetland, and site hydrology was monitored for a year prior to construction.

The marsh is composed of at least four separate wetland zones including different assemblages of plant species. There is some uncertainty about classification of these communities, given their long history of human and agricultural disturbance and natural dynamics. Among the names applied to the existing plant assemblages by those who have been there, are Piedmont Fen or Meadow Bog, Wet Meadow, Marsh Hibiscus Pool and a Boggy Alder Thicket. There is also a willow and birch lined ditch and a large, tree-covered clay pan which functions like an extended ephemeral pool. Each aspect of these areas offers a variety of wildlife habitat based on the diversity of plant species and water quality.

Present are zones of shrubs such as buttonbush (*Cephalanthus occidentalis*), swamp rose mallow (*Hibiscus moscheutos*) and tag alder (*Alnus serrulata*). Woody plants scattered throughout include silky dogwood (*Cornus amomum*), swamp rose (*Rosa palustris*), and the non-native multiflora rose (*Rosa multiflora*). Herb-dominated zones include sedges (*Carex* spp.) and grasses, American bur-reed (*Sparganium americanum*), and cattail (*Typha latifolia*). Other herbs scattered throughout include monkeyflower (*Mimulus ringens*), lamp rush (*Juncus effusus*), arrowleaf tearthumb (*Polygonum saggitatum*), swamp milkweed (*Asclepias incarnata*), orange touch-me-not (*Impatiens capensis*), white vervain (*Verbena urticifolia*), and a hedge hyssop (*Gratiola* sp.). Drier areas support ironweed (*Veronia noveboracensis*),

tick trefoil (*Desmodium* sp.), and grasses such as redtop (*Agrostis stolonifera*), fescue (*Festuca* sp.), and timothy (*Phleum pratense*).

The mitigation plan included a 40 acre buffer of old fields around the wetland site. Key to the project success may be these enhancements, which restored additional parts of this floodplain to a wetland condition, increasing its value as a functional and biodiverse wetland. Ditches were filled, two more pools were excavated, and raised berms and a freeboard dam were constructed to control water levels in the area. Continued monitoring of the plant community development and hydrology are taking place in restored areas now that the construction phase is completed.

On-going threats to the site are primarily a result of the nearby human population. The major threat to water quality is fertilizer runoff from nearby develop-ments, and buffers have been constructed to help absorb some of the excess. The primary animal threats to wildlife are from free-ranging domestic cats and an apparent over-abundance of raccoons. Cats hunt wildlife even if they are well fed at home. Raccoons proliferate as a result of free food offered by humans in the form of garbage, compost piles, and pet food left on porches. These predators endanger the eggs, young, and adults of most reptiles found in the site; the eggs and chicks of ground nesting birds; and almost all other small animals. Biologists' recommendations for the site include management for these pest species. They menace many conservation initiatives throughout eastern North America.

SITE SIGNIFICANCE: Regionally significant due to the size of the wetland, the complexity of its natural communities, and the presence of at least one species listed as threatened and several uncommon species.

PROTECTION STATUS: Easements, management plan, and transfer of the land to a qualified conservation organization after the NCDOT mitigation requirements are fulfilled, will accomplish long-term protection.

Ann Berry Somers

Beavers kill large trees by girdling them, eliminating patches of canopy. This technique also works well when used by humans to limit shading.

colonize so thickly that other plants are excluded, including the rare pitcher plant.

Plants can be topped, limbed, or cut back to the ground in order to make openings. However, this treatment often may cause a bushy regrowth. Felling of large trees can also have a literal impact, depending on what they hit when they fall. Another method, bark girdling, removes the bark cutting off nutrient supplies to the roots, resulting in the death of the tree while leaving it standing as a snag. Standing dead snags can provide additional habitat for many species for many years. Eventually the tree will fall and provide important habitat and cover for animals and other species. Girdling is an easy, effective, and selective technique that can cheaply kill woody species using simple tools.

Managing Woody Debris

Cutting techniques generate lots of debris, which may also need to be managed. In some cases this accumulation must be removed from the wet region, and may be used to create nearby brush piles for animal habitat. Another use for this material may be within the wet

core area —by placing it as a beaver might to make low dams perpendicular to the slope of the valley. These structures slow down the flow of water and spread the flows into sheets across the ground surface. They also increase the ability of the wetland to filter and trap sediments, capturing material to increase the organic material retention. They can be used in conjunction with other methods to increase retention of water in the site (see Chapter 6). If these structures are effective in altering the surface hydrology, this modification may increase the wetness of the site and might also help modify surrounding vegetation for the benefit of wetland species like pitcher plants. Excessive flooding may occur during springtime or other wet periods and should be avoided, as it may drown eggs or otherwise harm some wetland species.

Mowing and Using Heavy Equipment

On those sites where it is deemed appropriate to use heavy equipment to fell and remove trees or mow down herbs and brush, care must be taken to minimize the adverse impacts of this type of work. Not only the physical impact of the equipment, intentional and incidental, but also the probability of fuel and oil spills, and other contamination must be expected and planned for. It is important that the equipment operator be aware of management goals or work under close supervision.

Box 5.3 Woody Vegetation Cutting Suggestions

- With the help of a professional, assess what to cut based on the desired outcome.
- Use the least impact method possible.
- Limit canopy removal to 25-50 percent per year.
- Plan to use or manage the cuttings.
- Avoid stepping on hummocks and other areas where hatchlings or eggs could be disturbed.
- Disturb only one patch of the site at a time. Assess the impact before continuing.

In many cases a skilled equipment operator can use experience and finesse to augment the plan and make necessary corrections once work has started. Do not leave an operator unsupervised as most equipment can make a dramatic impact quickly, and some mistakes are uncorrectable.

Many agricultural techniques like mowing and haying can also be used to manage vegetation in and around wetland sites. The timing of any vegetation management operation should be such that no harm is done to native species of plants and animals encouraged by the wetland management plan. Care should be taken to avoid cutting pastures too low, which can damage nests, kill small animals, and scalp tufting, clumping, and climbing vegetation. Consultations with local biologists and wildlife managers can be used to plan the best time and frequency of cutting, mowing, or haying operations. Slight alterations in typical farm activities can profoundly impact a wetland and its native communities. Delaying mowing just a few weeks or leaving an unmowed area as a buffer and refuge, may only slightly affect farm operations, but may be critical to a flowering or nesting species' reproductive success for the year.

Horse logging, a technology of a past era, is regaining favor for use in conditions where environmental impact from standard equipment is a concern. Horses can get into tighter areas with less surface stability than wheeled equipment. Horses can also disturb the surface less during log skidding. Horse hoof prints also do not channel water flow in the same way as tire ruts which can dramatically change the way surface water flows.

Grazing and Browsing Animals as a Means of Vegetation Control

Many types of animals make their homes in native wetland communities, living off the productivity of the plant communities in a particular area. Commonly, large animals like deer and beaver can crop woody vegetation enough to have a dramatic impact. Other

Box 5.4 Mowing and Heavy Equipment Use Suggestions

- Use the least impact method possible.
- When mowing, don't cut close.
- Don't mow more than once a year, less often if possible. Unmowed grassy and weedy areas provide important refuges and foraging areas for many forms of wildlife, including various game species, songbirds, and butterflies.
- Minimize ruts and compaction of soils and vegetation.
- Plan to minimize and mitigate fuel, oil, and grease contamination in the site.
- Avoid working during known breeding times and in suspected breeding places.
- Limit canopy removal to 25-50 percent per year.
- If using heavy equipment, disturb only one patch of the site at a time. Assess the impact before continuing.

animals like small mammals, insects, and birds can have an equally impressive impact on native plant communities by eating vegetation, pollination, seed dispersal, and other activities. As the biodiversity of the wetland restoration increases, many more levels of structure and interaction become evident.

Animals can be one of the most effective and important means of controlling unwanted vegetation by their grazing, browsing, bark stripping, root eating, and other woody vegetation manipulations. While some animals graze fresh succulent new growth, others gnaw at bark and, in the case of beavers, even fell sizable trees. Common large animals, like cows, horses, goats, and sheep, can keep vegetation well trimmed in any paddock. These and other agriculturally important farm animals have been used as vegetation management tools for centuries.

Livestock Grazing

Benefits derived from limited grazing include retardation of woody vegetation and shrubs, and prevention of channel formation. Hooves break up the rootstocks of shrubs and allow sheet flow to be restored. When livestock are removed from wetlands, water no longer pools in hoof prints, channels appear, and water flowing out of the site is increased. This enhanced flow in channels can cut deep grooves into the soil, increasing the detrimental effects of water lost to the system. Besides inhibiting channel formation, hoof prints also provide hiding areas for bog turtles and other wetland animals and exposes mineral soil for seed germination. However, excessive numbers of livestock can create problems by denuding vegetation and increasing nutrient input from fecal droppings.

At one time many conservationists thought that removing grazers was important for many rare wetland species populations to persist. In light of recent studies however, cattle and other livestock are now considered vital in maintaining site suitability for bog turtles and other rare species. The benefits derived from grazing can far outweigh negative impacts such as accidental trampling of plants and animals, compaction of soil, and additional nutrient enrichment.

A flexible system with the capacity to move animals into and out of the wetland, or provide grazer access only at specified times of the year will be the most useful and potentially the most agriculturally productive. Paddock management, fencing, alternative watering sources, heavy use areas, and controlled wallows have proved to be positive investments in many streamside and wetland sites—benefiting both the farmer's business and the environment of the watershed. These are practices where the strength of conservation agencies can help landowners with new technical information and financial assistance (see Chapter 7).

The best grazers for promotion of bog turtle habitat appear to be beef cattle; goats or sheep may have similar or perhaps greater benefits, but these have not been studied. Limiting grazing density to no more than one animal unit (= one mature beef cow, also see Glossary) per acre will optimize the situation for both pasture health and turtle success.

Kenneth A. Bridle

Managing wetlands may include seasonal exclusion of livestock.

Adjustments can be made when other types of grazers, such as dairy cattle, horses, or sheep, are involved. Once a grazing regime is in place it can be fine-tuned by removing or adding livestock to the site.

The use of excluder fencing and seasonal grazing (winter grazing) are important conservation tools for the management and protection of bog turtle and other wetland species habitats. Seasonal exclusion of cattle has been proven to be an effective management tool in regulating soil and vegetation impact: denuded areas become reestablished with vegetation, sensitive plants can grow, and safer conditions exist for wetland nesting animals. Cattle can be permitted free access to the wetland during late fall and winter, permitting the benefits described above. Researchers studying a dangerously small population of bog turtles in North Carolina recorded a population increase of 85% within a 5-year period after seasonally restricting cattle. Other strategies include allowing grazers access to the sites year-round, but drastically limiting their numbers. Protection of nesting areas is paramount to the success of turtle populations.

Although bog turtles and some other rare species do indeed coexist with wild and domestic grazers, some plants cannot tolerate interaction with livestock. The size and type of wetland community have to be correctly matched with the amount and type of grazing in order to limit negative impacts on the wetland natural communities.

Box 5.5 Wetland Grazing Suggestions

- Allow only light to moderate grazing.
- Beef cattle are the preferred grazer; but horses are also highly effective. Goats and sheep may also have important beneficial effects.
- A ratio of 1 animal unit per acre is preferred.
- Grazing on a seasonal (winter only) rotation basis is acceptable. Construct a fence around the site allowing a buffer of native vegetation to filter polluted runoff.
- Use fertilizer and lime sparingly when applying to lawns and fields surrounding any wetland.
- Use excluder fencing around known or suspected turtle nesting areas, sensitive plants or plant colonies.

Chemical Controls of Vegetation

The modern tools of vegetation control include herbicide chemicals. In any vegetation management project, questions will always arise regarding the advisability of chemical herbicides for the control or elimination of undesirable plants. Chemical herbicides are complex formulations mixed to meet specific goals in specific situations. Because of the complexity of testing, labeling, and use, most herbicides are targeted for major markets, like agriculture, lawn care, or terrestrial weed control.

Using Chemicals with Caution

Each year chemicals are released into the environment in many forms ranging from raw petroleum products to refined pharmaceuticals. These chemicals amount to billions of pounds each year. The fates of these chemicals and the life cycle of their products in the environment are largely unknown. The release into the environment of chemicals commonly known

as pesticides can be especially risky as they are designed to be toxic. When deciding to use pesticides, one must consider the balance between benefit and risk. Herbicides are a type of pesticide used to kill plants.

Registration of herbicides follows a complex set of rules that seek to allow the sale and use of chemicals judged to produce more benefit than harm. However, out of all theoretical possibilities, it is only possible to research the likely and obvious uses of chemicals. Therefore the labels of herbicides are specific about how they can and should be used. Use of any herbicide in a manner not intended on the label is illegal and both personally and environmentally risky. Because of the relatively small amount of applications of herbicides in and around water and the complexity of adding chemicals to aquatic solutions, few herbicides are labeled for use in aquatic or wetland conditions.

Testing for labeling includes herbicide toxicity in several types of models: breakdown products, persistence in the environment, potential to accumulate in the food chain, and hazards to non-target species. This complex assessment allows chemical manufacturers to claim benefits as weighed against potential and documented risks. Few chemicals have been tested with rigor for their impact on the environment, including unintentional consequences to non-target organisms and humans. Many chemicals can and do react to form complexes of products, most of which have not been well-studied. The interactions and accumulation of these products and their unintended consequences have, however, been documented with a few now famous case studies of DDT and 2,4 D effects on wildlife. Caution in the use of herbicides is always recommended. It is therefore crucial to apply herbicides according to label recommendations.

There may be conditions in wetlands where concerns for the effectiveness and efficiency of plant growth control offset unintended impacts of chemical herbicides. In these situations the selection of the proper chemical, application, timing, and technique can reduce negative impacts as well as enhance effectiveness.

At the time of development of your management plan, a review of the available labeled herbicides should be undertaken. Labels and chemical formulations change as older compounds are replaced with newer formulations for new uses. It is often best to check with the local cooperative extension agent to get an update on what might be available to achieve the intended goals for chemical vegetation control. Names and product descriptions given in Appendix G are for discussion and are not intended as endorsements.

Application Techniques

Herbicides are typically applied as sprays, liquid paints, injections, granular formulations, or fumigants. There are no granular formulated products or fumigants appropriate or labeled for wetland conditions. Some of these might be used in adjacent crops and these measures should be researched relative to the management plan.

The use of spray equipment allows for many combinations of nozzle type, orientation, and pressure to achieve correct delivery and contact of the herbicide with the target plant while minimizing drift. Label recommendations are given regarding equipment and acceptable weather conditions approved for use. It is worth emphasizing that the use of spray equipment, while perhaps the easiest strategy, produces the most non-target damage and drift. See Appendix G for more details of herbicide use in wetland restoration.

Simple tools can be used to stem inject using the cut and frill technique. A sharp knife or hatchet is used to make cuts down into the cambium, leaving the bark attached. The bark stays attached and forms a cup for application of the herbicide. These cuts, called frills, should be arranged to encircle the stem or trunk. The number of cuts is proportional to the diameter of the stem. Each of these cuts is then filled with herbicide using a squirt bottle or brush.

A treatment called stem injection uses a hatchet equipped with herbicide to inject herbicide with each cut. Cut and frill and

stem injection techniques are good methods to deliver the active ingredient only to the target plant, thus minimizing unintended impacts on other vegetation. The number of cuts or injections made in the stem controls delivery of the active ingredient. Larger stems require a larger number of cuts or injections, usually one per inch of stem diameter. Stem injection and cut and frill may not be useful on stems less than a few inches in diameter.

When using the cut and frill, or stem and stump painting techniques, the likelihood of an herbicide spill is high and must be considered likely. The results of dripping or splashing herbicide onto the ground, water, or non-target plants might be risky in habitat containing rich biodiversity or rare species. Extreme care should be taken when using these techniques.

In the specific case of the bog turtle and some wetland herbaceous species, woody vegetation forms a closed canopy over the wetland target of the vegetation management. With the removal or opening of the canopy vegetation, an equally important colonization of the surface by herbs will most likely be promoted. These herbs are not only important cover and root mass to hold the deep mud in place, but also the basis for the food chain. As plants are the foundation of the food chain, animals that depend on them will ultimately be affected by their loss. If herbicides can be confined to the canopy or inside the body of woody stems, the chance of negative impact on the herbaceous feeders on the ground is diminished.

Care must be taken whenever manipulations of wetland vegetation might have impacts broader than the target goals. There should always be concern for the sensitivity of non-target species to herbicide chemicals or their by-products in the wetland ecosystem.

Timing and Application Variables

Given a choice of a particular herbicide and its labeled uses, a wide range of treatment variables will affect the outcome. The amount of active ingredient needed for the desired effect will vary, depending on the seasonal and daily timing of the herbicide treatment, the species of plant and its stage of growth, the weather, temperature, and the thoroughness and consistency of the application technique. An effective result may be hard to duplicate if these parameters are not well documented. This difficulty is the reason why most manufacturers recommend a small test area before large-scale use of herbicides. This recommendation is especially useful if there is concern about effectiveness and other impacts in a situation where there is little experience.

Many herbicides achieve maximum effectiveness during the period of maximal growth of the target plant, a situation which in this case may also coincide with the maximum activity of the bog turtle and other wetland species. If convergence is deemed a problem, adjustments in treatment time might still prove effective. For example, avoiding herbicide application during the turtle breeding and nesting period may lower herbicide effectiveness. However, there are obvious benefits of not bothering the turtles during this important part of their life which may justify this action. Perhaps just avoiding the known nesting habitat during the active season might be another solution.

Target Species

Target plant species that need to be managed in freshwater wetlands include the native woody species that dominate later stages of succession into a wetland forest community. The climax woody species of canopy size include Canada hemlock (Tsuga canadensis), red maple (Acer rubrum), black gum (Nyssa sylvatica), tuliptree (Liriodendron tulipifera), sweet gum (Liquidambar styraciflua), black willow (Salix nigra), green ash (Fraxinus pennsylvanica), and sycamore (Platanus occidentalis). Shrubs may include great laurel (Rhododendron maximum), mountain laurel (Kalmia latifolia), silky willow (Salix sericea), tag alder (Alnus serrulata), silky dogwood (Cornus amomum), southern wild raisin (Viburnum nudum), poison sumac (Toxicodendron vernix), and spicebush (Lindera benzoin).

Many freshwater wetlands in the Piedmont and Mountain regions have been invaded by introduced alien species like multiflora rose (Rosa multiflora) and Chinese privet (Ligustrum sinense), often specifically mentioned as labeled species controllable by herbicides. Poison ivy (Toxicodendron radicans) may pose a problem in some wetlands as it can become dominant in disturbed wet areas along the edges of farm pastures. Any opening of the canopy may become an area colonized by poison ivy. This danger may actually be more of a deterrent for human visitors than resident species. Poison ivy is, however, a target species for many herbicides, which in fact have proved successful in management of this potentially aggressive vine.

When a chemical treatment is considered for wetland vegetation control, it should be integrated into a management plan that outlines ultimate goals and timelines of steps used to achieve these goals. These chemical techniques can and should be used in conjunction with other methods of woody vegetation management. It would be unlikely that a single herbicide treatment would achieve all the management goals in the typical wetland.

When used with care, a single herbicide treatment, correctly and environmentally applied, can be an effective tool. However, the use of herbicides brings with it many documented problems and unknown effects that may endanger long-term success of wetland management. In areas where rare species are found, all recommendations from the EPA and chemical manufacturers suggest that chemicals be considered only as an option of last resort.

Box 5.6 Chemical Use Suggestions

- Use chemicals only as a last resort.
- Use chemicals with the least impact.
- Minimize non-target vegetation impact.
- Plan to minimize and mitigate chemical contamination of the site.
- Leave refuges for wildlife.
- Avoid treating during known breeding times and in suspected breeding places.
- Limit vegetation removal to 25-50 percent per year.
- Use chemicals only on one patch of the site at a time. Evaluate the impact before continuing.
- Use an application technique that is targeted and appropriate.

Fire as a Management Tool

The influence of fire on the natural communities of the Mountains and Piedmont has not been fully appreciated. Studies suggest that naturally ignited fires burned regularly in the native plant communities of North America. More frequent and larger fires on the Coastal Plain grade to less frequent and smaller fires in the Mountains and Piedmont. The topography and variability of habitats make for barriers, limiting the spread of fire through the major communities. The impact of fires on formation of wetland communities is not definitively known. Indeed, no publications about fire ecology in these small, freshwater, Mountain and Piedmont wetlands were found. Likewise, the use of fire as a management tool in these sites is only vaguely covered in the literature. However, it would be reasonable to assume that wetlands are not immune from fire when conditions are right. Some parts of a wetland, like the fringe communities and the canopy, could burn without the most sensitive core of the wetland surface experiencing a hot fire situation. As more is learned about the dynamics and development of natural communities, we will understand the essential role that fire can, (and in some cases must) have on natural systems.

Fire is a useful tool, common in the tool kit of many landowners and land managers. Many people and agencies have experience with using prescribed fires for maintenance of fire dependent natural communities. Forest management went through a period of fire suppression and prevention which has proved both damaging to natural communities and dangerous when excess combustible fuel accum- ulates. Foresters have begun to re-introduce fire as a part of the natural and healthy ecology of many managed areas.

Kenneth A. Bridle

A hand-held torch can be used to spot burn individual woody plants.

There is now significant evidence that fire is an efficient and selective tool, worth using in the right situations. There are also specific techniques that use fire to control invasive weedy plant species, prepare seedbeds, promote seed germination, reduce combustible litter, and enhance soil fertility from the ash. Most of these forestry techniques rely on prescribed and controlled ground fires set with drip torches and wicks. These fires propagate along the surface and in the herb, shrub, and sub-canopy species, are generally controlled in such a way as to limit the impact on canopy trees. Fire roads, fire breaks, backfires, teamwork, preplanning, permitting, and a careful watch of the weather are all necessary parts of a successful burn. This type of burn is an integral part of most terrestrial landscapes; however, the use of these techniques might be inappropriate or impossible to use in wetlands. In some cases a limited ground fire might be the right tool for a wetland management job and therefore should be considered.

Other techniques that use fire as a management tool rely on torches to burn only the target species and are much more selective. Several versions of commercially available torches have been developed for use in special applications. These propane-based torches are usually small, light weight, and easy to use. Torches have been used on specific targets like weeds growing in cracks in sidewalks or at the base of metal fences. Some have been used for weed control in greenhouse, nursery, and tree farming situations. Smaller units have even been advertised for homeowner use in weeding flower and garden beds. The advantage of control and selectivity makes these torches promising in the control of wetland vegetation where burning the surface can be avoided. It is often on the surface that the most significant and least fire adapted wetland plants and animals are found.

The benefits of this technique on the target vegetation depends on the type of fire treatment and the sensitivity of the species involved. The frequency and seasonal timing of fire can dramatically influence effects on the target plants. In most cases hot and intense fire can kill plant tissues directly with the effects of the heat, desiccation, and direct combustion of leaves, stems, and seed. Plants with significant underground stems or tubers or fire protected stems and buds can survive and recover from fire. Plants without these adaptations may not be directly killed by the fire, but may be stressed to the point that they become susceptible to attack by insects or other pathogens, which can then kill the plant. A good source of information about the effects of fire as a management tool can be found in the Fire Effects Information System (FEIS). FEIS provides up-to-date information on fire effects on plants and animals. It was developed at the USDA Forest Service Intermountain Research Station's Fire Sciences Laboratory (IFSL) in Missoula, Montana. The National Wildfire Coordinating Group and the USDA Forest Service sponsor this national inter-agency information source. The FEIS Information Center is maintained by the Intermountain Region computer staff. The database is available on the Internet at: www.fs.fed.us / database / feis / welcome.htm.

Prescribed controlled burns have been used to try to eliminate reed canary grass (Phalaris arundinacea) in a bog turtle wetland in Pennsylvania. This strategy is based on a report from Illinois that burning five years in a row effectively controls this species. Three

years of early December burns have not proven effective at the Pennsylvania site. This same group is also using experimental light grazing (1 animal unit / acre) on a rotational basis to reduce cover, create water pockets, and control invasive species. They also girdle trees to control succession to forest and are considering some burning in the tussock sedge habitats of the bog. The results of this management study have not been published.

One technique of using a torch to eliminate woody vegetation depends on the promotion of systemic pathogen infections that subsequently causes plant death. In this method the target vegetation is cut 6-12 inches off the surface at some time early in the growing season. Several weeks later the plants resprout new succulent growth, when air and water temperatures have warmed. At this point a flame from a torch is used to singe or sere these new shoots, breaking the surface cuticle and damaging the outer cell wall defenses of the plant. This procedure leaves the plant susceptible to invasion by naturally occurring pathogens that can find their way into these open wounds. Experiments show that this treatment results in a higher probability of plant death than cutting alone. Several field tests of this technique in bog turtle habitat have documented some its effectiveness in the short term. The long-term effect of this treatment over several seasons is also being observed. There is need for both experiment and long-term follow-up on the effects of fires in freshwater wetlands. Also, the results of different variations and augmentations of the torch technique, along with more traditional ground fire, will undoubtedly improve our understanding of the critical aspects of the technique and improve its application to wetland vegetation management.

A related technique, using super-heated steam, has also proved effective in weed control. With water as the active ingredient and only by-product, this technique should be attractive for use in wetlands. Currently, the equipment is produced in New Zealand and is only recently becoming available in the United States.

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Additional Resource

Fire Effects Information System database is available on the Internet at:
www.fs.fed.us / database / feis / welcome.htm. An online resource with specific information on a broad list of plant species and their responses to fire. Examples, management case studies, and literature review for many species.

6

Managing Hydrology

Ann Berry Somers

Spring peeper (Pseudacris crucifer).

Managing Hydrology

A wetland is defined by its soil, vegetation, and hydrology. Of these hydrology is a primary factor in the development and long-term survival of all wetlands. Hydrology, as used here, includes both the hydrologic cycle and the hydrologic budget. The hydrologic cycle is the movement of water between the atmosphere and Earth. It consists of precipitation, evaporation, runoff, and infiltration of water into the ground. The hydrologic budget applied to many fresh water wetlands consists of six parameters arranged mathematically as:

Outflow = Precipitation $\pm$ Groundwater + Surface water - Evaporation - Transpiration

The outflow is dependent upon the precipitation that falls within the watershed of the wetland, surface run-off and flooding, and groundwater that is either discharged or percolates downward through the soil profile. Groundwater flows through the internal hydrogeologic framework of the wetland and may act as a source or sink for surface water. In some wetland systems, the hydrologic budget can be manipulated.

The Hydrology of Meadow Bogs and Related Wetlands

The Meadow Bog internally consists of fine-grained silts and clays in a mixture of cobbles and gravel. This mixture forms an internal permeability, allowing groundwater to migrate through the bog at various depths below the ground surface. This patchy and diverse hydrology promotes an equally diverse mixture of plant and animal life.

The hydrologic system in a Meadow Bog is analogous to a sieve with a sponge inside.

Ann Berry Somers

Vegetation changes when hydrology is altered. Trees die as new beaver activity results in deeper water in this lowland.

The sponge serves as the wetland. The sieve would be tilted just enough to provide internal energy gradients for water to flow through the sponge. Water is input from a hose in the upper portion of the sieve, mimicking a series of springs. Water is

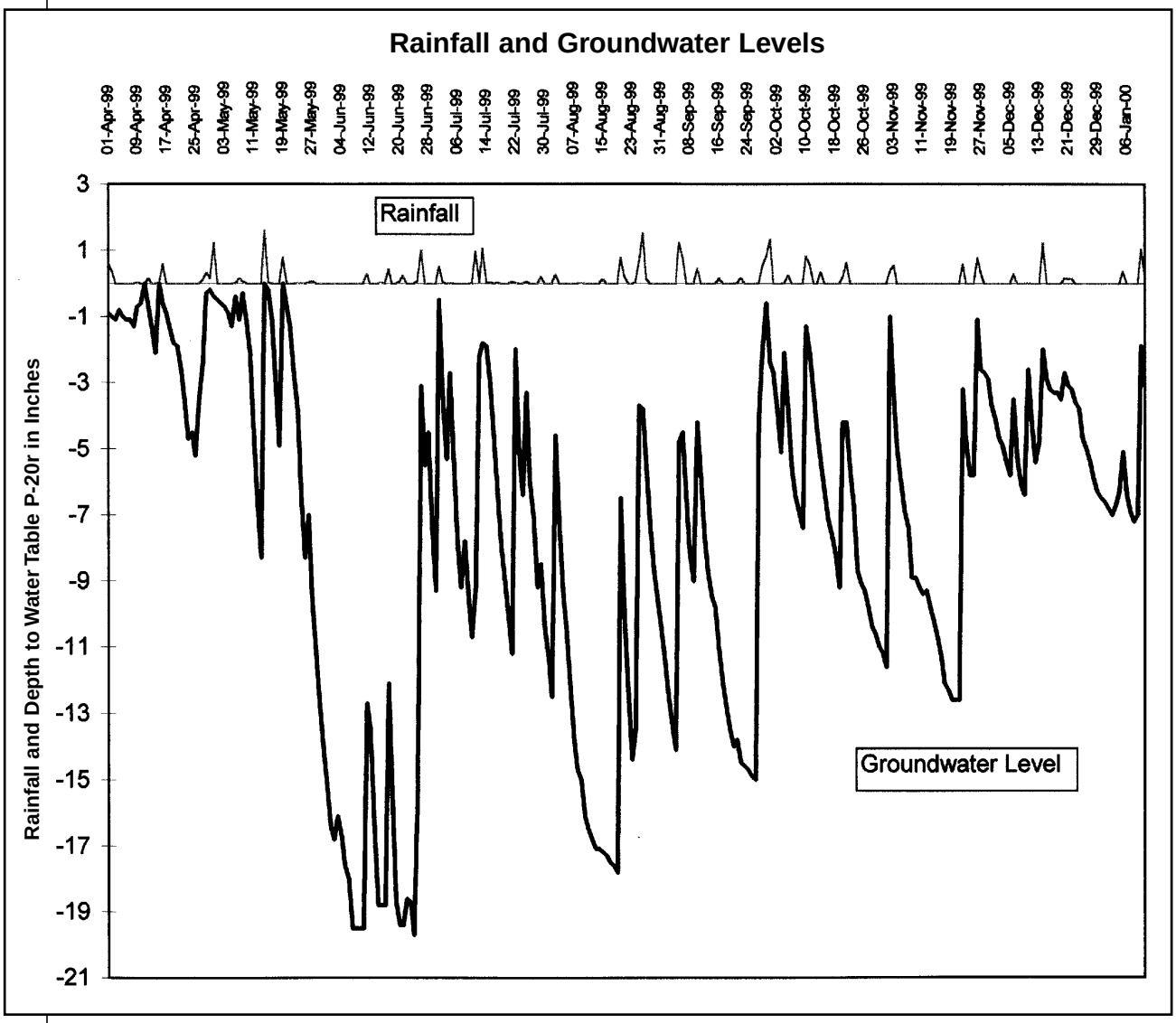

Figure 6.1 *Groundwater fluctuates with rainfall. Hydrologic management goals should include increasing the duration of ground-level saturation.*

occasionally sprinkled onto the sponge (precipitation). Water is then allowed to evaporate from the sponge, a process simulating evapotranspiration. A hole added to the sponge center acts as a drainage ditch. Through this analogy, we can develop ideas to balance the input and output of the altered system. In order to form a functional wetland, the water level must be maintained to saturate the top of the sponge.

In many freshwater wetlands the depth of water and the period of saturation are the major factors determining the structure of native plant communities. Typical bog communities, including bog turtle habitat, have a wet core area even in the driest summer. Areas that surround the core fluctuate in wetness seasonally or in relation to run-off patterns.

Figure 6.1 shows how the water table fluctuates seasonally and in response to precipitation events in a Piedmont Meadow Bog. Note that the level of the water table stays within 6 inches of the surface much of the year with occasional drops to below 13 inches during low rainfall periods. The post-restoration condition should reflect water at or above the surface for longer periods during years of average rainfall.

Natural changes and human activity can also cause significant changes in the hydrology, which promote changes in plant

communities. As local conditions change, some wet spots dry up and other dry habitats become wetter. Such changes are easy to observe when beaver activity begins: A wetland forms behind the newly created dam and woody trees and shrubs that are not adapted for growth at the new level of saturation begin to die. A similar result can be expected in wetland restorations where the hydrology is changed to increase saturation depth or duration. In some cases the woody plants adapted to drier conditions will drown because their roots cannot get the needed oxygen. Many woody plants are adapted for saturated conditions during winter and spring, but require dry conditions during summer. If continually or temporarily flooded for an extended period during the summer, they may die.

Ann Berry Somers

This staff gauge and electronic water table monitor are protected from cattle by a small barbed-wire fence.

Remediation Hydrology

One promising place to look for wetlands to revive is where past efforts at ditching and draining have been less than successful, a situation resulting in low wet areas, not quite suitable for crop production and usually left in persistently wet pasture. These places are usually viewed by the landowner as examples of failure to dry the site out and make it agriculturally useful and productive. Once the functions and values of wetlands (Table 1.1) become understood by these landowners, restoration and management will become equally, if not more, rewarding than altering the land use to a marginal activity. With added benefits from conservation technical assistance, easements, and cost-share programs, landowners can be compensated for their restoration and management of wetlands.

In many instances attempts to drain a wetland for agricultural use altered internal hydrologic systems. This was usually accomplished by digging a ditch near the lower end of the bog or installing tiles to drain the internal groundwater supply. It may be possible to alter this outflow and re-establish the internal hydrologic system to a degree that the bog can function as it did prior to intervention. Manipulating the hydrology of a wetland should not be undertaken casually, and professionals should be consulted when this strategy is considered. Permits or certification may be required for some activities, including adding fill material or installing well-monitoring equipment.

When restoring the ecological function of wetlands, the goal may be to saturate the ground without producing deep-standing water. Deep water decreases the muddy terrestrial habitats available to species like the bog turtle, Gray's lily, and many other wetland plants.

Land managers should use the water budget on site to restore a wetland of optimum size, structure, and function. Historical maps, photos, physical evidence, and soil sampling can help determine the past extent of the wetland. Management of a fresh- water wetland generally requires that the hydrology of the site be maintained or enhanced by protecting the water source quantity and quality. Past alterations that drained off water or dropped the water level should be reversed if possible so that more water resides in the site, especially if this condition expands the wetland or increases the level or duration of saturation.

An accurate assessment of site hydrology is essential for restoration or enlargement of wetlands. In some instances hydrologic conditions are apparent or may only require accounts of recurring conditions by knowledgeable local residents or the

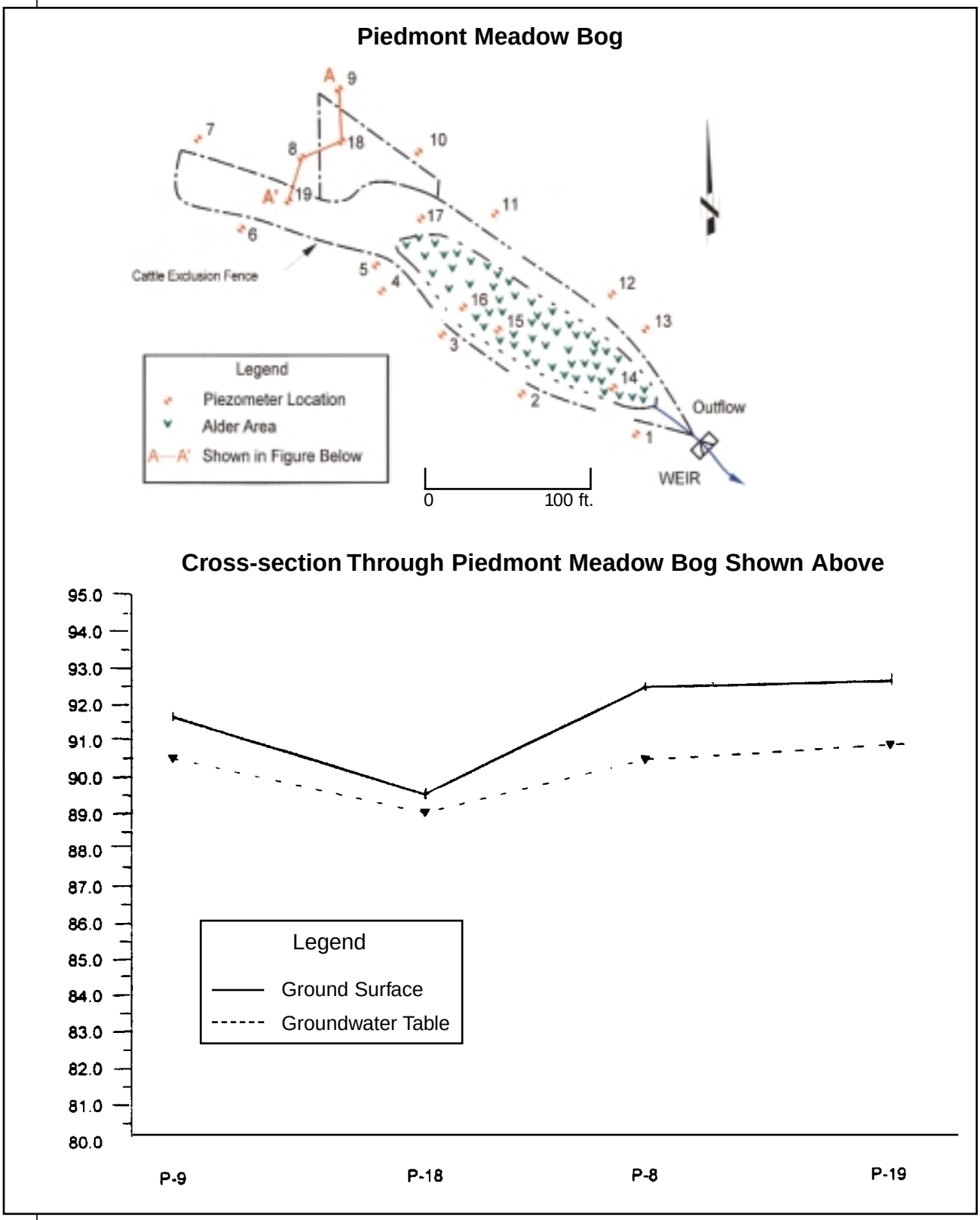

Figure 6.2 *Cross-section through a Meadow Bog showing the position of the water table with respect to the width of the wetland and the ground surface.* Note: Ground surface elevations are based on an arbitrary site survey benchmark of 100'.

examination of documents such as historical photographs. In other cases trained personnel are needed to confirm the suspected hydrologic regime. For a site where the hydrology is not known, measurement of groundwater levels with piezometers (small diameter wells) over the course of a year or two (assuming normal weather conditions) will provide valuable information about subsurface water levels. If rainfall or precipitation levels are excessively high or low during the period of monitoring, the monitoring should be extended to account for average conditions. Surface water levels can be measured using a staff gage in the site. Total surface water outflows can be measured with V-notch weirs or flumes at the inlet and outlet points of surface flow. V-notch weirs, flumes, and similar devices should be installed in such a say as to not alter the existing patterns of surface water flow.

These measurements can be compared in relation to seasonal weather and storm events to give a better understanding of the site's water dynamics. As with other ecological resources there is no extension beyond the water budget, so pairing the management objectives to the site capabilities requires hydrologic knowledge of the site.

The position of the water table throughout one Meadow Bog in the foothills of North Carolina was tracked over a two-year period. In this wetland system the water table generally mimicked seasonal precipitation highs and lows with lag times of one to two months. The relative position of the water table in this bog was higher adjacent to the spring, with a low towards the mid-line of the bog and a slightly higher water table along the lower side of the bog. Figure 6.2 is a cross-section showing the position of the water table through a section of the site.

Altering Flow

Using woody debris to create obstructions or low dams in water channels should alter the flow of surface water in the site (see Managing Woody Debris, Chapter 5). Another way in which the hydrology can be manipulated is by obstructing water flow at the outlet of any ditch that may exist. Installing a dirt plug or dike in the drainage ditch is the preferred method and requires the least resources and management over the long-term. Plugs should incorporate a small spillway or weir set at the desired water level. Standard surveying equipment can be used to determine the extent and depth of flooding for a given spillway elevation.

Kenneth A. Bridle

A V-notch weir to measure water flow.

Increasing the depth of surface water to more than a few centimeters above the surface is disadvantageous for many rare species, but may be a temporary by-product of hydrologic manipulations. If erosion or digging has resulted in loss of substrate near the outlet, then surface water up-grade of the dam may initially become deeper than desired, forming a small pool. The pool will become shallower over time as the normal flow of sediment fills the area, deeper water infiltrates surrounding

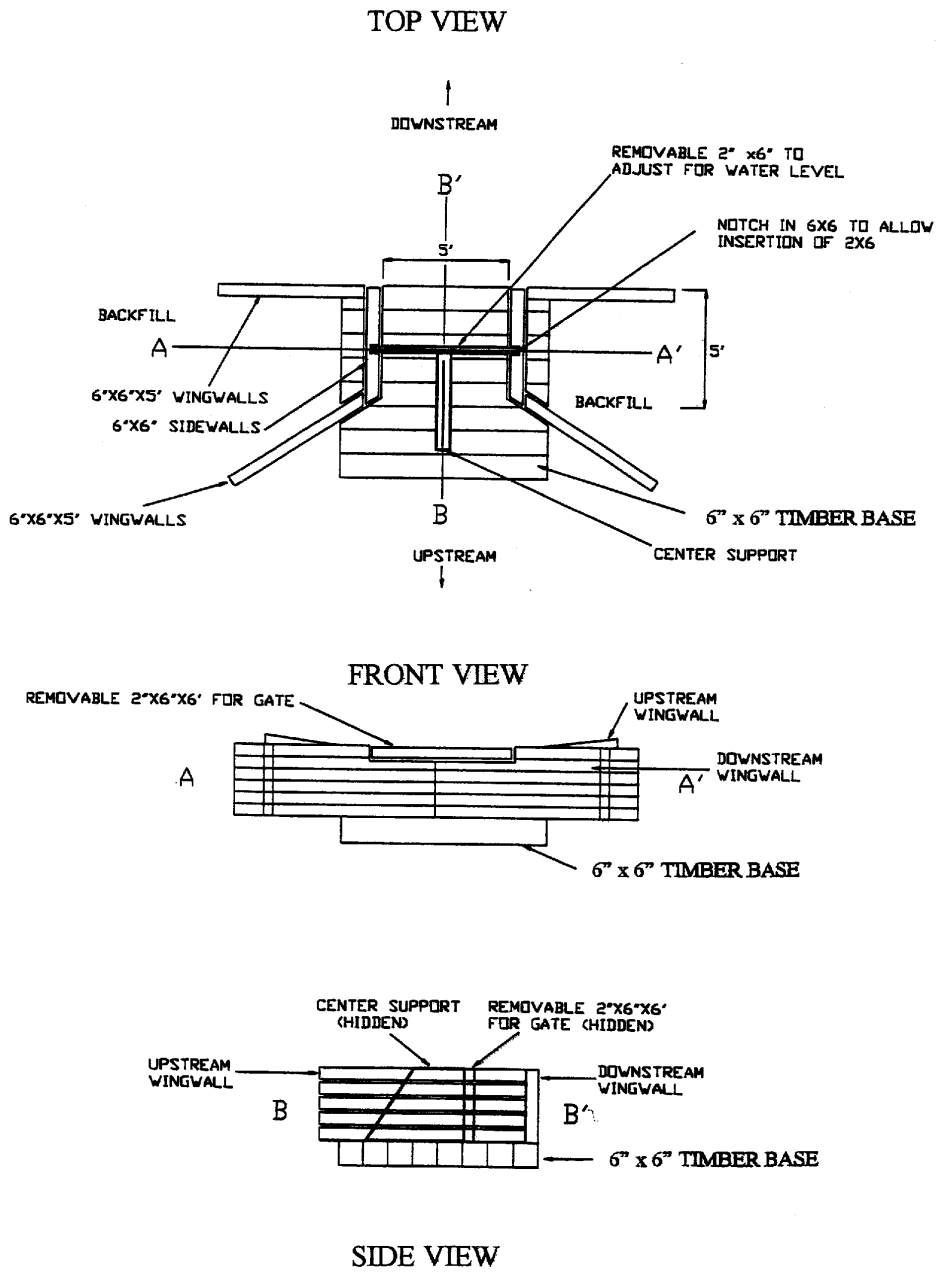

Figure 6.3 *Timber gate system used to manipulate surface and groundwater levels at the outlet point of the Meadow Bog.*

unsaturated zones (soil above the water table), and a balance is achieved in the wetland water budget.

Soil for the plug can often be found beside the ditch where it was placed as the ditch was being dug. Other sources for soil may be nearby, but they should roughly approximate the composition, grain size, and permeability (ability to have water flow through) of that removed to drain the site. The coarser the grain size, the longer the plug should be. Plant cover on soils disturbed by construction should be re-established. Advantages of this method are low maintenance and reduced risk of flooding.

In wetlands where tiles have been installed to collect and channel water from the area, tiles can be plugged with a low

permeability, clay-type soil. Ideally the entire length of the tiles should be removed and the resulting ditch treated as outlined above.

Changes in Water Levels

Changes in the median water table level are often not observable for many months after changes in precipitation, i.e., the water table may not rise immediately with increased rainfall. An immediate "spike" followed by a drop to the median water level may be observed (see Figure 6.1). It is also likely that changes to the outlet will require similar lag times for long-term groundwater response. Surface water response will be much quicker and must be monitored closely to prevent flooding of critical areas.

Slowing down drainage from the site will increase the size and depth of the core wetland in most cases, so as to encompass the entire original wetland area. This development can be a benefit in returning the wetland to its former size and function, but might mean that the landowner would suffer a small reduction in agricultural lands. Each landowner must weigh costs and benefits individually. It may become important to find a way to promote the value of the wetland thus resulting in community support and possibly assistance for the landowner.

Dealing with Climate Change

There is no question that human overpopulation and overconsumption are causing profound changes in the landscape and the chemistry of the atmosphere, and a large body of evidence indicates that global climate change is one result. Human activity working in combination with natural fluctuations is most likely causing the observed shift in rainfall patterns and daytime and nighttime temperatures. It is reasonable to expect that most ecosystems will be affected, but it is too early to make predictions about how the wetlands of the Mountains and Piedmont of the Southeast will respond. Additional management options will be needed to preserve these ecosystems and the communities they support.

During restoration of most wetland types, benefits can be derived from manipulation of water levels at critical times to control the establishment and colonization of woody and herbaceous species. Hydrologic controls may seem expensive to construct, but may become one of the most reliable and efficient methods for long-term vegetation management. The ability to control wetland water level may also make the site more adaptive to changing conditions of climate or the watershed.

Sites are being evaluated in the western Piedmont to determine the potential for installing a control gate along with plugging an outlet ditch in restoring the original hydrologic regime in a Meadow Bog. Installing a freeboard dam with an outlet control gate or a V-notch weir may have benefits over the simple plugging of the outlet ditches. Although these systems are not recommended at this time because they require constant management and maintenance, they are included to inform the readers of experimental techniques under consideration and to stimulate interest in the development of new and creative ideas in hydrologic management of small wetlands.

The weir is used to measure the outflow from the wetland. The construction of an outlet control gate allows for manipulation of the discharge in the same manner as a dam and gate system. Figure 6.3 shows how a system of log-size timber can form a low dam with the capacity to change the height of water across and through the bog simply by installing or removing gate sections. Timbers should never be constructed of new creosote materials because of possible water contamination by toxic chemicals used to treat the lumber. To allow for water level manipulation, the section of the central "gate" extending above ground should have a removable section as shown on the figure.

A system such as the one described above may quickly alter surface water discharge to allow the internal groundwater system to build back to pre-drainage levels. Further manipulations maintain an "optimum" level of surface and groundwater in the bog. The time frame for achieving maximum benefits has not yet been determined. Currently the "optimum" groundwater level and the time frame for returning a degraded bog to its pre-

drained status is being evaluated in different situations and locations.

The ability to control water level in wetland restoration may also have other practical advantages, such as allowing better access for management by people or equipment. The major drawback to this system is that it requires attentive and judicious management to prevent flooding. A decision to use this method must be made with caution—it is still experimental. Damming of surface flows may be beneficial in some cases, but not in all (see Wetland Management by Beavers, this Chapter).

Wetland Buffers to Control Polluted Runoff

Projects that are ditch and drain restorations will have similarities across many sites. In most cases the surrounding land is pasture, cropland, residential, or industrial, and may be regularly limed, fertilized, and impacted by manure and agricultural chemicals. These substances find their way into wetlands during rainstorms and may profoundly affect plants and aquatic life. Nutrient overloads from sources such as fertilizer and manure, may produce aquatic algal blooms and stimulate growth of weedy plant species. In addition to loss of biodiversity, uncontrolled nutrient runoff may result in an unstable, fluctuating ecosystem that will be more difficult to restore to a stable wetland requiring only minimal maintenance.

Runoff from nearby roads or parking lots can complicate the problem by adding oils and other petroleum products, asbestos from brake pads, and other substances such as anti-freeze and salt. While trapping and removal of chemicals is one of the important functions of wetlands, we should try to reduce chemical loads entering a wetland, if only to make the restoration and management more predictable and successful.

Changes in surrounding land-use practices to reduce nutrient and chemical runoff must be part of the restoration and management plan in a ditch and drain restoration. Reducing runoff of agricultural chemicals is a priority of many agencies, and landowners can find plenty of help to accomplish these tasks. Buffer strips (filter strips) of native grass and herbs fringing a wetland can help absorb this nutrient load and may be used with ditches that divert the contaminated surface water away from the most sensitive parts of the wetland. Filter strips designed to utilize native vegetation can also have important benefits for native terrestrial species, including game species such as grouse and turkey.

Box 6.1 Hydrologic Management Suggestions for Meadow Bogs

- Formulate flow alteration strategy with the help of a professional.
- Determine whether permits are needed.
- As one option, consider installing a ditch plug to grade.
- Determine the best time of year to begin the manipulation.
- Avoid flooding hummocks and other areas where hatchlings or eggs could be disturbed.
- Use generous native vegetation buffers around the wetland to filter nutrient and chemical runoff and benefit wildlife.
- Use debris resulting from woody plant removal to construct small dams along water channels within the site to allow water to be diverted and retained.

Wetland Buffers as Life Zones for Wildlife

Terrestrial areas around wetlands have traditionally been considered vegetational buffers intended to provide some degree of protection for the water quality and wildlife supported by the wetland. This view is gradually giving way to an understanding of the greater biological importance of these structures. Studies indicate that they are more critical to the well being of many forms of wetland wildlife than first suggested. For salamanders and some other semiaquatic species, upland terrestrial zones are more than just areas where these species occasionally

Box 6.2 Culvert Use by Bog Turtles

By Dennis W. Herman

Bog turtle habitats are often fragmented, preventing normal movement between habitat patches. Most fragmentation of habitat comes from roads bisecting wetlands to create an often fatal dispersal route across the offending strip of pavement or gravel. The installation of 12" to 15" diameter culverts or pipes under the roads in normal seepage channels or small streams can provide bog turtles with a safe route from one habitat patch to another and connect wetlands with a natural water flow. State departments of transportation should provide culverts to connect wetlands and furnish bog turtles and other species dispersal routes safe from road crossings. The following case illustrates culvert use by bog turtles in a Tennessee study site.

Bog turtles were first reported from Tennessee in May 1986 from two small wetlands in the same valley. Shortly thereafter a mark-and-recapture study was initiated at the two sites by Bern Tryon of the Knoxville Zoo. The larger site was comprised of two habitat patches separated by a paved road. Bog turtles captured in the smaller habitat patch (the Annex) were found to be using a 15" culvert with several inches of mud on the bottom, as a means of moving between the two wetlands. Since 1987, fifteen individual turtles (33%) have been captured in the Annex; seemingly their movements are dependent on the hydrology of the site. The Annex is used by turtles when the wetland is unusually wet and water is flowing through the culvert. No bog turtles have been observed crossing the road or dead on the road during Tryon's 14-year study.

Additional use of culverts by bog turtles has been observed recently in other states. Culvert installation for connecting fragmented wetlands should become policy when wetland restoration projects are being considered. It is an inexpensive method of providing natural water flow between wetlands and safe dispersal routes for small animals.

feed or wander. They are considered "life zones"; critical for feeding, growth, and maturation. Although bog turtles hibernate and nest within wetlands, they are known to use nearby dry areas, and experienced turtle biologists know when to look for them in surrounding fields. Some species of amphibians use wetlands for breeding, but their juvenile and adult populations depend entirely upon the surrounding drier terrestrial areas. Some species move great distances and may spend long intervals away from the wetland before returning at maturity. Spotted salamanders (Ambystoma maculatum) in Kentucky were recorded traveling up to 220 meters from the breeding wetland. The size of buffer needed to maintain biological integrity is indeed a question requiring more study and certainly will vary depending on wetland size and type. Ideally the buffer zones planned for a wetland project will include not only upland vegetation regions surrounding the wet area, but buffers which allow connections to nearby streams and forests. Maintaining connections between the wetland and surrounding areas will be critical to successful biodiversity protection and may sometimes conflict with economic interests.

Managing Roadways

The negative effects of roads on wildlife are often underestimated. In cases where roads bisect wetlands, they have a fragmenting effect on the ecosystem and can profoundly change the nature of species movements, interactions, and survivorship. Increased mortality within an isolated population can severely limit the potential of that population to persist into the future. Road mortality means fewer individuals successfully move between habitat patches and the risk of inbreeding increases. Additional problems result when hydrology is altered, a circumstance which is often the case when roads cross wetlands.

In wetland habitats already bisected by roads, installation of small diameter (12"- 15")

pipes beneath the roadbed may provide a means to reconnect wetlands that have been fragmented (see Box 6.2). Traditional roadway fences should not block connections between fragmented sections, but a different type of fence can sometimes be used to direct small mammals, reptiles, and amphibians to protected openings. Fashioned after drift fences used by biologists to study small vertebrate fauna, these structures can be less than 20 cm in height and buried a few centimeters into the soil. They should be positioned in such as way as to gradually lead to the opening. Dense vegetation can also be planted to discourage road crossings. Ramps may be needed in some circumstances. More information is needed on the effectiveness of such measures, but the cost is minimal and these or similar techniques may prove highly effective.

Many wildlife species would benefit from the installation of open bridges over small streams and wetlands instead of culverts. Stream corridors often provide considerable cover and many species travel along them. Most small streams go under roads through culverts, leaving no place to cross under the road unless the animal can swim or is big enough to wade. Bridges over larger creeks and rivers usually have some dry land (floodplain) that animals can use to cross under the road. Reptiles (box turtles and snakes), medium sized mammals (mink, weasels, raccoons, skunks, rabbits, etc.), and some invertebrates would benefit the most. However, it is critical to manage the floodplain resource as part of the whole road building project so that planning to offset impacts such as those cited above can be mitigated.

Restoring Hydrologic Regimes to Floodplain Wetlands

Piedmont and Blue Ridge streams are typically entrenched in a larger floodplain. Ephemeral pools sometimes form in floodplain depressions. These wetlands are often discovered in a disturbed state and are in need of remediation efforts. Depending on the wetland location with respect to the river or stream, it is possible to re-establish periodic flooding of this wetland system by the main stream. The entrenchment factor in this system can be used to effect over bank flooding at a specific flood stage. This flooding is accomplished by cutting a ditch at the correct height and sloping it from the stream back to the floodplain containing the wetland. Use of this natural system to flood the wetland regularly and also possibly to fill ephemeral (temporary) pools within the floodplain can be used to enhance the wetland hydrologic cycle. Figure 6.4 illustrates the concept and a means for periodically flooding riparian wetlands and adjacent floodplains. Care must be exercised when digging the flooding ditch. The wrong angle can result in draining instead of flooding.

Bog turtles, it should be noted, and many other wetland species do not live in wetlands prone to frequent flooding. This technique may also harm preferred habitats. However, many floodplains contain wetlands requiring flooding, such as floodplain pools, and these would benefit from this manipulation. Many ecological functions of floodplains have been lost because of the disconnection of streams from their floodplains, a phenomenon which has occurred in many human land uses. Reconnecting the stream with its floodplain is an important part of wetland restoration techniques currently in use.

Wetland Management by Beavers

Beavers build dams to defend their dens and to change local conditions favoring this animal's semiaquatic lifestyle. By simply cutting woody stems to build a dam across the flow of surface waters, beavers often form pools and fringing, spreading wetlands. Eventually, as local beaver populations increase, food supplies decline, the pool begins to fill with sediment, and the beavers will then range farther in search of new sites to build. When a better site is found, the beaver colony will abandon the old site, allowing it to recover and begin the succession toward the climax community for that spot.

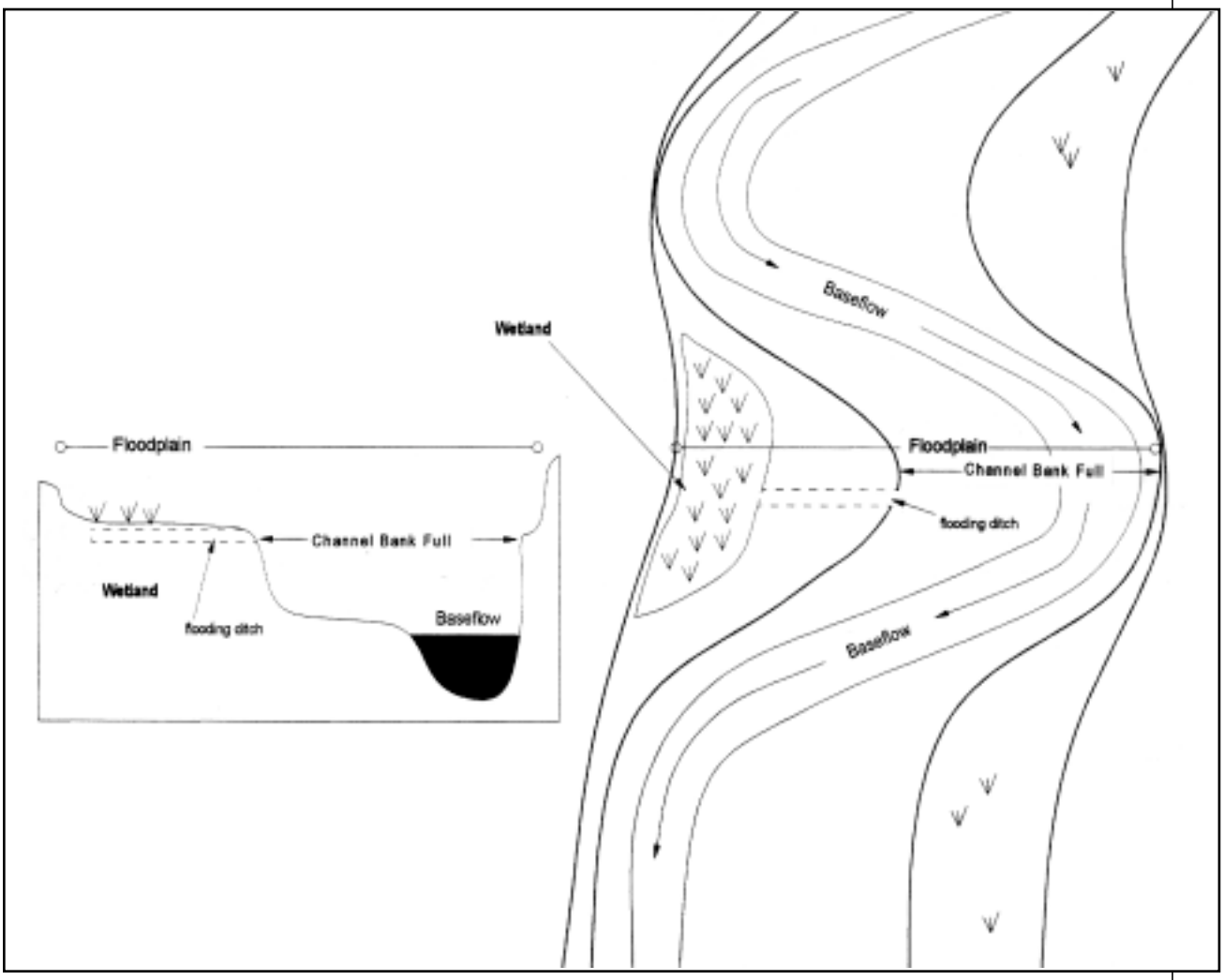

Figure 6.4 *Illustration of a means for restoring periodic flooding of floodplain wetlands. Flooding is accomplished when a channel bank fills as a result of rains. Care must be taken to carefully angle the ditch so the wetland fills rather than drains.*

The pre-Columbian North American landscape was full of lush watersheds, which were a mosaic of beaver maintained and abandoned wetland landscapes. The result was the biodiversity and natural wealth for which this continent was prized. With human development many wetlands were cleared and drained, and beavers were hunted to near extinction around the end of the 19th century. Beaver populations are now on the rebound and there is no reason to doubt that they will return to many of their former habitats and again begin constructing dams and wetlands. But they are returning to a different world.

Contemporary landscape and stream systems differ from those of pre-settlement times. Roads now transect streams and wetland habitats, cutting off important wildlife corridors. Most streams have been straightened and incised and have only a small fraction of the riparian vegetative cover of past times. By increasing the instability of streambanks, and the consequent erosion and down cutting, beaver dams can be detrimental to modern riparian wetland habitats. It is too early to determine whether beavers will help or hinder the restoration and management of wetlands for the benefit of human-perceived functions and values. Undeniably, however, they greatly impacted the environment in the past and are currently recovering from a century of absence throughout the Southeast. In this regard they, too, will have to be monitored and managed in the modern landscape.

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7

Programs and Permitting

Nora A. Murdock

Mountain sweet pitcher plant (Sarracenia rubra ssp. jonesii).

Programs and Permitting

Federal and State Programs for Conservation of Wetlands

The US Department of Agriculture and state government agencies sponsor a host of conservation programs that provide reimbursement to landowners who undertake natural resource conservation work such as wetland restoration. It is not necessary to seek only one conservation program that can fund an entire project. Multiple sponsors can support a project, and they often prefer to work in partnership with landowners, conservation organizations, and other government agencies. Also, it may be possible for landowners to obtain the greatest financial advantage by using several programs to underwrite the cost of separate elements of their wetland conservation plan.

The programs offered are too numerous and varied to describe here, but some, with the greatest significance to wetland restoration in the Mountains and Piedmont, are described below:

1. **Wetlands Reserve Program**
   The Wetlands Reserve Program (WRP) provides an opportunity for landowners to receive compensation for voluntarily restoring wetlands. Participation in WRP is not limited to farmers. WRP authorizes the US Department of Agriculture's Natural Resources Conservation Service (NRCS) to pay for wetland restoration projects. Landowners may also choose to receive substantial land payments by selling a site's development rights to NRCS through a 30-year or permanent conservation easement. NRCS thus works with landowners and partner agencies to develop a wetland restoration plan and to guide its implementation. Virtually all the methods described in this manual may be incorporated into a WRP wetland conservation plan. At the time of this writing, North Carolina has four mountain wetland sites enrolled in WRP. Each site involves only a few acres of former pastureland and riparian forest. Although small, these areas provide important habitat for wetland dependent wildlife and plants. One project has a perpetual conservation easement, two have 30-year easements, and one is simply a 10-year contract for restoration with no easement at all. Examples of restoration measures include: plugging drainage tiles, fencing, restoring stream channel morphology to raise the water table, creating shallow pools using excess cut and fill material, controlling woody vegetation, and re-establishment of sphagnum moss beds.

2. **Wildlife Habitat Incentives Program**
   The Wildlife Habitat Incentives Program (WHIP), an NRCS program, that reimburses for development of wildlife habitat on private and local government lands. Not just limited to farmers, WHIP emphasizes restoration and management of rare and declining wildlife habitats through 5 to 10-year agreements. It may be used for restoration and management of native early successional vegetation on and around small wetlands.

3. **Environmental Quality Incentives Program**
   The Environmental Quality Incentives Program (EQIP) of the NRCS provides

reimbursement and special incentive payment to farmers who voluntarily adopt systems that protect natural resources. EQIP can address a wide array of farming related conservation concerns such as fencing for grazing management, stream bank stabilization, vegetative filter strips, riparian buffers, and livestock watering systems. The list does not end with these examples. The largest federally sponsored agricultural conservation program, EQIP awards hundreds of new contracts each year. The program reimburses up to 75% of the cost of installing Best Management Practices (BMPs) covered under a 10-year agreement.

4. **State Agricultural Cost Share Programs**
State Agricultural Cost Share Programs may provide another source of reimbursement for installation of agricultural BMPs (Best Management Practices) that reduce soil erosion and nutrient loss from agricultural land. Included in these programs may be fencing for livestock exclusion and grazing management, managing livestock watering facilities, and providing vegetative filter strips.

5. **Partners for Fish and Wildlife: Habitat Restoration Program for Private Landowners (FWS).**
The Partners for Fish and Wildlife Program provides technical and financial assistance to private landowners who restore and enhance fish and wildlife habitat on their property while leaving the land in private ownership. Anyone interested in the conservation of wildlife habitat on private lands can qualify as a partner, including ranchers, farmers, local agencies, private organizations, corporations, urban residents, government agencies, and educational institutions.

Totally voluntary, the program concentrates on funding such practices as restoring the following: cleared, drained, or otherwise degraded wetlands and riparian habitats; breeding and roosting habitat for neotropical migratory birds; fish habitat; and the habitats of endangered and threatened species. Currently most restoration being completed is that of wetland restoration.

Ditched and drained farm fields are the most common types of freshwater wetlands being restored. These areas can be completely drained or may remain wet only during certain parts of the year. Riparian restoration is usually undertaken when stream and river banks have little or no vegetation left and in places where soil erosion from nearby areas is degrading adjacent watercourses. Habitat restoration for specific fish and wildlife species, such as endangered species, can take many forms, depending on the habitat needs of the individual species.

As partners in the project, the US Fish and Wildlife Service and any combination of other governmental agencies and public or private organizations will share the cost of restoration. The landowner may participate as a partner and may contribute use of equipment such as tractors, or funds to assist with the restoration.

The maximum amount of Service funds that may be expended on a person's property during any single fiscal year is $10,000. Although some exceptions are possible, funding of project components or phases in sequential years is not generally allowed.

Private landowners must sign a minimum 10-year habitat development agreement. This pact specifies what each party will provide and commits the signers to maintain the restored habitat over the term of the agreement. Under specified conditions, habitat development agreements may be modified or terminated by either party.

Priority emphasis for projects is on Federal trust resources: e.g., migratory birds, endangered and threatened species, wetlands, floodplains, and riparian areas. The program emphasizes habitat restoration (i.e., hydrology and vegetation), and to a lesser extent habitat improvement and creation (see attached definitions). Other factors being equal, projects with in-kind services provided by the

landowner (e.g., the landowner agrees to install structures for water control, etc., and maintain them over the period of agreement) receive a higher priority.

For habitat restoration, the total project cost is eligible for funding. For habitat improvement projects (e.g., fall / winter flooding of crop fields), at least 50 percent of the total project cost must be covered with in-kind services and / or non-service funds.

Service funding through the Partners for Fish and Wildlife Program cannot be used to purchase land-use rights to secure landowner participation (e.g., cannot purchase easements, pay rent). Landowners may be reimbursed for certain expenses such as water pumping costs.

Examples of projects funded by the service:

- Restoring hydrology on a previously altered site, including plugging drainage ditches, constructing levees, reestablishing historical topography and associated periodic flooding, installation of water-control structures, and related work.
- Restoring natural vegetation types on altered sites.
- Restoring and protecting riparian and floodplain areas: e.g., the Service will pay for fencing and any revegetation efforts along a stream or floodplain.
- Restoring, improving, and protecting habitat for threatened, endangered, or rare species: e.g., bog turtles, or Gray's lilies.
- Removal of exotic plants and animals which, competing with native fish and wildlife, alter their natural habitats.
- Installing fencing and off-stream livestock watering facilities to allow for restoration of stream and riparian areas.
- Planting native grasslands.
- Prescribed burning as a method of removing encroaching species and restoring natural disturbance regimes necessary for some species' survival.
- Reconstruction of in-stream aquatic habitat through bioengineering techniques.

Local Soil & Water Conservation District personnel are one of the best resources for providing wetland conservation expertise. These professional conservationists can explain financial assistance programs available to landowners, and can also provide important design and planning assistance. A Soil & Water Conservation District office is usually located near a county's center of government and in an agricultural service center. To contact the local Soil & Water Conservation District office, look in the telephone book under "Local Government, Soil & Water Conservation".

Non-governmental Organizations

Conservancies and Land Trusts

Conservancies and land trusts are non-profit organizations created to preserve and restore natural resources. The scope of each organization varies. Regional land trusts focus on a local area or a specific resource, such as a river or lake. Some larger organizations, such as The Nature Conservancy, are interested in exceptional resources around the world. There are many different preservation methods that involve conservancies and land trusts. In addition to protecting a natural resource, some of these options offer financial benefits. Following are brief descriptions of a few options:

- ***Management Agreements***

Management agreements are made between the landowner and a conservation organization. The agreements are temporary and each is designed to fit the particular desires of the landowner. Management agreements involve the development of a conservation plan, to be implemented by the conservation organization or the landowner.

- ***Conservation Easements (no transfer of land ownership)***

Conservation easements are voluntary legal arrangements specifying that the property in question can only be used in ways that preserve its natural assets. Usually managed by a conservation organization, the easement is tailored to the desires of each landowner, and conservation trust. Conservation easements can reduce federal and state

income tax, estate tax, gift tax, state inheritance tax, and sometimes state and local property taxes. Conservation easements are usually perpetual. Temporary easements are possible, but in most cases tax benefits only apply to perpetual easements.

• ***Leases***

Leases of property to a conservation organization are no different from any other property lease. They are temporary and provide income to the landowner without change in ownership. The use of the property by the conservation organization is specified within the lease.

• ***Sales***

Conservation organizations generally have a limited amount of funds for land acquisition. Because of these financial constraints, they usually purchase property at a reduced or "bargain sale" price. The landowner may receive an income tax reduction by claiming the difference between the selling price and the fair market value as a charitable donation. Selling at a reduced or "bargain sale" price also reduces capital gains taxes by decreasing the amount taxed.

• ***Donations***

Donating property to a conservation organization is the most effective method of reducing taxes. Benefits include federal income tax deductions equal to the fair market value of the land, estate tax benefits, and avoidance of capital gains tax. The North Carolina Conservation Tax Credit Program also permits a dollar for dollar state income tax credit and an income tax reduction for larger gifts. For full details contact a local land trust or conservancy. Also see Appendix D for a list of organizations that can provide more information about wetland protection methods and assist with protection decisions.

Wetland Partnerships

Forming partnerships is a good way to bring a variety of technical and financial resources to bear on a project. Restoring and managing wetlands is a complex process requiring knowledge of a wide array of technical topics. Financial needs are a major concern in carrying a project to completion. In many cases, one agency or organization will not have all the resources necessary to address all of a project's needs. Meeting each partner's needs and expectations and insuring good communication is important in maintaining unity of purpose and insuring the success of the project.

Developing and implementing a wetland restoration or management plan requires input from a number of diverse technical disciplines. These can include, but are not limited to, hydrologists, engineers, ecologists, wetland scientists, geomorphologists, botanists, agricultural specialists, and foresters. Sources of expertise in these disciplines can include local, state, and federal agencies, non-governmental organizations, private consulting firms, and universities. In addition to bringing knowledge of their discipline, technical partners will often bring specialized equipment, such as data logging piezometers, to the project.

Financial assistance programs often have a narrow focus for their funding. Many states have cost share programs that assist agricultural land users to install Best Management Practices (see Glossary). These programs may focus on water quality, soil quality, or nutrient management concerns. State and federal agencies fund wetland restoration for mitigation purposes or to benefit specific game and nongame wildlife species. Universities may have financial resources that are dedicated to research relating to wetland functions or specific plant or animal species. Often a project will involve a number of these issues including: restoring wetlands, water quality concerning livestock, and research into restoration or wetland management techniques. Carrying out a project of this scope requires tapping into

a number of funding sources. The best way to accomplish this is to include partners who have access to or expertise in acquiring the type of funding needed to carry out the project.

To secure participation and insure long-term commitment, it is important to involve partners from the beginning of the planning process. They must have a stake in the success of the project, each partner with specific goals they hope to accomplish as a participant in the project. These goals may be as varied as developing habitat for an endangered species, improving water quality as part of a river basin plan, or documenting the economics of livestock management practices. If the partner's participation is important to the success of the project, their goals must be incorporated in the project plan. It is important to understand that, while their goals may be different, partners can work together to expand the scope and improve the quality of the overall project.

In a partnership, particularly one with widely varied goals, it is necessary to establish a well-defined plan and decision making process. The project plan and goals must be well spelled out. A process must be in place to adapt the plan as the project proceeds. Depending on the scope of the project, a formal steering committee and chairperson may be necessary.

The project leader must facilitate involvement and information sharing among the partners. All the partners must be notified of scheduled activities that are important to the project. While the hydrologist's responsibility is monitoring groundwater levels, they may be interested in seeing how a vegetation inventory is conducted. Teamwork and opportunities for involvement in all aspects of the project help maintain long-term commitment. Communication can best be served through regularly scheduled meetings or communications such as letters and email. This helps to insure that each partner's needs and concerns are being addressed. Restoration and management activities will require scheduling and coordination, another good reason to insure that good lines of communication are established at the beginning of a project.

Permits Required Under the Clean Water Act

Restoration activities in wetlands often require prior permit approval from the US Army Corps of Engineers (Corps) under Section 404 of the Clean Water Act. The construction of berms or weirs for water management, the restoration of a channelized stream to reinitiate overbank flooding, the filling of drainage ditches, or the mechanical removal of nuisance vegetation are but a few examples of activities that may require a Department of the Army (DA) permit. The key to the Corps permit determination is whether or not the proposed activity results in a discharge of dredged or fill material into jurisdictional wetlands or surface waters. If so, then a DA permit is required.

There are basically two types of permits in the Corps Regulatory Program: general permits and individual permits. General permits are issued regionally or nationwide for categories of activities that have minimal impact on the aquatic environment both individually and cumulatively. Regional general permits are commonly referred to simply as general permits and nationwide general permits as nationwide permits. These permits are available to the landowner or project proponent, usually with a minimum of processing, provided that certain impact thresholds are not exceeded and certain conditions are met. Some general and nationwide permits require notification to the Corps before beginning work (pre-discharge notification or PDN) while others do not. There may also be exceptions to the PDN requirement on a regional level. For example, in the 25 counties of western North Carolina containing trout waters, a PDN to the Corps and the North Carolina Wildlife Resources Commission is required for nationwide or general permits. Proposed activities in any "Mountain or Piedmont Bog" of North Carolina would also require notification. Individual permits are processed on a case-by-case basis for projects that have more than minimal impact. These permits involve a public notice review process, coordination with

Box 7.1 Agency Assisted Restoration and Research

By Dick Everhart

This project, in western Piedmont North Carolina, began as an effort to restore habitat for the federally listed bog turtle (*Clemmys muhlenbergii*). The US Fish and Wildlife Service, through their Partners for Fish and Wildlife Program, provided initial funding for the project. A local non-governmental organization with an environmental education focus, the Foothills Nature Science Society, agreed to receive and manage the funds for the project. As the project developed, it quickly became apparent that there was very little information available on the restoration or management of habitat for the bog turtle. As a result, the scope of the project was expanded and new partnerships developed. The local Soil and Water Conservation District approached Pilot View Resource Conservation and Development, Inc. for assistance in identifying funding sources and securing additional funding. The Natural Resources Conservation Service's Wetland Science Institute provided the funding required to carry out the necessary research.

Areas identified as needing additional research were: hydrology, vegetation control, habitat preferences, determining the presence of bog turtles and the impact of livestock on Meadow Bogs and bog turtle populations. A local consulting firm interested in contributing to the science of ecological restoration was hired to carry out a study of the site hydrology. A consulting botanist worked with the regional office of The Nature Conservancy to look at options for controlling woody succession in Meadow Bogs. A faculty member and students from the University of North Carolina at Greensboro looked at habitat preference and methods for determining the presence of bog turtles. The NC Chapter of the Sierra Club provided a summer intern to assist with the UNCG effort. The coordinator of living collections for the North Carolina State Museum of Natural Sciences drew on a number of years of field data and experience to address the issue of livestock and Meadow Bogs. The local NRCS and staff assisted with data collection. Pilot View Resource Conservation and Development, Inc. helped to manage both the project schedule and finances, and insure that the goals of the funding agencies were met.

Most of the partners participated in a majority of the field activities that took place at the study site. Communication was insured through regular meetings and use of email. Points of contact were established for both technical and financial decision making. The results are that the information needed to develop and implement a restoration and management plan is now in hand. The original restoration will be carried out as planned and the information gathered can be used to benefit bog turtle populations throughout their range.

The study site has become important because of the long-term monitoring of hydrology and turtle populations. Since the erection of a fence in 1994 to seasonally exclude livestock, the dangerously small bog turtle population has nearly doubled!

Federal and State regulatory and resource agencies, and a public interest determination.

For the type of work advocated by this manual, that is the restoration and management of small wetlands, it is anticipated that nationwide permits could be used to authorize most work in waters or wetlands. This approach is to the advantage of both the landowner / proponent and the Corps because it minimizes impacts, processing time, and paperwork. Nationwide permits do not require any fees. A summary description of the nationwide permits (NWP) most applicable to wetland restoration work follows. A complete listing of nationwide permits and conditions is found in the Federal Register (61 FR 65874), December 13, 1996. The Federal Register can also be accessed on the Internet through the US Government Printing Office at www.access.gpo.gov. On March 9, 2000 the Corps published a notice in Part III of the Federal Register (65 FR 12818 - 12899) announcing the issuance of five new NWPs, the modification of six existing NWPs, the modification of nine NWP general conditions, and the adoption of two new NWP general conditions.

The new NWPs are designed to replace NWP 26. These changes took effect on June 7, 2000. The March 9, 2000 Federal Register notice is available for viewing on the Internet at www.saw.usace.army.mil/wetlands/regtour.

a. NWP 18, Minor Discharges: authorizes the discharge of up to 25 cubic yards of fill material into surface waters or the loss of up to 0.1 acre of wetlands. If the discharge is in wetlands or exceeds 10 cubic yards in surface waters, then notification to the Corps is required. The discharge must be part of a single and complete project and cannot be used in conjunction with NWP 26.
b. NWP 26, Headwaters and Isolated Waters Discharges (note: these permits, though no longer issued, are included because the information below is still applicable to those issued in the past): authorizes discharges of dredged or fill material into headwater streams, their adjacent wetlands and isolated waters provided that the discharge does not cause the loss of more than 3 acres of wetlands or more than 500 linear feet of stream bed. Discharges causing the loss of greater than 0.33 acres of waters and/or wetlands require notification to the Corps. Regional conditions in North Carolina also require notification for over 150 linear feet of stream bed impacts. The discharge must be part of a single and complete project. This NWP expired on June 7, 2000 and will not be renewed. Activities verified by the Corps under NWP 26 will remain authorized until February 11, 2002. Under the grandfather provision of the nationwide permit regulations, any permittee has 12 months, after the expiration of the NWP, to complete construction of the Corps' authorized activity. To qualify for the grandfather provision, the permittee must have begun construction or had a contract to begin construction prior to the expiration date.
c. NWP 27, Stream and Wetland Restoration Activities: This modified NWP authorizes activities in waters or wetlands associated with the restoration of former waters, the enhancement of degraded tidal and non-tidal wetlands and riparian areas, the creation of tidal and non-tidal wetlands and riparian areas, and the restoration and enhancement of non-tidal streams and non-tidal open water areas. Projects accomplished through agreements with the US Fish and Wildlife Service or the Natural Resources Conservation Service are authorized as well as work undertaken by other public agencies or private individuals. Notification to the Corps is generally required. This NWP is intended for projects that serve to restore natural wetland hydrology, vegetation, and function to altered and degraded tidal and non-tidal wetlands and the natural functions of riparian areas. In its current modified form, this NWP is also intended for projects that create, enhance or restore natural stream structure and stream habitat. It does not authorize the conversion of streams or natural wetlands to another aquatic use such as a waterfowl impoundment. Stream channelization is not authorized and only native plant species should be used if the permittee is vegetating the project site.

As previously mentioned, there are a number of conditions that must be met to work under the NWPs. With this manual's emphasis on restoring endangered and threatened species habitat, it is important to note that one of these conditions restricts the use of any NWP if the activity would jeopardize the continued existence of a threatened or endangered species or its critical habitat. If

Box 7.2 Alternative Livestock Watering Systems and Program Support

By Matt Flint

Wetland restoration projects in the Mountains and Piedmont often occur in working pastureland, so it is important to consider how livestock watering needs can be met without causing harm to wetland resources.

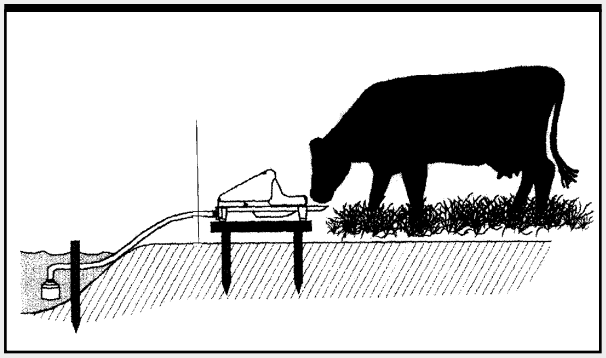
Livestock require dependable sources of clean drinking water. A lactating cow can drink up to 35 gallons of water per day. One beef animal or horse can drink up 20 gallons of water per day. A fully effective livestock watering system will meet the animal operation's needs while protecting water quality and the integrity of important wildlife habitats, such as wetlands. EQIP and state agricultural cost share programs can help landowners with expenses incurred when installing environmentally friendly watering devices.

Streams, ponds, wells, and springs have all been traditionally used as sources of livestock water. Heavy animal foot traffic and accumulation of feces around watering areas call for treatments that minimize soil erosion and protect water quality. For the purpose of this manual, livestock watering systems that have the least impact on wetland habitats will be discussed.

Generally, uncontrolled livestock access to ponds and streams are discouraged due to water quality concerns and a need to prevent transmission of livestock disease. Development of springs can divert water out of the wetland system, thereby preventing full hydrologic functioning and degrading wetland habitat. Excavation of ponds in wetlands eliminates natural wetland plant communities and destroys wet meadow habitat.

Alternatively stream, pond, and well water can be delivered to tanks or troughs by means of gravity flow or pump. Gravity feed pipelines or siphons can provide water from streams and ponds if proper elevations can be achieved in a reasonable distance within the pasture. These pipelines extend to a trough or a series of troughs equipped with a shutoff float or overflow standpipe. A filter on the inlet end of the pipeline prevents debris from clogging the system.

Electrically powered pumps provide dependable powerful movement of water, but their installation and operating costs may be high. Solar powered electric pumps and hydraulic-ram pumps are lower cost options capable of moving water without connection to outside electric power sources. A solar powered electric pump uses a panel of solar cells to run a pump motor and charge an automobile type battery for back-up power. A hydraulic-ram pump uses water's natural head pressure to lift water into a distribution pipeline. It is a good option for Mountain wetland conservation, but requires careful design and installation to ensure proper operation. A natural pool in a stream is selected as the location for the inlet pipe. The inlet is typically a 4-inch plastic well screen that prevents entry of debris. The elevation of the inlet pipe is especially critical for correct operation. The ram must be located in an accessible area that is protected from dislocation or damage by floodwaters.



Pressure from a drinking cow's nose causes a simple pump to lift freshwater from the fenced-out stream. This energy-efficient system can provide an alternative to pond construction and stream development for livestock water.

A nose pump or pasture pump is another device used to pump water for livestock. The force of drinking animals pumps the water. When a nose plate, positioned above a drinking bowl, is depressed the pressure on the nose plate compresses a piston that draws water out of a stream or pond.

No one livestock watering system will fit all situations. The landscape topography, the number of animals served, the yield of the water supply, and the costs are all factors for determining the most appropriate system or combination of systems.

restoration work is being proposed in a wetland such as a Mountain Bog or Swamp Forest/Bog Complex that is likely to harbor such species, it would be essential to coordinate the proposal with the US Fish and Wildlife Service. Projects that do not meet the terms and conditions of the NWPs must be processed as individual permits in a public review process.

This is not meant to be a definitive description of the Corps' Regulatory Program but rather to provide the reader with a starting point at which an informed dialogue regarding a restoration project can begin. Given the seeming complexity of this program, particularly to those who do not work with it on a daily basis, it is best to contact the Regulatory Branch/Division of the Corps of Engineers District in your state or your local Regulatory Field Office. It is recommended that contact be made at the concept phase of a project prior to detailed design. A complete description of the Regulatory Programs of the Corps of Engineers can be found in the Federal Register (51 FR 41206), November 13, 1986 or through the US Government Printing Office Internet address above. Information on the Regulatory Program in North Carolina can be accessed through the Wilmington District's Internet Home Page at www.saw.usace.army.mil.

Reporting Wetlands Violations

Most citizens are not adequately trained to determine whether or not ditching is illegal, so any suspicious ditching or draining should be reported to the Corps of Engineers. Federal and state regulations are often not adequate to protect important wetland ecosystems, especially small ones. Although citizens and biologists experience disappointment that some ditching and draining of wetlands are not illegal, perseverance in the reporting process is important if illegal activities are to be discovered! The following telephone numbers are for the Corps of Engineers Districts in the Southern Appalachian region.

Wilmington District (NC) . . . . . .(910) 251-4511
Norfolk District (VA) . . . . . .(804) 441-7068
Charleston District (SC) . . . . . .(803) 727-4330
Savannah District (GA) . . . . . .(912) 652-5768
Nashville District (East TN) . . . .(615) 736-5181
Huntington District (WV) . . . . . .(304) 529-5487

Some states have wetland protection regulations that are more effective or stringent than the federal ones. If the reported activity is not a violation of federal law, it may be illegal in your state. Consultants at the Corps of Engineers can help you get in touch with the appropriate state agencies. The more phone calls you make, the better.

Bibliography

Clean Water Act, P.L. 92-500, 86 Stat. 816, as amended; 33 U.S.C.A. 1251-1376. Sections applicable to bog protection restrict the placement of fill in wetlands without a permit from the US Army Corps of Engineers.

Endangered Species Act of 1973, as amended. P.L. 93-205, 87 Stat. 884, as amended; 16 U.S.C.A. 1531-1540. Prohibits taking of Endangered and Threatened species from the wild without a permit; prohibits Federal agencies from funding, authorizing, or otherwise carrying out activities that would jeopardize the continued existence of federally listed endangered or threatened species.

Natural Resources Conservation Service. 1997. National Range and Pasture Handbook. NRCS Grazing Lands Technology Institute, NRHP 190-vi. Sept. 1997. A government document describing the ecology and management of native rangeland and domestic pastureland used for grazing and haying.

Natural Resources Conservation Service. 2000. Field Office Technical Guide, Volume IV. Raleigh, NC. A government document describing standards and specifications for agriculture-related natural resource conservation practices in North Carolina.

Natural Resources Conservation Service. 1997. National Range and Pasture Handbook. NRCS Grazing Lands Technology Institute, NRHP 190-vi. Sept. 1997. A government document describing the ecology and management of native rangeland and domestic pastureland used for grazing and haying.

North Carolina Department of Environment and Natural Resources, Division of Water Quality. 1999. A Guide for North Carolina Landowners: Financial Incentives and Technical Assistance Programs Which Apply to Wetlands, Streams and Streamside (Riparian) Areas. North Carolina Department of Environment and Natural Resources, Division of Water Quality, North Carolina Wetlands Restoration Program. September 1999. This booklet provides landowners, land-use planners, and natural resource managers with the most current information about federal, state, and other assistance related to conservation of wetlands, streams, and streamside areas in North Carolina. Contains reference material about program requirements, land protection options, eligible land types, and other information sources. It is available on-line from: http://h2o.enr.state.nc.us/wrp/files/landown.htm

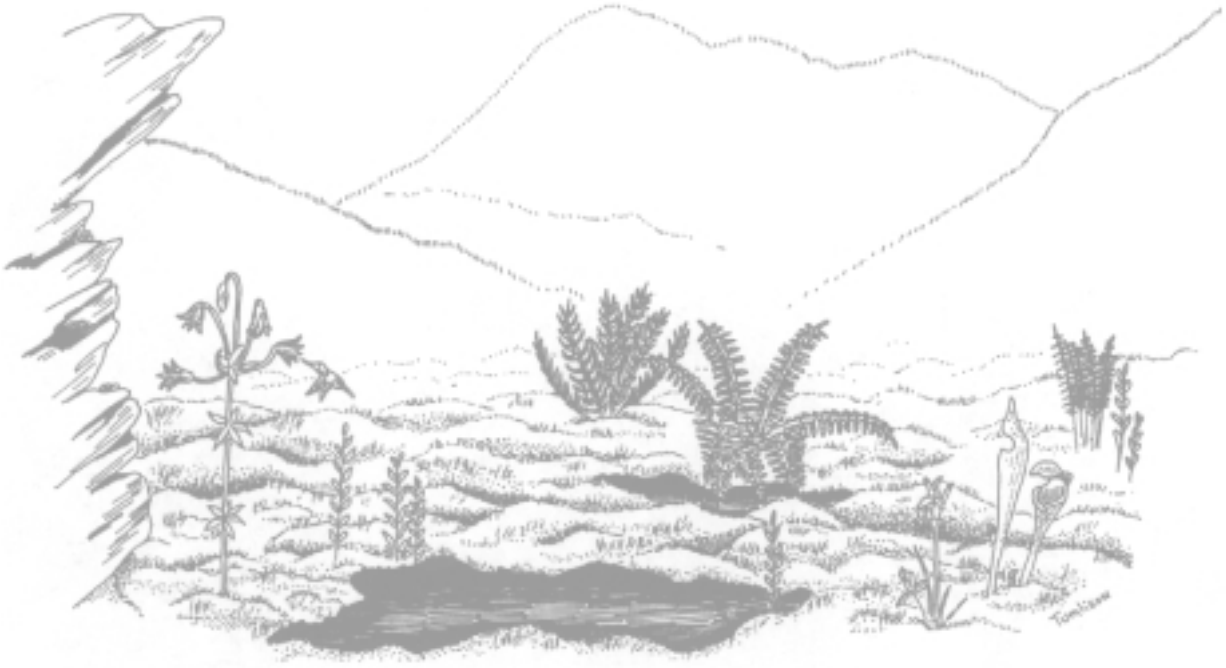
Many additional sources are available on the web.

A

Reference Wetland Plant Communities

Kenneth A. Bridle, Ph.D.

Illustrating the range and complexity of the most common wetland types in the Mountains and Piedmont of the Southeast.



Mountain bog.

Reference Wetland Plant Communities

The natural assemblages of plants that occur together in one type of habitat are called communities. Natural communities generally occur in continuously varying patterns. There are seldom discrete breaks in the pattern of the natural diversity. Most environmental factors that determine communities vary over continuous gradients. Species populations respond individualistically to these gradients producing, continuous variation in composition. Aside from being of theoretical and educational interest, classification of natural communities can be useful in practical ways. Communication and study of natural systems is greatly facilitated with commonly used names. Therefore, any restoration and management can benefit from the experience and knowledge gained at other similar sites. This is especially true of wetland plant communities, which often are small, remote, and generally unnoticed and ignored by the general population. There are important differences in freshwater wetlands that can be identified based on the species composition of the plant community. Below are listed some simple descriptions of the common wetland plant communities as described by Shafale and Weakley (1990).

It is important to note that many wetlands are suitable habitat for invasive weedy species like Chinese privet (Ligustrum sinense), Japanese grass (Microstegium vimineum), multiflora rose (Rosa multiflora), and Japanese honeysuckle (Lonicera japonica). The abundance of weedy species in a disturbed wetland may obscure any remnants of the natural community type.

Resources for the identification of wetland plants can be found in common keys and field guides of plants. It is important to be sure that the guide or key being used to identify an unknown plant is intended for that use and covers the geographic area where the plant occurs. There are also specialty publications dealing with wetland plants, and more details can be found if the search is narrowed to a specific plant subject like ferns, grasses, or plants in winter.

Upland Depression Swamp Forest

This is a rare community type, distributed at scattered locations in the Piedmont on poorly drained upland flats or depressions. The clay hardpan that is usually present holds water and restricts root depth for trees. This community commonly contains shallow, open water pools in springtime which dry during summer. Many types of ephemeral pools are so small that they fit in and under other natural community types.

Typically willow oak (Quercus phellos) dominates the closed canopy, but other trees such as red maple (Acer rubrum) and sweet gum (Liquidambar styraciflua) may also be present. Some examples support uncommon trees such as swamp chestnut oak (Quercus michauxii) and overcup oak (Q. lyrata). The understory is very sparse and may support only scattered red maple or sweet gum. Shrubs are also sparse but may include blueberries (Vaccinium spp.), black haw (Viburnum prunifolium), or arrowwood (Viburnum dentatum). Vines such as poison ivy (Toxicodendron radicans), trumpetvine (Campsis radicans), and common greenbrier (Smilax rotundifolia) may be prominent. Mosses usually form thick mats in and around depressions. Herbs are very sparse, consisting primarily of sedge species (Carex spp.).

A few bottomland, spring-ephemeral species are sometimes present. Upland Depression Swamp Forests are important as amphibian breeding habitat, with potential for rare salamander species.

Piedmont/Low Mountain Alluvial Forest

This type of forest is found along Piedmont streams. It occurs where levee, bottomland, or backswamp topography is well developed as it often is in large river floodplains. Piedmont Alluvial Forests are moist and occasionally flooded, but not subjected to standing water for long periods of time. They occur on alluvial soils of variable textures that are fairly rich from nutrient-rich sediments deposited by flooding and from nutrients leached from adjacent slopes and uplands.

The closed canopy of moisture-loving tree species may include river birch (Betula nigra), sycamore (Platanus occidentalis), sweet gum (Liquidambar styraciflua), elms (Ulmus sp.), black walnut (Juglans nigra), green ash (Fraxinus pennsylvanica), tuliptree (Liriodendron tulipifera), red maple (Acer rubrum), and other species. The open to dense understory may include ironwood (Carpinus caroliniana), box elder (Acer negundo), patches of cane (Arundinaria gigantea), and shrubs such as pawpaw (Asimina triloba), spicebush (Lindera benzoin), yellowroot (Xanthorhiza simplicissima), strawberry-bush (Euonymus americanus), and silky dogwood (Cornus amomum). The herb layer is typically moderately dense and may be very dense in sunny streamside openings. Typical herbs include bottlebrush grass (Elymus hystrix), false wood-nettle (Boehmaria cylindrica), spring beauty (Claytonia virginiana), orange touch-me-not (Impatiens capensis), violets (Viola spp.), buttercups (Ranunculus spp.), fringed sedge (Carex crinita), fish-on-a-string (Chasmanthium latifolium), Christmas fern (Polystichum acrostichoides), jumpseed (Tovara virginianum), water horehound (Lycopus virginicus), and others. Vines such as Virginia creeper (Parthenocissus quinquefolius), poison ivy (Toxicodendron radicans), cross-vine (Anisostichus capreolata), common greenbrier (Smilax rotundifolia), and grapes (Vitis spp.) may be present.

The community often grades to Mesic Mixed Hardwood Forest, and less frequently to Dry-Mesic Oak-Hickory Forest, on adjacent slopes. It may grade to other wetland forest communities at junctures with large stream or river floodplains.

Piedmont/Mountain Bottomland Forest

Bottomland Forests occur on rich alluvial soils in wide floodplains of large streams or rivers. Intact examples are among the rarest of communities in the Southeast. They do not occur on active levees adjacent to river channels, but are subjected to infrequent flooding. Due to the fertility and infrequent flooding of this community type, many have been converted to pasture or agriculture.

The closed canopy of bottomland trees may include tuliptree (Liriodendron tulipifera), sweet gum (Liquidambar styraciflua), swamp white oak (Quercus bicolor), white oak (Q. alba), Shumard oak (Q. shumardii), willow oak (Q. phellos), green ash (Fraxinus pennsylvanica), bitternut hickory (Carya cordiformis), sugarberry (Celtis sp.), and other species. Understory species may include ironwood (Carpinus caroliniana), red maple (Acer rubrum), flowering dogwood (Cornus florida), and American holly (Ilex opaca). The shrub layer is patchy with species such as pawpaw (Asimina triloba), spicebush (Lindera benzoin), strawberry bush (Euonymus americanus), hollies (Ilex spp.), and potentially others. The sparse to lush herb layer may include Christmas fern (Polystichum acrostichoides), sedges (Carex spp.), false wood-nettle (Boehmaria cylindrica), jumpseed (Tovara virginianum), fish-on-a-string (Chasmanthium latifolium), slender spikegrass (Chasmanthium laxum), jack-in-the-pulpit (Arisaema triphyllum), heartleaf aster (Aster divaricata), honewort (Cryptotaenia canadensis), or other species.

The community may grade to Piedmont/Mountain Swamp Forest or Piedmont/Mountain Levee Forest within the floodplain and to Mesic Mixed Hardwood or Oak-Hickory communities on adjacent slopes.

Piedmont/Mountain Swamp Forest

This uncommon community occurs on backswamps, sloughs, and flats on large floodplains. It typically occurs back from the stream channel and active levee areas and may grade to a Bottomland Forest community on slightly elevated floodplain terraces. It is seasonally to frequently flooded, often for relatively long periods of time.

Flood-tolerant tree species often include sweet gum (Liquidambar styraciflua), red maple (Acer rubrum), black willow (Salix nigra), or green ash (Fraxinus pennsylvanica) which dominate this closed canopy. An understory is often absent and may include species such as winged elm (Ulmus alata), ironwood (Carpinus caroliniana), deciduous hollies (Ilex spp.), or dense tag alder (Alnus serrulata). Vines such as poison ivy (Toxicodendron radicans), cross-vine (Anisostichus capreolata), and greenbriers (Smilax spp.) may be prominent. Herbs are generally sparse and may include lizard's-tail (Saururus cernuus), false wood-nettle (Boehmaria cylindrica), orange touch-me-not (Impatiens capensis), and sedges (Carex spp.).

This community can grade to Levee Forest at the riparian interfaces and various Mesic Forest types as elevation and distance from the riparian zone increases.

Piedmont/Mountain Levee Forest

This uncommon community type occurs occasionally on well-developed active levees or point bars along large stream or river channels on sandy alluvial soils.

The canopy typically supports sycamore (Platanus occidentalis), river birch (Betula nigra), box elder (Acer negundo), sugarberry (Celtis spp.), sweet gum (Liquidambar styraciflua), tuliptree (Liriodendron tulipifera), green ash (Fraxinus pennsylvanica), American elm (Ulmus americana), bitternut hickory (Carya cordiformus), black walnut (Juglans nigra), willow oak (Quercus phellos), Shumard oak (Q. shumardii), or other species. The understory is often variable in density and may support ironwood (Carpinus caroliniana), pawpaw (Asimina triloba), box elder, American holly (Ilex opaca), or the canopy species. The shrub layer is typically patchy and may include spicebush (Lindera benzoin), yellowroot (Xanthorhiza simplicissima), or cane (Arundinaria gigantea). Vines such as poison ivy (Toxicodendron radicans), Virginia creeper (Parthenocissus quinquefolius), cross-vine (Anisostichus capreolata), greenbriers (Smilax spp.), or trumpetvine (Campsis radicans) may be prominent. The herb layer can be lush and diverse, with species such as jumpseed (Tovara virginiana), false wood-nettle (Boehmaria cylindrica), fish-on-a-string (Chasmanthium latifolium), slender spikegrass (Chasmanthium laxum), bottlebrush grass (Elymus hystrix), heartleaf aster (Aster divaricatus), spring beauty (Claytonia virginiana), and green-head coneflower (Rudbeckia laciniata).

The community is distinguished from Bottomland Forest by its location adjacent to river channels, and from Swamp Forest by being higher and drier, as well as by its composition of plants.

Low Elevation Seep

This community occurs where seepages and springs flow from bases of slopes along streams or at the edges of floodplains. It exists as very small areas on saturated, mucky soils and usually occurs in moist forests near streams. Low Elevation Seeps differ from ephemeral pools in that they generally drain, though often sluggishly, and support sparse to dense herb communities.

They are habitat for widespread wetland herbs such as orange touch-me-not (Impatiens capensis), fringed sedge (Carex crinita), green-head coneflower (Rudbeckia laciniata), cinnamon fern (Osmunda cinnamomea), royal fern (Osmunda regalis), kidneyleaf buttercup (Ranunculus abortivus), hooked buttercup (Ranunculus recurvatus), or turtleheads (Chelone spp.). Herb cover may be fairly dense to almost absent.

The seeps are less frequently flooded than adjacent streambeds and probably function as seed sources for establishment of plants downstream to replace those dislodged in floods. They may also be important breeding habitat for various amphibians. In agriculturally disturbed areas these seeps often take the form of Meadow Bogs.

Swamp Forest-Bog Complex

This community occurs in poorly drained bottomlands, generally with visible microtopography of ridges and sloughs or depressions.

It is a forest with closed or open canopy and open or dense shrub layer interspersed with small boggy openings in depressions. The canopy includes Canada hemlock (Tsuga canadensis) or red maple (Acer rubrum), depending on the location and elevation. A subtype of this community has red spruce (Picea rubens) as a canopy tree. Other trees include black willow (Salix nigra), sweet birch (Betula lenta), white oak (Quercus alba,) white pine (Pinus strobus), and a few other alluvial species. The dominant shrubs are usually great laurel (Rhododendron maximum) and mountain laurel (Kalmia latifolia), with silky willow (Salix sericea), tag alder (Alnus serrulata), silky dogwood (Cornus amomum), southern wild raisin (Viburnum nudum), and poison sumac (Toxicodendron vernix). The herbs in the boggy open areas include seepage goldenrod (Solidago patula), New York aster (Aster novae-angliae), robin runaway (Dalibarda repens), cinnamon fern (Osmunda cinnamomea), northern long sedge (Carex folliculata), mountain fringed sedge (Carex gynandra), little bog sedge (Carex leptalea), straight sedge (Carex stricta), purple pitcher plant (Sarracenia purpurea), broadleaf arrowhead (Saggittaria latifolia), and rice cutgrass (Leersia virginica). In the closed canopy forest areas melic mannagrass (Glyceria melicaria), clubmoss (Lycopodium obscurum), sensitive fern (Onoclea sensibilis), Canada mayflower (Maianthemum canadense), New York fern (Thelypteris novoboracensis), and royal fern (Osmunda regalis) are common herbs. Scattered sphagnum mats occur in the boggy areas. This is an important community for bog turtles.

The factors that are responsible for creating and maintaining these communities are not well known. Some of the known examples are very old and apparently stable. The boggy openings are generally associated with small depressions. As in the Southern Appalachian Bogs, beaver activities may be a significant factor in these communities. The frequency of flooding is not known.

Southern Appalachian Bog

Southern Appalachian Bogs occur on flat or gently sloping areas in valley bottoms that are not subject to flooding; on wet organic or mucky mineral soils; and in very acidic conditions. Water comes from groundwater seepage.

The vegetation is concentric or patchily zoned around wetter spots. This is an herb and shrub dominated plant community, with a rich mix of plants, both vascular and bryophytes, with large sphagnum mats. Alluvial and wetland trees like red maple (Acer rubrum), white pine (Pinus strobus), and Canada hemlock (Tsuga canadensis), may occur in areas within the wetland or dominate the edges. Shrubs may include tag alder (Alnus serrulata), swamp rose (Rosa palustris), silky willow (Salix sericea), red chokeberry (Aronia arbutifolia), mountain laurel (Kalmia latifolia),

and great laurel (Rhododendron maximum). The herb layer may include a rich list including cinnamon fern (Osmunda cinnamomea), northern long sedge (Carex folliculata), mountain fringed sedge (Carex gynandra), a sedge (Carex scabrata), little bog sedge (Carex leptalea), straight sedge (Carex stricta), white beakrush (Rhynchospora alba), woodland bulrush (Scirpus expansus), cottongrass bulrush (Scirpus cyperinus), Gray's lily (Lilium grayi), lamp rush (Juncus effusus), woods rush (Juncus subcaudatus), tawny cottongrass (Eriophorum virginicum), kidneyleaf grass-of-Parnassis (Parnassia asarifolia), swamp saxifage (Saxifaga pennsylvanica), and golden club (Orontium aquaticum). Sphagnum mats cover more than an acre at several sites.

The factors that are responsible for creating and maintaining these communities are not well known. Grazing and browsing have been factors in almost all bog habitats. Most bogs experience an invasion of trees and shrubs in the absence of grazing. The current tendency for rapid succession suggests that some form of periodic or chronic natural disturbance, now disrupted, may have kept the bogs open.

Southern Appalachian Fen

This natural assemblage of plants occurs in flat or slightly sloping areas which are not subject to flooding. These wet areas are fed by seeping mineral–rich groundwater of circum-neutral or only mildly acidic water and are generally found over shallow bedrock. The only known example of this habitat type is at Bluff Mountain, North Carolina. However, some other sites have certain characteristics of this community type, only less developed.

The vegetation is a complex mixture of herbaceous wetland species . The dominant species include white beakrush (Rhynchospora alba), brownish beakrush (Rhynchospora capitellata), woods rush (Juncus subcaudatus), twig rush (Cladium mariscoides), straight sedge (Carex stricta), autumn sneezeweed (Helenium autumnale), little bluestem (Schizachyrium scoparium), Canada burnet (Sanguisorba canadensis), and cluster goldenrod (Solidago glomerata). Other herbs commonly found include lamp rush (Juncus effusus), tawny cottongrass (Eriophorum virginicum), grass-of-Parnassus (Parnassia grandifolia), sticky bog asphodel (Tofieldia glutinosa), northern long sedge (Carex folliculata), cone shaped sedge (Carex conoidea), Buxbaum's sedge (Carex buxbaumii), and little bog sedge (Carex leptalea). Characteristic bryophytes include sphagnum (Sphagnum subsecundum), golden glade moss (Rhytidium rugosum), a moss (Hypnum pratense), and others.

Because of the complex zonation, small changes in drainage or water supply could cause major shifts in vegetation. Water level manipulation may thus be a useful management technique in many bog types. The natural factors which prevent the succession to woody cover are not well known, but must include the level of saturation and the shallow depth to bedrock, which often leads to woody plant uprooting during storms. The seepage of high pH water might also be a detriment to woody species as well as making this community one of the rarest in the Southeast.

High Elevation Seep

These communities are usually on slopes at high elevations sites that are subject to constant seepage. Soils are rocky, gravelly, or mucky and the sites are usually too small to appear on soil maps. Generally an open to dense bed of wetland herbs is present. Seeps are often small enough to be substantially shaded by trees rooted in adjacent communities, but some are larger and more open.

The dominant plants include turtleheads (Chelone spp.), American speedwell (Veronica americana), umbrella-leaf (Diphylleia cymosa), branch lettuce (Saxifraga micranthidifolia), mountain bittercress (Cardamine clematitis), autumn sneezeweed (Helenium autumnale), American golden

saxifrage (Chrysosphlenium americanum), knotweeds (Polygonum spp.), round-leaf sundew (Drosera rotundifolia), spotted water-hemlock (Citcuta maculata), brownish beakrush (Rhynchospora capitellata), woods rush (Juncus subcaudatus), twig rush (Cladium mariscoides), straight sedge (Carex stricta), northern long sedge (Carex folliculata), mountain fringed sedge (Carex gynandra) little bog sedge (Carex leptalea), other sedges (Carex spp.), New York aster (Aster novae-angliae), orange or yellow touch-me-not (Impatiens pallida and / or I. capensis), St. John's worts (Hypericum spp.), violets (Viola spp.), mountain pennywort (Hydrocotyle americana), green-head coneflower (Rudbekia lacinata), red bee balm (Monarda didyma), seepage goldenrod (Solidago patula), false hellebore (Veratrum dioicum), Gray's lily (Lilium grayi), cinnamon fern (Osmunda cinnamomea), trailing wolfsbane (Acontium reclinatum), and meadowrues (Thalictrum clavatum and T. dioicum). Sphagnum is often present and may occasionally have significant coverage. Woody species usually include great laurel (Rhododendron maximum), mountain laurel (Kalmia latifolia), tag alder (Alnus serrulata), southern wild raisin (Viburnum nudum), and red maple (Acer rubrum).

This community type is apparently stable, although variations in hydrology from year to year may influence species dominance. Occurrence is related to the strike and dip of metamorphic foliation or fractures in the underlying rocks. High elevation seeps grade to various high elevation terrestrial communities. This is still a tentative classification for a community that is known to include significant variation and which might include other conceptual groupings. The small size of these community occurrences makes them sensitive to disturbance and destruction. These are often point-sources for freshwater in a headland forest watershed, and thus require more understanding and appreciation for their role in the watershed.

Upland Pool

Upland Pools are small upland depressions in the Piedmont and Mountain regions, where water is pooled over an impermeable substrate. Soils are shallow muck over a clay or rock layer. They are generally too small to be on soil maps. The hydrology is palustrine, seasonally to permanently flooded. Rainfall is the main source of water. Since they often occur in late winter and early spring, they are commonly called vernal pools.

Various wetland shrubs and herbs dominate the vegetation. Trees such as black gum (Nyssa sylvatica), water oak (Quercus nigra), red maple (Acer rubrum), and sweet gum (Liquidambar styraciflua) may be present along the edge or on islands. Shrub species include buttonbush (Chephalanthus occidentalis), vaccinium species (Vaccinium spp.), swamp doghobble (Leucothoe racemosa), and in some areas ti-ti (Cyrilla racemiflora). Herbs include royal fern (Osmunda regalis), many sedges (Carex spp.), lamp rush (Juncus effusus), sphagnum (Sphagnum spp.), and other mosses.

Over long periods, these pools presumably will fill with sediment and organic matter. They tend to succeed to Upland Depression Swamp Forests in time. They are becoming rare community types and can be important habitats for local populations of amphibians.

Hillside Seepage Bog

Hillside Seepage Bogs are small areas in the Mountains, Piedmont, or upper Coastal Plain at the break of slopes or edges of bottomlands that are constantly saturated with groundwater seepage. They contain wet, mucky, and often deep soils over rock or gravel. Hydrology is palustrine, permanently saturated to intermittently dry.

Vegetation is typically zoned in relation to substrate and saturation. The outer zone of trees and shrubs includes black gum (Nyssa sylvatica), tuliptree (Liriodendron tulipifera), red maple (Acer rubrum), and sweet gum (Liquidambar styraciflua), along with some herbs such as royal fern

(Osmunda regalis), partridgeberry (Mitchella repens), Virginia chain fern (Woodwardia virginica), and species from the interior zone. The interior zone can have a low canopy of tall shrubs like tag alder (Alnus serrulata), red chokeberry (Aronia arbutifolia), mountain laurel (Kalmia latifolia), and tuliptree (Liriodendron tulipifera). The interior, wettest parts of the community are composed of sedges (Carex spp.), pipeworts (Eriocaulon spp.), pitcher plants (Sarracenia flava and S. purpurea), grass pink (Calopogon tuberosus), cinnamon fern (Osmunda cinnamomea), and a few other common wetland forbs and graminoids. There may also be a range of Sphagnum species forming various mats. These communities are distinguished from Upland Pools and Upland Depression Swamps by being wetted by seepage. They are distinguished from Low Elevation Seeps by the well-developed sphagnum mats and the importance of other bog species.

The dynamics and maintenance of this system are not well known. All known bogs are undergoing rapid proliferation of shrubs and trees, as if some disturbance that used to maintain these sites is no longer acting. Both natural fire and impact of grazers have been suggested as woody vegetation control agents. Beaver removal from the Piedmont during the last 200-300 years, and their subsequent reintroduction, may provide more clues to the impact these grazing and wetland-building animals have on these wetland types.

Low Elevation Seep

This plant community occurs at the base of slopes or edges of floodplains. Its saturated soils are not generally noted on soil maps. The palustrine hydrology type is permanently flooded.

These are generally small enough to be shaded by trees rooted in surrounding communities. Occasional wetland trees like red maple (Acer rubrum), or willow oak (Quercus phellos) may grow in the midst of the seep. A variety of wetland herbs can be found in seeps including lizard's tail (Saururus cernuus), orange touch-me-not (Impatiens capensis), cinnamon fern (Osmunda cinnamomea), royal fern (Osmunda regalis), false nettle (Boehmeria cylindrica), green-head coneflower (Rudbeckia laciniata), hooked buttercup (Ranunculus recurvatus), turtleheads (Chelone glabra), rushes (Juncus spp.), and branch lettuce (Saxifraga micranthidifolia). These are also wonderful sites for breeding amphibians and may serve as local centers where many individuals return to breed each year. The loss of these small sites contributes to the local decline of salamander and frog populations.

The dynamics of these small systems are poorly known; however, many have been stable for a long time. These communities respond to drops in the water table and to extended drought. Well-developed Low Elevation Seeps contrast sharply with adjacent plant communities and land uses in both their vegetation and soils. While they lack some of the high elevation and northern species and most of the Sphagnum mosses, they are very rich local centers of biodiversity deserving of restoration and management.

Floodplain Pool

This natural community occurs in depressions in abandoned river channels on floodplains, holding standing water all or part of the year. The soil types of these small areas are generally not distinguished on soil maps.

The central parts of this community may contain standing water and may or may not have higher plants. The edges may or may not include zones of aquatic vegetation, like sedges (Carex spp.), false nettle (Boehmeria cylindrica), seedbox (Ludwigia spp.), touch-me-not (Impatiens capensis), cinnamon fern (Osmunda cinnamomea), and royal fern (Osmunda regalis). Shrubs such as tag alder (Alnus serrulata) and spicebush (Lindera benzoin) may occur along the edges.

The dynamics of these pools are not well known. Major floods may flush accumulated sediment out of these pools, alter their shape, and maintain their aquatic communities. They are common and larger in low gradient Coastal Plain valleys, and smaller and more rare in the Piedmont and Mountains. These communities are generally surrounded by Bottomland or Alluvial Forest types or land converted to agricultural use.

Meadow Bog (Wet Pasture)

The term Meadow Bog is used to describe a Mountain or Piedmont wetland that has been altered by human use. Meadow Bogs are frequently found on agricultural land, primarily in pastures and wet spots in hay fields. These bogs are swampy wet areas vegetated with sedges, herbs, shrubs, and sparse trees. The vegetation is a mixture of one or more of the natural communities that occur in the area and alien plants typical of human-altered fields, forests, and farms. Native plants that are sensitive to disturbances are largely rare or missing and introduced weedy species are common. Depending on the kind and type of disturbance, Meadow Bog vegetation patterns may also be modified by increased fertilizer and chemical loading, grazing, seeding with fescue, herbicides, dumping, and other alterations.

The animal communities of a healthy wetland are also altered in the Meadow Bog. Populations of native animal species decline with loss of habitat and distance to the nearest human activity. In the case of many urban and suburban wetlands, increased predator numbers (raccoons, skunks, cats, and dogs) result in declines in prey species. Compound this with loss of habitat, road intrusion, hydrologic changes, chemical assaults, and a host of other wetland "land-uses," native animal communities are under serious pressure.

Bibliography

Shafale, M.P. and A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health, and Natural Resources. Classifies known natural plant communities in North Carolina and gives ecological discussion of each, with comparisons and examples.

B

Rare Animals and Plants of Southern Appalachain Wetlands

Nora A. Murdock and Patrick D. McMillan

Southern bog lemming (Synaptomys cooperi).

Table I

Rare Animals of Southern Appalachian Wetlands*

SPECIES	HABITATS				
	Bogs**	Swamps	Ephemeral Pools	Swamp Forest	Wet Meadows
mole salamander (Ambystoma talpoideum)			✓	✓	✓
bog turtle (Clemmys muhlenbergii)	✓				✓
star-nosed mole (Condylura cristata parva)	✓	✓	✓	✓	✓
Baltimore butterfly (Euphydryas phaeton)	✓				✓
four-toed salamander (Hemidactylium scutatum)	✓	✓	✓	✓	✓
Diana fritillary (Speyeria diana)	✓				✓
Southern bog lemming (Synaptomys cooperi)	✓				✓

* Species listed may be state or federally listed, for more information consult your state agency listed in Appendix F.
** Southern Appalachian Bog. See Chapter 2.

Table II

Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
bog rose (Arethusa bulbosa)	✓					
bog jack-in-the-pulpit (Arisaema triphyllum ssp. stewardsonii)	✓			✓	✓	✓
blunt-lobed grape fern (Botrychium oneidense)	✓					
fringed brome (Bromus ciliatus)			✓	✓		
marsh marigold (Caltha palustris)	✓					✓
marsh bellflower (Campanula aparinoides)	✓	✓				
Mountain bittercress (Cardamine clematitis)				✓		
Mountain watercress (Cardamine rotundifolia)				✓		

Table II, continued
Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
hay sedge (Carex argyrantha)						✓
Barratt's sedge (Carex barrattii)	✓			✓?		
brown bog sedge (Carex buxbaumii)	✓	✓				✓
cone-shaped sedge (Carex conoidea)	✓					✓
small crested sedge (Carex cristatella)	✓					
a sedge (Carex deflexa)			✓			
a sedge (Carex lasicocarpa var. amaericana)	✓					
Oklahoma sedge (Carex oklahomensis)				✓		
few-seeded sedge (Carex oligosperma)	✓			✓		
necklace sedge (Carex projecta)	✓		✓	✓	✓	✓
Schweinitz's sedge (Carex schweinitzii)					✓	
a sedge (Carex trichocarpa)	✓					
three-seeded sedge (Carex trisperma)	✓	✓			✓	
a sedge (Carex utriculata)	✓					
a sedge (Carex vesicaria)	✓	✓				
Cuthbert's turtlehead (Chelone cuthbertii)	✓	✓		✓	✓	✓
twig-rush (Cladium marisoides)	✓	✓		✓		
Long-bracted frog sedge (Coeloglossum viride var. virescens)				✓		

Table II, continued
Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
Goldthread (Coptis trifoliata ssp. groenlandica)	✓					
robin runaway (Dalibarda repens)	✓				✓	
bog oatgrass (Danthonia epilis)	✓	✓		✓		
purpleleaf willowherb (Epilobium ciliatum)	✓	✓		✓		
Texas hatpins (Eriocaulon texense)				✓		
queen-of-the-prairie (Filipendula rubra)		✓				✓
fringed gentian (Gentianopsis crinita)		✓	✓	✓		
yellow avens (Geum aleppicum)	✓					
Bent avens (Geum geniculatum)				✓		
rough avens (Geum laciniatum var. trichocarpum)	✓					
rattlesnake mannagrass (Glyceria canadensis)	✓					
lax mannagrass (Glyceria laxa)	✓	✓				✓
Smoky Mountain mannagrass (Glyceria nubigena)			✓			
littleleaf sneezeweed (Helenium brevifolium)		✓		✓		
plains sunrose (Helianthemum bicknellii)		✓				
swamp pink (Helonias bullata)	✓				✓	
holy grass (Hierochloe odorata)	✓	✓				
Appalachian fir-clubmoss (Huperzia appalachiana)		✓	✓	✓		

Table II, continued
Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
long-stalked holly (Ilex collina)	✓	✓			✓	
rough rush (Juncus caesariensis)		✓				
rough blazing star (Liatris aspera)		✓				
Heller's blazing star (Liatris helleri)		✓				
yellow Canada lily (Lilium canadense ssp. canadense)	✓	✓				✓
red Canada lily (Lilium canadense ssp. editorum)	✓	✓				✓
Gray's lily (Lilium grayi)	✓	✓	✓	✓		✓
Fen orchaid (Liparis loesellii)		✓		✓		
American fly-honeysuckle (Lonicera canadensis)	✓	✓				
bog clubmoss (Lycopodiella inundata)	✓					
a clubmoss (Lycopodium dendroideum)	✓	✓				
Hickey's clubmoss (Lycopodium hickeyi)	✓	✓				
largeflower Barbara's buttons (Marshallia grandiflora)	✓					
buckbean (Menyanthes trifoliata)	✓					
bristy muhly (Muhlenbergia glomerata)		✓		✓		
sweet gale (Myrica gale)	✓					
bog asphodel (Narthecium americanum)	✓					
perennial sundrops (Oenothera perennis)	✓					

Table II, continued
Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
largeleaf grass-of-Parnassus (Parnassia grandifolia)		✓		✓		
swamp lousewort (Pedicularis lanceolata)		✓		✓	✓	
northern beech fern (Phegopteris connectilis)			✓			
northern rein orchid (Platanthera flava var. herbiola)		✓				
large purple-fringed orchid (Platanthera grandiflora)	✓		✓	✓		
white fringeless orchid (Platanthera integrilabia)	✓			✓		
purple fringless orchid (Platanthera peramoena)	✓					✓
bog bluegrass (Poa paludigena)	✓					
white beakrush (Rhynchospora alba)	✓	✓				
bunched arrowhead (Sagittaria fasciculata)	✓				✓	
Canada burnet (Sanguisorba canadensis)		✓	✓	✓		✓
mountain sweet pitcher plant (Sarracenia rubra ssp. jonesii)	✓					
green pitcher plant (Sarracenia oreophila)	✓			✓		
swamp saxifrage (Saxifraga pensylvanica)	✓			✓		
balsam ragwort (Senecio pauperculus)	✓	✓				
bog goldenrod (Solidago uliginosa)	✓	✓		✓		
greenfruit bur-reed (Sparganium chlorocarpum)	✓					✓?
freshwater cordgrass (Spartina pectinata)						✓

Table II, continued
Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
shining ladies'-tresses (Spiranthes lucida)		✓				
Epling's hedge-nettle (Stachys eplingii)	✓					
longstalk starwort (Stellaria alsine)				✓		
bog featherbells (Stenanthium robustum)	✓	✓				✓
Canada yew (Taxus canadensis)	✓				✓	
bog fern (Massachusetts fern) (Thelypteris simulata)	✓					
sticky bog asphodel (Tofieldia glutinosa)	✓	✓		✓		
small bladderwort (Utricularia minor)	✓					
cranberry (Vaccinium macrocarpon)	✓			✓		
American speedwell (Veronica americana)	✓			✓		
Mosses						
yellow starry fen moss (Campylium stellatum var. stellatum)		✓				
liverwort (Cephaloziella hampeana)		✓				
bog broom-moss (Dichranum undulatum)	✓			✓		
narrowleaf peatmoss (Sphagnum angustifolium)	✓					
northern peatmoss (Sphagnum capillifolium)	✓					
pretty peatmoss (Sphagnum fallax)	✓					
flexuous peatmoss (Sphagnum flexuosum var. flexuosum)	✓					

Table II, continued
Rare Plants of Southern Appalachian Wetlands*

SPECIES	HABITATS					
	Bogs**	Fens	High Elevation Seeps	Seeps	Swamp Forest	Wet Meadows
brown peatmoss (Sphagnum fuscum)	✓					
fen peatmoss (Sphagnum warnstorfii)	✓	✓				
southern dung moss (Splachnum pennsylvanicum)	✓					
orange peatmoss (Sphagnum subsecundum var. subsecundum)	✓	✓				

* Species listed may be state or federally listed; for more information consult your state agency listed in Appendix D. Some of these species occur in other habitats in addition to mountain wetlands.

** Southern Appalachian Bog. See Chapter 2.

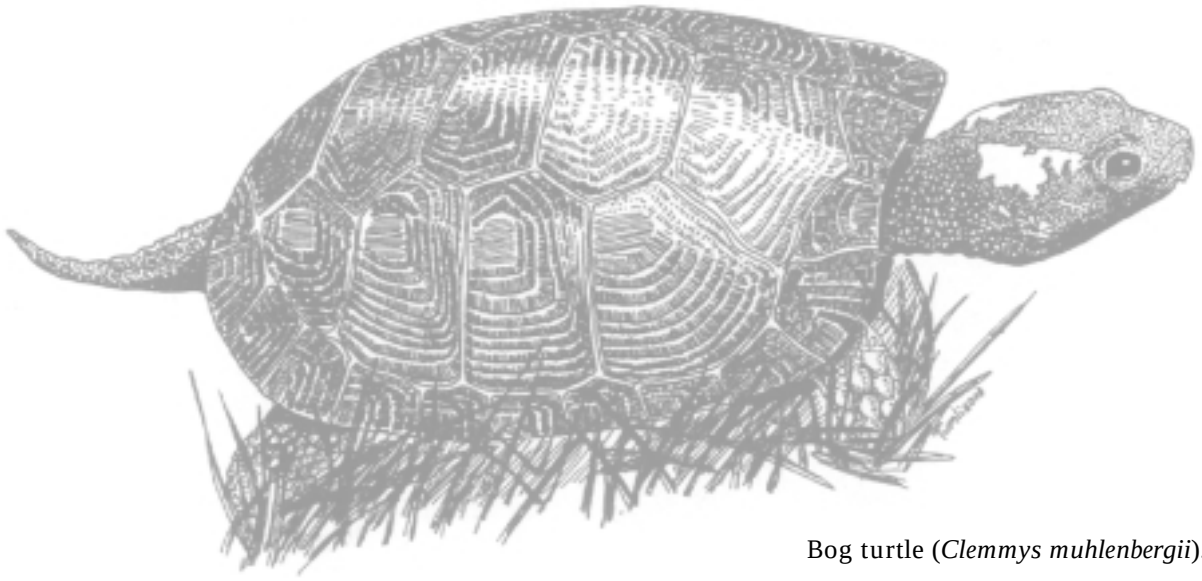
✓? Highly likely but warrants further study.

C

Example Handout on Endangered Species

Kenneth A. Bridle, Ph.D.

This document was prepared at the request of the Piedmont Land Conservancy in North Carolina. The intent was to have a document that summarized the applicable rare species laws for landowners and aid in obtaining permission to conduct biological inventories on private property. An additional document is provided, listing rare species for that region. Together these inform the landowners of their rights and the land trusts' intentions. Organizations considering landscape scale inventory or restoration projects should consider developing a similar document for their jurisdictions. If the possibility exists that rare species are involved in the project, it is best to have a discussion of all federal, state, and local laws that might affect the management plan and the landowner's willingness to cooperate.



Bog turtle (*Clemmys muhlenbergii*).

Endangered Species and Piedmont North Carolina Landowners

Kenneth A. Bridle, Ph.D.

An understanding of endangered species and the laws designed to protect them are important for the proper functioning of any land conservancy. Rare plant and animal species occur in our region and stewardship of these resources is a part of our mission. We also strive to work with private landowners to achieve this mission. However, a common fear often prevents landowners from working with conservation organizations. The concern of some landowners is that if the existence of an endangered species is discovered on their land, restrictions and land-use limitations will be imposed. This belief is largely based on a lack of knowledge and understanding of the law and misinterpretations of its record. Also, in the current climate of political confrontation, the issue of endangered species protection is a rhetorically charged debate, often with little regard for the truth. The following is derived from the relevant federal and state laws regarding endangered species and is presented as a brief summary of those sections that most directly impact landowners and private land use.

Summary of the Federal Endangered Species Act

The Endangered Species Act of 1973 (ESA or the Act), as amended, serves as the basis for the federal program and the model for most state programs, including North Carolina. In the first paragraph of the Act, Congress recognized the value of endangered species by stating that "endangered species of fish, wildlife and plants are of aesthetic, ecological, recreational, educational, historical, and scientific value to the nation and its people." These values include commercial commodities, environmental health and quality indicators, educational, and recreational public interests.

The Act sets up a mechanism for placing species on the List of Endangered and Threatened Wildlife and Plants. It also defines most of the appropriate terms in non-ambiguous ways (for example—endangered species is a group "which is in danger of extinction throughout all or a significant portion of its natural range"). Listing species provides a method of tracking and planning for each species' recovery. Each listing involves many levels of review by the public, government agencies, and the scientific community. The Act empowers the US Fish and Wildlife Service and National Marine Fisheries Service to manage permits and enforcement, implement recovery plans, recommend research, monitor endangered species populations, and cooperate with other public and private entities to conserve listed species. The goal is to ensure recovery to a point where the species no longer needs protection under the Act. An important and often overlooked provision of the Act requires the Secretary of Interior to consider economic and other costs in the protection plans for each species when designating critical habitat (areas essential to the survival and recovery of a species). This provision promotes a balance between costs and benefits of this regulatory action. In the mid-1990s this judgment was used to exclude from protection 3 million of 9 million acres of spotted owl critical habitat in an effort to lessen the impact on the logging industry.

With regard to listed animals, the Act states it is illegal to
- Engage in interstate or foreign trade without a permit.
- "Take" any listed species (Take = harass, harm, pursue, hunt, kill, trap, etc.).
- Possess illegally taken endangered or threatened species.
- The maximum penalty: $50,000 and/or 1 year in prison.

With regard to listed plants, the law says that it is illegal to
- Engage in interstate or foreign trade without a permit.
- Remove and reduce to possession such plants from federal lands.
- Maliciously damage or destroy any such species on federal lands.
- Remove, cut, dig up, damage or destroy an endangered plant on land other than your own in knowing violation of the law, including trespassing.
- The maximum penalty: $50,000 and/or 1 year in prison.

In addition, the Act requires federal agencies to develop programs to conserve listed species and prohibits them from carrying out any action that would jeopardize the continued existence of listed species or adversely modify critical habitat. The Act also protects species from the potentially harmful actions of private landowners. However, the Act offers several flexible tools for resolving conflicts between private landowners and endangered species. For example, private landowners can lawfully "take" listed species if it's "incidental to and not the purpose of carrying out otherwise lawful activities" and the landowner implements a conservation plan for those species. Implementation of the Act is designed to "foster creative partnerships between the private sector and government agencies in the interest of endangered species conservation."

From 1979-1999 there were over 120,000 federal projects reviewed for impact on endangered species. Of these, less than 1% were found to significantly impact an endangered species overall, even though a particular project may have caused local destruction of a population, and only 34 (<0.03%) of those development projects were stopped as a result of the ESA. Far from being the uncompromising straitjacket that its opponents portray, the ESA is replete with requirements to balance the needs of endangered species conservation with private property owners and developers. Private developers can obtain federal permits to legally harm or even kill endangered species on their property, provided they show that they tried to minimize their impact on the species in other ways. Other tools to avoid conflict between rare species and landowners include Section 10 permits, such as habitat conservation plans, safe harbor agreements, and candidate conservation plans. As an ultimate balancing of endangered species and economics, there exists the Endangered Species Committee which is authorized to exempt activities from the ESA when the benefits of the project clearly outweigh the conservation of a species, even though this may result in the complete extinction of a species. Due to other flexibilities in the ESA only three cases have ever come before this committee.

The underlying reality is that rare species, like other rare objects, are valued because of their rarity. Most of the people prosecuted under the Endangered Species Act are wildlife traffickers who illegally and knowingly collect rare wildlife and plants to sell for personal profit. The existence of an endangered species on private property legally has no effect unless the landowner (or someone else) is planning a project that requires a federal permit, uses federal funds, or will clearly result in the illegal taking of a listed species. Even where a private landowner's property is designated as critical habitat for an endangered species, private landowners are not regulated by the ESA; only federal actions that would adversely alter critical habitat are regulated. Critical habitat is an official designation of areas essential to the survival and recovery of a species, made by the Interior Secretary after review of all available scientific and economic data. At the present time only three fishes and one plant have designations of critical habitat in North Carolina.

None occur in the northwest Piedmont. Currently there are five federally listed plants and seven listed animals in this area.

Federally Endangered or Threatened Plants in Piedmont North Carolina

- **Small-anthered Bittercress** . . *Cardamine micranthera*
- **Smooth Coneflower** . . . . . *Echinacea laevigata*
- **Schweinitz's Sunflower** . . . . . *Helianthus schweinitzii*
- **Small Whorled Pogonia** . . . . . *Isotria medeoloides*
- **White Irisette** . . . . . *Sisyrinchium dichotomum*

Federally Endangered or Threatened Animals in Piedmont North Carolina

- **Eastern Cougar** . . . . . *Felis concolor cougar* (no longer in this region)
- **Kirtland's Warbler** . . . . . *Dendroica kirtlandii* (occasional migrant through this area)
- **Bald Eagle** . . . . . *Haliaeetus leucocephalus* (proposed for delisting due to recovery)
- **Red-cockaded Woodpecker** . . *Picoides borealis* (Sandhills region)
- **Bachman's warbler** . . . . . *Vermivora bachmanii* (last seen in the early 1960s, possibly extinct)
- **Cape Fear Shiner** . . . . . *Notropis mekistocholas*
- **Peregrine Falcon** . . . . . *Falco peregrinus* (migrant, now nesting in this area, delisted Aug. 1999)
- **Bog Turtle** . . . . . *Clemmys muhlenbergii* (Threatened by similarity of appearence to northern population)

Summary of North Carolina Endangered Species Laws

After the establishment of the ESA, many states developed their own endangered species laws to deal with cases of local or regional decline that are not regulated by national law. North Carolina has rich biological diversity in habitats ranging from the mountains to the sea. This state is home to some organisms that occur nowhere else and are declining in numbers. For other species, our state is only part of a larger range, but their populations here may be threatened. It is these species that are covered by the North Carolina endangered species laws.

Animals:

Using the federal Endangered Species Act as a model, North Carolina enacted General Statutes 113-331 to 113-337, effective 1987, which authorizes the Wildlife Resources Commission to develop a system to monitor and protect rare animal species in the state. The Commission was mandated to undertake rare animal species listing and designation of critical habitats upon recommendation of the Nongame Wildlife Advisory Committee. The Commission then coordinates the development and implementation of management plans for listed species. Chapter 392 (H832), 1995 of North Carolina Legislation amended the Commission's mandate to take into consideration a wider range of conservation, protection, and management measures that may be applied to species and habitats. Costs of protection, economic impact, and reasonably available options for minimizing costs and adverse impacts must be considered in each plan. Most importantly to landowners, "no rule may be adopted that restricts use or development of private property."

The protection of endangered animals in this state is essentially similar to the federal ESA in that it is targeted at illegal trafficking of rare animals and products, and protection of native

populations from poaching. Landowners can do almost anything they want with state listed rare species on their property except possess, sell, or kill them without a permit.

Plants:

The Plant Protection and Conservation Act (Chapter 106, Article 19B; 202.12-202.22 of the General Statutes of North Carolina) authorizes the North Carolina Department of Agriculture to monitor and protect rare plant species in the state. The Commissioner of Agriculture does the listing of plants at the recommendation of the North Carolina Plant Conservation Board. The Agriculture Department is required to work with other state agencies to monitor and develop management plans for each listed species. Currently the Natural Heritage Program (Division of Environment and Natural Resources) maintains the database which tracks rare plant populations and the Agriculture Department maintains a Plant Protection Office for the purpose of management and legal protection of native plant species in peril. The Plant Protection Office also issues permits regarding collection, propagation, and trade of rare plants for sale—most notably ginseng.

Like the federal ESA, this law is primarily aimed at protecting rare plants from the actions of illegal traffickers who collect the plants for profit and to minimize the impact of state development projects on rare plant populations. In the section outlining the "unlawful acts," a specific line was included to protect private property owners. It states that "the incidental disturbance of protected plants during agricultural, forestry, or development operations is not illegal so long as the plants are not collected for sale or commercial use." Here again the bottom line is that a private property owner can do whatever they want with the native rare plants on their land except sell them without a permit.

The preparation of this document was made possible with help and advice from the following:

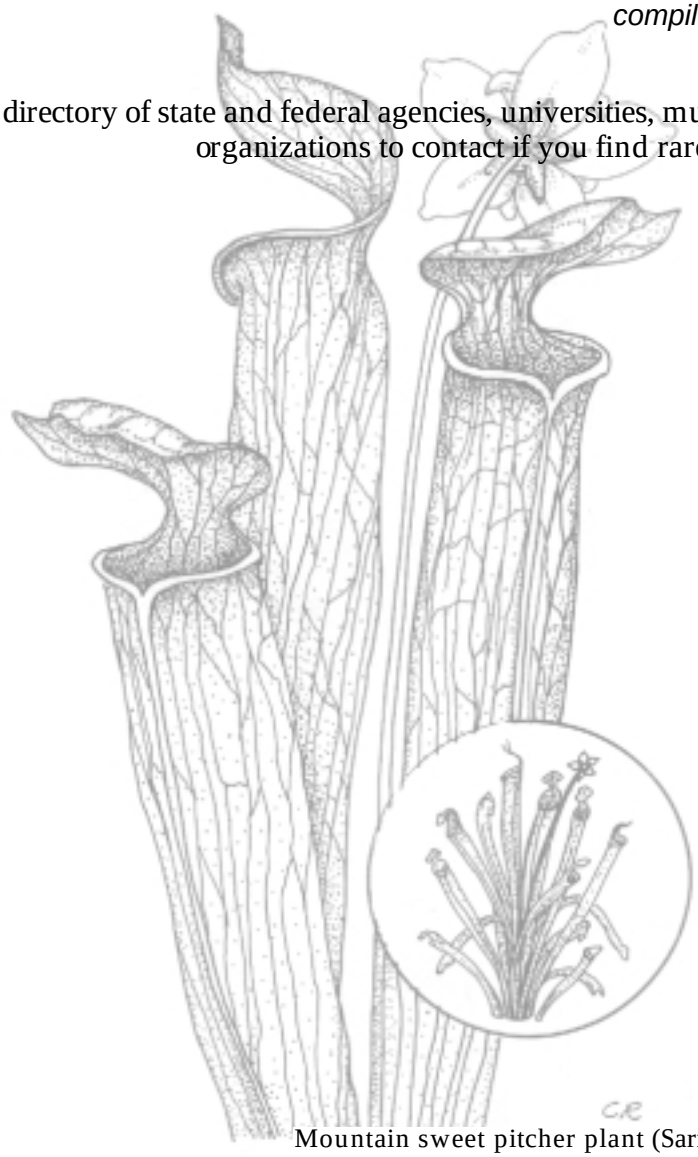
- **Marjorie W. Boyer**, *North Carolina Department of Agriculture, Plant Industry Division, Raleigh, NC*
- **Nora A. Murdock**, *US Fish and Wildlife Service, Ecological Services Field Office, Asheville, NC*
- **Randall C. Wilson**, *North Carolina Wildlife Resources Commission, Division of Wildlife Management, Raleigh, NC*

D

Directory of Contacts for Rare Species

compiled by Dennis W. Herman

A directory of state and federal agencies, universities, museums, and independent organizations to contact if you find rare plant or animal species.



Mountain sweet pitcher plant (Sarracenia jonesii).

Directory of Contacts for Rare Species

Directory of Contacts for Rare Animal Species (Including Bog Turtles)

GEORGIA

Federal Agency Contacts

Nora Murdock
Fish and Wildlife Biologist
US Fish & Wildlife Service
160 Zillicoa St.
Asheville, NC 28801
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Email: Nora_Murdock@fws.gov

State Wildlife Agency Contacts

John B. Jensen
Georgia Department of Natural Resources
Wildlife Resources Division
Nongame-Endangered Wildlife Program
116 Rum Creek Drive
Forsyth, GA 31029
Phone: (912) 994-1438
Email: John_Jensen@mail.dnr.state.ga.us

Other Agencies or Organizations

Kenneth M. Fahey, Ph.D.
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State Wildlife Agency Contacts

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Mountain Projects Leader
NC Wildlife Resources Commission
315 Morgan Branch Road
Leicester, NC 28748
Phone: (828) 683-0671
Email: mcgrathc@ncdial.net

Other Agencies or Organizations

Alvin Braswell
Curator of Reptiles and Amphibians
NC Museum of Natural Sciences
P.O. Box 29555
Raleigh, NC 27626-0555
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Project Bog Turtle
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11 West Jones St.
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SOUTH CAROLINA

Federal Agency Contacts

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State Wildlife Agency Contacts

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TENNESSEE

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State Wildlife Agency Contacts

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Other Agencies or Organizations

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State Wildlife Agency Contacts

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Directory of Contacts for Rare Plant Species

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State Agency Contacts

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Georgia Department of Natural Resources
2117 US Hwy 278 SE
Social Circle, GA 30279
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State Agency Contacts

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Other Agencies or Organizations

The Nature Conservancy - Virginia Chapter
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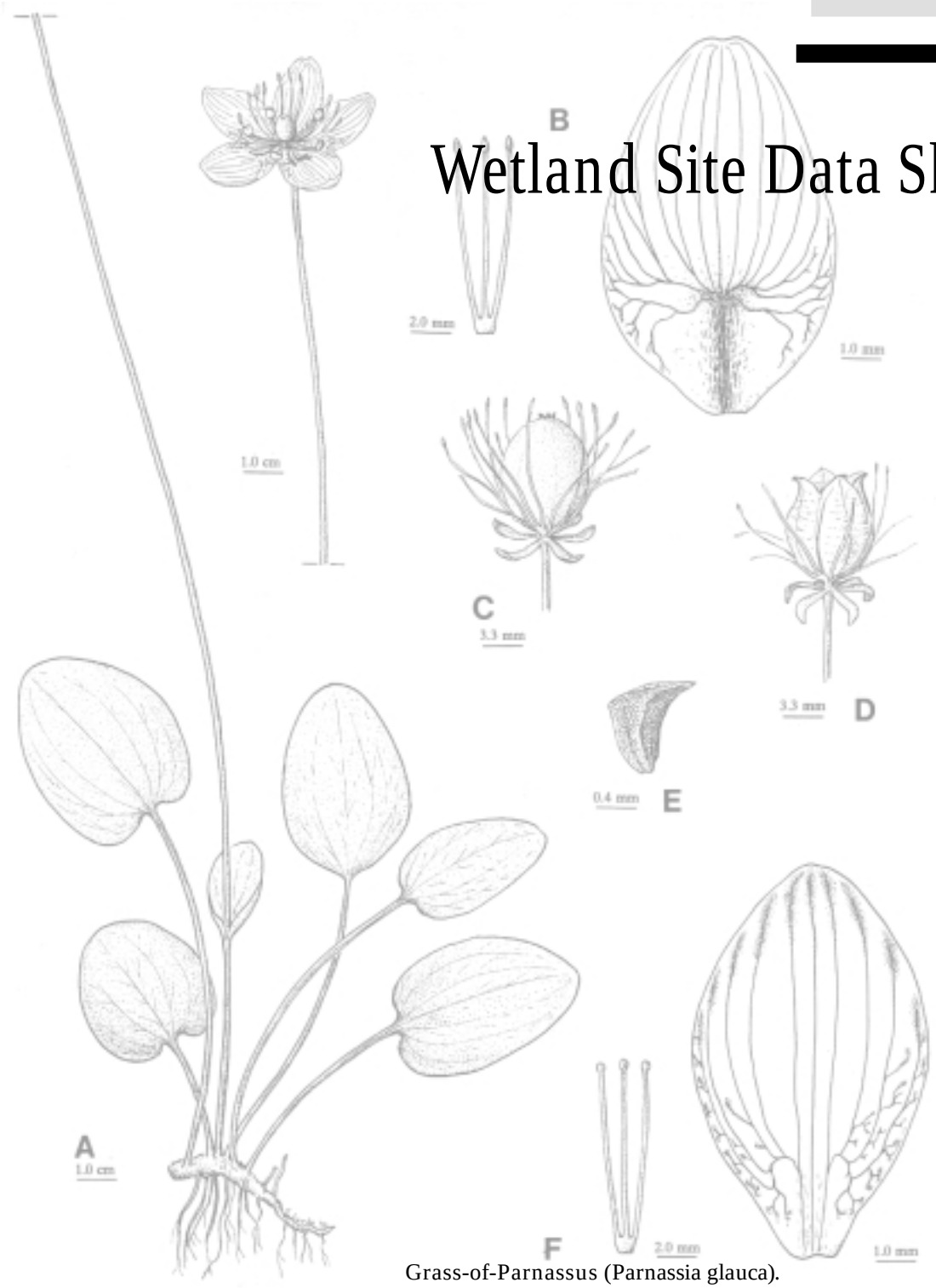
Phone: (804) 295-6106

E

Wetland Site Data Sheet



Grass-of-Parnassus (Parnassia glauca).

Wetland Site Data Sheet

Site Name: _____ County: _____

Report prepared by: _____ Date: _____

Landowner Name, Address, Phone, Email: _____

_____

_____

Drainage: _____ USGS Quadrangle: _____

Location (use road numbers and mileage from intersections or towns, etc.): _____

_____

DeLorme Atlas Page No. and Coordinates:_____

Significance of Site: _____

_____

SOILS

Soil Survey Sheet Nos.: _____ Approx. Elevation: _____

Have the soils been mapped or evaluated (circle one)? Y N Describe: _____

_____

HYDROLOGY

Is the site muddy? Yes No

Do you need knee boots to walk into the site? _____ Hip boots? _____

Hydrology on date form filled out: Low _____ Average _____ High _____

Approx. Size of Wet Area: _____

Describe the primary hydrologic inputs (rainwater, spring-fed, runoff, snowmelt, etc.): _____

_____

_____

_____

_____

Describe previous attempts to drain or fill: _____

Evidence of sediment loading or pollution (describe): _____

VEGETATION

% Open Area (herbaceous or weedy)_____ % Canopy _____ % Shrub Layer _____

Native plant species observed (include ferns): _____

Invasive plant species (comment on abundance):

Protected or rare species observed:

Native animal species observed:

Potential amphibian breeding sites (moss clumps, rocks in and around moving water, small pools along t
edges of streams or rivulets, submerged rocks, partially submerged or saturated logs, etc.):

Is there any evidence of recent grazing (grazers visible, fencing, fresh manure, tracks, etc.)? What type of grazers did you observe (cows, horses, deer, Canada geese, others)? Try to approximate numbers. Include other pertinent information.

Evidence of other domestic species (cats, dogs, etc.): _____

Rate potential for bog turtles (1 lowest - 5 highest, 6 = don't know): _____

Offsite stresses to site integrity (landscape influences): _____

Characterize the dominant land use within a 1.0 mile radius (circle one):

1. Less than 25% of the land is agricultural. Large tracts of woods.
2. Less than 50% of land is agricultural, areas of woods and undeveloped areas.
3. Rural/agricultural. Much more open area than #2. Few subdivisions.
4. Suburban, some open areas. Many subdivisions.
5. Urban, dense network of roads. Large amount of land devoted to shopping centers, businesses, educational facilities, or industry in area.

Additional comments on site integrity: _____

Management recommendations: _____

Portions of this data sheet were adapted from

Klemens, M.W. 1993. Standardized bog turtle site-quality analysis. Submitted to the US Fish and Wildlife Service. American Museum of Natural History, New York.

F

Informative Handouts for Landowners

1. So, I Have Bog Turtles ... 2. Meadow Bogs (Wet Pastures) 3. Project Bog Turtle

Grass-pink orchid (Calopogon tuberosus).

So, I Have Bog Turtles …

Q. What are bog turtles?

A. Bog turtles are one of the smallest turtles in the world. They inhabit wetlands in eastern North America. Bog turtles have a black to mahogany colored shell and distinctive orange to yellow spots on the sides of their heads. The average adult length is 3 - 3.5 inches. The wetlands they inhabit are usually small, acidic, and have soft mud. Bog turtles are very secretive. They rarely bask in full view like other turtles. They spend most of their time in the mud, sometimes with part of their shell sticking out to collect heat.

Q. Why are they so special?

A. The number of bog turtles has decreased significantly. This is mostly due to habitat loss and collection for the pet trade. Because of the decrease in populations, bog turtles are currently listed as threatened or endangered in all states they inhabit. Listing as a threatened or endangered species makes collection of the turtles illegal.

Q. Why do people want to study them?

A. One main purpose in studying bog turtles is to gather information to assist in their recovery so they can be removed from the listing. In order to accomplish this, we need to know more about the turtles. Scientists study the turtles to learn about their life cycles, migration, and habitat choice. With this information we can determine the best way to manage bog turtle sites so that the turtles flourish.

Q. What does it mean to have turtles on your property?

A. Having bog turtles on your property is very special. Very few people will ever get to see a bog turtle other than in captivity. You have the opportunity to help preserve a threatened species. It does not mean that your property can be taken from you.

Q. Can anyone come on my property without my permission?

A. No, it is your property. The access of your property to others is your decision.

Q. Can I still use my property?

A. Yes. Having bog turtles does not effect your right to use the property. In some cases bog turtles inhabit wetlands in cattle pastures or hay fields. Current studies indicate that cattle grazing has a beneficial effect for bog turtles. It is believed that seasonal grazing maintains the open sedge areas that the turtles prefer.

Q. What if I want to drain my wetland?

A. Before you consider draining your wetland, check to make sure you would not violate any state or federal laws or risk losing USDA benefits. Most of the wetlands that bog turtles inhabit are small. Thus, the expense of draining these areas would far outweigh the financial benefit of having a bit more pasture or field.

Q. What are the benefits of protecting bog turtles?

A. There are many benefits to protecting bog turtles. Protecting bog turtles helps keep them from going extinct. Extinction is a normal process, but the current rate of extinctions is unnaturally high. The most common cause of extinction is habitat loss—in other words, humans have caused this inflated extinction rate. Slowing the rate of extinction is important because every species plays a part in nature. Each species that is lost affects the natural system. Also, to protect bog turtles you must protect the wetlands they inhabit. Wetlands perform many functions that have value to humans, including wildlife habitat, flood control and filtering of pollutants and sediment in the water.

Q. How can I protect bog turtles?

A. There are many different ways to protect bog turtles. To protect the bog turtle, you must protect their habitat—bogs. There are preservation programs designed for the purpose of wildlife and wetland protection and restoration that can offer technical assistance. Also, conservancies and land trusts offer many preservation options, some with financial benefits. Contact:

Project Bog Turtle
NC State Museum of Natural Sciences
11 West Jones St.
Raleigh, NC 27601-1059

Phone: (919) 733-7450 ext. 511

Web site: www.projectbogturtle.org

Meadow Bogs (Wet Pastures)

What is a Meadow Bog?

The term "Meadow Bog" describes a Mountain or Piedmont wetland that has been altered by human use. Meadow Bogs frequently occur on agricultural land, primarily in cattle pastures or hay fields. Most Meadow Bogs are characterized by using the three "S" system: They are spring-fed, sunny, and soggy. Most are swampy or wet areas vegetated with sedges, herbs, shrubs, and sparse trees. Meadow Bogs are true wonderlands performing many important functions which provide valuable benefits to people and wildlife.

What are the Values of Meadow Bogs?

A Meadow Bog is Important for Water Quality

Meadow Bogs are important for water quality, especially during storm events. Acting as a sponge, Meadow Bogs absorb excess storm water rushing over the land, reducing flood damage and the amount of soil entering the streams. They also improve water quality by filtering out excess nutrients, pesticides, sedimentation, and other pollutants.

Meadow Bogs Provide Habitat for Wildlife

Many rare and unusual species inhabit wetlands such as Gray's lilies, orchids, carnivorous plants, four-toed salamanders, and bog turtles. Even in altered or disturbed wetlands, like Meadow Bogs, these unusual species may still persist. Familiar species also inhabit Meadow Bogs such as frogs, songbirds, white-tailed deer, and woodcock. Furthermore, because wetlands keep streams and rivers clean, they help to maintain habitat for sport fish, such as trout.

Why Preserve Meadow Bogs?

The Southeastern United States has lost approximately 90% of its Mountain bogs. When wetlands disappear, so do the benefits they provide. The loss of wetlands has resulted in increased flooding, increased water contamination, and a decrease in waterfowl, migratory birds, fish, and other species that use wetlands. Because huge losses have already occurred, it is even more important to preserve and restore our remaining wetlands. There are many ways in which you, as a steward of the land, can help maintain our wetlands and the species that depend upon them.

Recommendations for Maintaining a Meadow Bog

Farming is a needed activity that can benefit some wetland species. For example, moderate grazing or occasional mowing provides open habitat for the rare and endangered bog turtle. These management activities control the growth of woody plants and shrubs that can otherwise take over open wetlands.

- Allow only moderate to light grazing
- When mowing, set the blades high to avoid destroying habitat and nests of birds and small mammals
- Mow as infrequently as possible to increase wildlife habitat. Good wildlife areas often look "weedy," but this isn't bad!
- Control woody vegetation by cutting when the area is becoming more shaded than sunny
- Provide native vegetation buffers around the wetland to filter pollutants and benefit wildlife

Want to learn more?

An excellent source for information on Meadow Bogs is the handbook titled The Restoration & Management of Small Wetlands of the Mountains & Piedmont in the Southeast: A Manual Emphasizing Endangered & Threatened Species Habitat with a Focus on Bog Turtles written by Ann B. Somers, Kenneth A. Bridle, Dennis W. Herman and A. Barry Nelson in cooperation with the Natural Resources Conservation Service, Watershed Science Institute, Raleigh NC, published in 2000. Contact Ann Berry Somers, Department of Biology, University of North Carolina at Greensboro, P.O. Box 26174, Greensboro, N.C. 27402-6174, 336-334-4978, absomers@uncg.edu.

There are programs that provide technical and possible financial support for Meadow Bog restoration and management. For further information on these options, contact your local USDA Natural Resources Conservation Service office, US Fish and Wildlife Service office, Project Bog Turtle,www.projectbogturtle.org, the North Carolina State Museum of Natural Sciences, or your local land trust.

Project Bog Turtle

Project Bog Turtle is an initiative of the Conservation Committee of the North Carolina Herpetological Society. The directors are Dennis W. Herman, Co-chair (NC State Museum of Natural Sciences, Raleigh, NC), Tom Thorp, Co-chair (Three Lakes Nature Center and Aquarium, Richmond, VA), and Ann B. Somers (the University of North Carolina at Greensboro). The original project was begun in the late 1970s by Dennis Herman as a continuation of a bog turtle distribution survey, by Robert T. Zappalorti (Staten Island Zoological Society), in southwestern North Carolina. The survey was expanded to include other southern states to locate new sites and populations of bog turtles. Most of the work, however, was conducted in North Carolina. The bog turtle project included mark-and-recapture studies in several sites and a captive propagation and headstart program at the Atlanta Zoological Park (now Zoo Atlanta). It was evident, as the project progressed, that additional personnel and assistance from the various state, federal, and private agencies would be needed.

In 1988, the NC Herpetological Society became an important partner in the project and began the NC Piedmont Bog Turtle Survey under the coordination and direction of Dennis Herman and Tom Thorp. This survey proved to be very successful, as several new county records and additional sites were located. Today, because of these surveys, there are 131 bog turtle occurrence records known from 20 counties in North Carolina. Dennis Herman, under a NC Wildlife Resources Commission contract in 1994, wrote a 156-page action plan outlining conservation and management strategies for the bog turtle in NC. This document was well received and an increased interest was generated to protect bog turtle habitats. The original bog turtle project and the NC Piedmont turtle survey were combined and renamed Project Bog Turtle in 1995. Project Bog Turtle's main goals are the following:

1. Protection of habitat through leases, purchases or easements.
2. Restoration of altered habitat.
3. Continued surveys to locate new populations.
4. Continued monitoring and study of population dynamics in selected sites.
5. Landowner education, cooperation, and involvement.
6. Consultation with, and dissemination of information to, federal and state agencies.

The project received funds from the US Fish & Wildlife Service for protection of bog turtle habitat by leasing sites from landowners and for conducting surveys in the Southeast for additional populations. In addition, the project obtained funds from USFWS Partners for Fish and Wildlife program for the restoration and management of sites in two North Carolina counties to enhance their habitat and bog turtle populations.

Project Bog Turtle is based at the NC State Museum of Natural Sciences and possesses one of the largest bog turtle databases in the Southeast. For additional information on PBT, or how you can support the project, please contact: Dennis W. Herman, Project Bog Turtle
NC State Museum of Natural Sciences, 11 West Jones St., Raleigh, NC 27601-1029
phone (919) 733-7450, ext. 511; email dennis.herman@ncmail.net or visit
www.projectbogturtle.org