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Ronald G. Eckstein
Wisconsin Department of Natural Resources, Rhinelander, WI

Robert C. Willging
U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control

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RONALD G. ECKSTEIN, Wisconsin Department of Natural Resources, Rhinelander, WI 54501
ROBERT C. WILLGING, U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control, Box 1064, Rhinelander, WI 54501

Abstract: The concept of managing natural resources to maintain and restore biodiversity has received increased emphasis from resource managers in recent years. Many state and federal land management agencies have incorporated biodiversity concepts into management plans and programs. Active management of both wildlife habitats and populations must increase as natural systems are simplified and fragmented by human activities. Wildlife damage management programs can be compatible with ecosystem management and maintenance of biodiversity. Species that are widespread but rare and, in particular, species with small and isolated populations remain at risk from environmental and genetic changes, competition, parasitism, and predation. There are many examples of wildlife damage management programs that directly protect and enhance rare plant and animal populations and promote biodiversity. There will be an increased need for wildlife professionals with expertise in wildlife damage management as state and federal agencies take a more active role in managing natural resources to maintain local and regional biodiversity.

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In recent years many state and federal agencies have considered using biodiversity as an organizing principle for natural resource management. Many resource managers are concerned that managing natural resources under a guiding principle of biodiversity will compromise both traditional wildlife management activities and support of traditional wildlife user groups. In this paper, we will attempt to define biodiversity, and explain how biodiversity concepts apply to wildlife biologists and wildlife damage management professionals.

WHAT IS BIODIVERSITY?

Biodiversity is a shortened form of the term biological diversity. The U.S. Office of Technology Assessment (1987) defines biodiversity as the variety and variability among living organisms and the ecological complexes in which they occur. The United States Department of Agriculture, Animal and Plant Health Inspection Service, Animal Damage Control (USDA-APHIS-ADC) Environmental Impact Statement (1994) defines diversity as the number of species in a given area. Biodiversity refers to the variety and number of species, their genetic composition, and the natural communities, ecosystems, and landscapes in which they occur. An ecosystem is a dynamic complex of plants and animals and the physical environment interacting as an ecological unit. Ecosystems occur at a wide variety of temporal and spacial scales. A rotting log over a 10-year period as well as an entire National Forest over a 100 year period are both ecosystems. Ecosystems have components called structure, composition, and function. To maintain biodiversity natural resource agencies are encouraged to consider the composition, structure, and function of ecosystems at a wide variety of temporal and spatial scales.

WHO SAYS BIODIVERSITY IS IMPORTANT?

The dramatic loss of natural habitats in recent decades has generated great concern among scientists and the general public. Traditional resource management philosophy seemed inadequate to address problems associated with the impending worldwide reduction of biodiversity. A new discipline, conservation biology, has developed as a result. Many colleges and universities now have departments and curricula in conservation biology. Conservation biology has the restoration and maintenance of biodiversity as its organizing principle and joins the more traditional disciplines of wildlife management, range management, and forestry in dealing with natural resource management issues. Many federal and state resource management agencies are incorporating biodiversity concepts into their management plans. The National Forest Management Act (1976) requires National Forests to maintain and enhance the diversity of plant and animal communities as they strive to meet management objectives. The Wisconsin Department of Natural Resources (WDNR) is currently proposing to apply the principle of ecosystem management to all phases of Department planning and programs (WDNR 1994).

WHY THE CONCERN?

Scientists are recording massive alteration and loss of wildlife habitat throughout the world. Tropical deforestation, the spread of deserts, pollution of lakes and rivers, commercial overfishing, widespread poaching, and continued conversion of natural habitats to agriculture are occurring

throughout the world. The demands on natural resources by ever expanding human populations has prompted a worldwide concern for the maintenance of biodiversity. In the next decade or so almost all of the world's natural temperate and tropical habitats will come under direct human influence.

As more people use more resources, many natural, wide-spread habitats become fragmented and simplified. Habitat fragmentation results from breaking up extensive natural habitats like grasslands, forests, and free flowing rivers into smaller patches within a given landscape. In these small fragments, former wide-ranging populations of plants and animals are restricted to small isolated areas. These small isolated populations are at increased risk from such things as inbreeding, genetic drift, and random disaster.

Random disasters can easily wipe out small isolated populations of plants or animals. Random disasters include such things as disease outbreaks, hurricanes, devastating wildfires, or floods. Of interest to wildlife damage professionals is that random disasters can also include the invasion of plant and animal competitors and predators into small isolated habitats. Competitors and predators can devastate populations of endangered, threatened, or rare species in small isolated habitat fragments. The problems of endangered species on the Hawaiian, Aleutian, Caribbean, and Pacific Rim islands attest to the impact that competitors and predators can have on native plants and animals.

HAVE WE DONE A GOOD JOB IN THE PAST?

Yes, resource managers have done a good job. The single species management approach has proven very successful, particularly in temperate climates and especially for large vertebrate species. However, if we are to consider all species and ecosystems, the species by species management approach is inadequate. A much broader approach using principles of ecosystem and landscape management is required. The management of entire ecosystems is necessary to maintain the full range of species that exist there.

HOW NATURAL RESOURCE AGENCIES CAN MAINTAIN AND RESTORE BIODIVERSITY

The basic resource management tools used will remain the same but the scales of space and time used for planning and analysis are different. Planning and analysis must occur at a wide variety of spatial scales from individual parcels of land to broad landscapes and large regions. For example, resource managers in northern Wisconsin may need to consider habitats and wildlife populations in adjoining states as well as entire regions when making decisions. We must think not only in terms of years and decades but also in terms of multiple generations of the longest lived animals and even in evolutionary time. The long term persistence of populations of plants and animals in functioning ecosystems requires this commitment to broad scales of planning and analysis.

While planning and analysis may change, ecosystems still have to be managed. Small, isolated populations of plants and animals will require more management than in the past. The basic tools of timber harvest, prescribed burns, hunting, trapping, grazing, disease control, mowing, cutting, and manipulating will remain the same. They will be used, however, to manage a broader range of habitats for a broader range of plants and animals. As an important component of wildlife management, wildlife damage management will play an important role in this process.

Wildlife damage management professionals are already successfully addressing many serious threats to biodiversity. Human induced changes in the landscape have lead to an overabundance of highly adaptable wildlife species, such as white-tailed deer (*Odocoileus virginianus)* , beaver (*Castor canadensis*), coyote (*Canis latrans*), and gulls (*Larus* spp.). High populations of these species can threaten the survival of less abundant species. In Wisconsin, a cooperative effort between United States Forest Service (USFS), WDNR, and USDA-APHIS-ADC has begun to protect threatened plant communities from beaver damage. In particular, northern white cedar swamp communities are very vulnerable to destruction from beaver impoundments. The USFS in Wisconsin has placed a high priority on protecting existing cedar swamps, as many unique plant species exist there, including several rare orchids (Crowe et al. 1993).

In Louisiana, USDA-APHIS-ADC works to protect the threatened Louisiana pearlshell *(Margaritifera hembeli)* from destruction caused by beaver impoundments. Critical habitat for this species consists of small fast flowing creeks, with high dissolved oxygen content and low turbidity. Beaver impoundments negatively impact this habitat, and the USFS has contracted USDA-APHIS-ADC to manage beaver populations in pearlshell habitat (D. LeBlanc, USDA-APHIS-ADC, pers. commun.). Resource managers in Eastern North America are recognizing serious threats to native flora and natural areas from overabundant deer populations. For example, high deer populations at Point Pelee National Park in Ontario were having serious negative impacts on rare plant populations and plant communities of the Park and control efforts were necessary.

Another major threat to biodiversity in North America and worldwide are exotics and those species that have expanded beyond their native ranges (Samson 1992). For example, wildlife damage management has been a key component in recovery efforts for the endangered Kirtland's warbler (*Dendroica kirtlandii*) in Michigan. Brown-headed cowbird (*Molothrus ater*) nest parasitism was recognized as 1 of 2 key limiting factors for Kirtland's warbler populations. Cowbirds were not abundant in Kirtland's warbler habitat until human-induced changes in the landscape allowed the cowbird's range to expand. An intensive cowbird control effort within their breeding habitat has largely eliminated this limiting factor, and has lead to increased nest productivity (R. Ennis, U.S. For. Ser., pers. commun.).

In Hawaii a wide variety of introduced invertebrate and vertebrate species threaten the survival of native plants and animals. Introduced rats, *Rattus exulans* and *Rattus rattus*, have had an enormous detrimental effect on native plants, birds, insects, and mollusks. The introduced small Indian mongoose

(*Herpestes auropunctatus*) preys on the eggs and chicks of several species of endangered birds (Stone and Anderson 1988). Wildlife damage management conducted by USDA-APHIS-ADC, United States National Park Service, United States Fish and Wildlife Service, and the State of Hawaii have made considerable progress in reducing the threat from introduced pests to Hawaii's unique animal and plant resources. In another island situation, the brown tree snake (*Boiga irregularis)* has virtually eliminated the native avifauna of Guam. The snake was introduced to Guam at the end of WWII. The USDA-APHIS-ADC in cooperation with the United States Department of Defense and the Territorial Government of Guam plays a critical role in preventing the dispersal of the brown tree snake to other Pacific islands and the United States mainland (Tim Ohashi, USDA-APHIS-ADC, pers. commun.).

In Alaska, wildlife managers have conducted intensive control of Arctic fox (*Alopex lagopus*) in the Aleutian Islands in order to save the Aleutian Canada goose (*Branta canadensis leucopareia*) from extinction. Arctic fox were not found on the islands prior to their introduction by fur traders. Nest depredations by fox greatly reduced Aleutian Canada goose populations, as well as populations of ground nesting seabirds. Total removal of fox from select islands was necessary to reestablish breeding pairs of geese and ensure survival of the Aleutian Canada goose (Aleutian Canada Goose Recovery Team 1982).

In Wisconsin, USDA-APHIS-ADC was contracted by WDNR to investigate any depredation caused by endangered or threatened species, primarily the Eastern timber wolf (*Canis lupus lycaon*) and bald eagle (*Haliaeetus leucocephalus*). The recovery plan for Eastern timber wolf includes depredation management as an important component (Eastern Wolf Recovery Team 1992). Professional and adequate management of human/wolf conflicts increases public tolerance of the animals and promotes survival.

In Louisiana, USDA-APHIS-ADC has taken a lead role in recovery of the threatened Louisiana black bear (*Ursus americanus luteolus*) by addressing bear complaints. Effective conflict resolution is necessary to increase private landowner and general public tolerance of bears and reduce illegal kill, a significant limiting factor (D. LeBlanc, USDA-APHIS-ADC, pers. commun.).

There are dozens of other examples of wildlife damage management programs that promote the survival of rare animal and plant species and habitats. The increased management emphasis on conservation of biodiversity will lead to increased demands for wildlife damage management programs.

THE FUTURE

In summary, initiatives to restore and maintain biodiversity will require the expertise of wildlife damage professionals. Managing ecosystems and landscapes with biodiversity in mind does not mean a lock up of resources. It does not mean an end to traditional resource management. It does not mean an end to game management, hunting, and trapping. It is not an anti-management issue. It does mean that we have to take a broader view when making management decisions. Considering biodiversity issues will add complexity to resource management planning and analysis.

When dealing with complex and abstract ideas such as biodiversity, there is certain to be a high level of conflict and disagreement. Special interest groups will interpret the concepts to suit individual goals and values, and will seek to influence policy. For this reason it is important that wildlife damage professionals educate themselves about biodiversity issues, and further define wildlife damage management's role in the process.

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