


1998

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Recommended Citation

Bernstein, Neil P. (1998) "Iowa's Declining Flora and Fauna: A Review of Changes Since 1980 and an Outlook for the Future," *The Journal of the Iowa Academy of Science: JIAS*: Vol. 105: No. 3 , Article 8.

Available at: <http://scholarworks.uni.edu/jias/vol105/iss3/8>

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Iowa's Declining Flora and Fauna: A Review of Changes Since 1980 and an Outlook for the Future

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The status of Iowa's biodiversity was first summarized at a 1980 Iowa Academy of Science (IAS) symposium that was published in *The Proceedings of the Iowa Academy of Science* (Vol. 88, No. 1) in 1981. The 1980 symposium was updated in a recent IAS symposium, and the proceedings from this symposium are published, for the most part, in volume 105 of this journal. Most of the authors noted some positive trends, but, overall, species declines and habitat destruction remained a concern.

In 1980, Roosa (1981) issued nine future challenges to conservation in Iowa. Since that time, some progress has been made in acquiring natural areas, documenting our natural history base, developing tax incentives for preservation, maintaining a state office for biological surveys, enacting river corridor management programs, publicizing Iowa's diminishing natural heritage, providing a non-game and endangered species program, and forming a coalition of environmental organizations. However, at this time, no monograph series exists on taxonomic groups.

Potential future threats to Iowa's biodiversity include: fragmentation and destruction of habitats in both Iowa and abroad, climatic instability, competition from introduced species, and competition/predation/parasitism from generalist species. Given these threats, conservation efforts should continue with the goal of limiting further damage to biodiversity.

INDEX DESCRIPTORS: biodiversity, conservation, preservation, Iowa biodiversity, fragmentation, habitat, climate change, introduced species.

At the close of the 1980 Iowa Academy of Science (IAS) symposium on Perspectives of Iowa's Declining Flora and Fauna (1981. *The Proceedings of the Iowa Academy of Science* 88:1-47), Iowa Department of Natural Resource (DNR) ecologist, Dean Roosa, presented 9 challenges to the preservation of biological diversity (Roosa 1981), or, as it came to be known, biodiversity (Wilson 1986, Lovejoy 1997). During the recent 1997 IAS symposium on the same topic as the 1980 symposium, participants documented general trends for several taxonomic groups and habitats since 1980, and they also established both a benchmark of knowledge regarding Iowa's biodiversity and a vision of the future. In summarizing the papers presented, I will try to evaluate changes to Iowa's biodiversity and habitats that have occurred since 1980, what efforts have been made to preserve biodiversity, and what potential threats to biodiversity still exist.

CHANGES TO BIODIVERSITY AND HABITATS SINCE 1980

While authors of the 1997 symposium documented a few positive trends in the status of organisms and habitats, overall, species were declining or, at best, predicted to decline in the future. Tiffany and Knaphus (1998) noted that while the status of fungi, myxomycetes, and lichens has not been conclusively documented, our knowledge of these organisms indicates that they are threatened by habitat loss and/or loss of their plant associates. Lewis (1998) and Phillips (1998) described declines in terrestrial and aquatic plants, respectively, again citing habitat loss and, in some cases, competition from introduced species as causes for declines. Phillips (1998) also noted improper management of resources as problematic, and Cruden and Gode (1998) and Schlicht and Orwig (1998) also found management prac-

tices and habitat destruction to be responsible for declines in two orders of insects.

The aforementioned organisms were not covered in the 1980 symposium, and, therefore, comparisons with their status in 1980 are difficult. What is the status of the habitats and organisms that were discussed in 1980? Bishop et al. (1998) noted that through major conservation efforts, prairie wetlands have increased since 1980. While Jungst et al. (1998) documented an increase in forested lands from 1974 to 1990, they cautioned that the increase may be temporary and that the current classifications of forest types may not present a total picture of a diverse forest ecosystem. Smith (1998) still found the prairie ecosystem to be fragile, and all the authors of the vertebrate groups (John Olson, pers comm; Christiansen 1998; Dinsmore 1998; and Bowles et al. 1998) noted overall species declines since 1980, although some native species have increased.

As troubling as these negative trends are, we know little if anything about the status of most prokaryotes, protists, non-vascular plants, and invertebrates. Arguably, these are not only the most numerous organisms, but also some of the most important for the ecosystem (Wilson 1992). As an example, Williams (1996) found over 100 species of arthropods associated with a single prairie plant species, *Onosmodium molle*. What role do these arthropods serve in the ecosystem as hosts to smaller parasites, prey, competitors, and predators? Are some of them pollinators or part of other mutualistic symbioses? We can only infer that as habitats and larger organisms decline, countless species of less noticeable, numerous organisms will also be negatively impacted, thus eroding the stability of the ecosystem.

CONSERVATION EFFORTS SINCE 1980

Conservation efforts since the 1980 symposium can be organized by nine "future challenges" to Iowa's conservation efforts that Roosa

(1981) outlined. Roosa (1981) called for the development of: 1) An expanded land acquisition program by the State of Iowa, 2) An inventory of our natural history base, 3) Land use legislation, 4) An Iowa Biological Survey, 5) River corridor management plans, 6) Publicity on Iowa's diminishing natural heritage, 7) A monograph series on taxonomic groups, 8) An expanded non-game and endangered species program, and 9) A coalition of concerned environmental groups.

An expanded land acquisition program by the State of Iowa:

Progress has been made towards this challenge in protecting natural areas since 1980. However, continued efforts are critical because tracts of natural habitat remain unmanaged or mismanaged in private ownership and existing preserves could be better protected by additional land to serve as buffer. It should be noted that there are also natural areas in public ownership that are unmanaged or mismanaged.

As cited by Roosa (1981), the 1978 State Comprehensive Outdoor Recreation Plan listed 203,647 ha (503,222 ac) as owned by the state, federal, and county governments. By 1995, the updated plan (Ott 1995) listed 270,576 ha (668,606 ac), an increase of 33% or 66,929 ha (165,384 ac). Therefore, compared with the area of the entire state, land in public ownership increased from approximately 1.4% to 1.8% between 1978 and 1995. Accompanying the acquisition of publicly owned land was a 57% increase in the number of state preserves from 56 to 88 between 1980 and 1996 (Daryl Howell, pers comm).

A major legislative initiative and several new conservation programs have aided in the effort to acquire land. In 1989, the Iowa legislature passed innovative, important legislation that established the Resource Enhancement and Protection program (REAP), which provides funds for conservation education, acquisition of open spaces, county conservation efforts (that could include land acquisition), city parks and open space (that could include land acquisition), soil and water enhancement, state land management, historical resource development, roadside vegetation management, and Iowa Department of Natural Resources (DNR) administration of the program (Szcodronski 1993). Through REAP's funding for open space acquisition, the state had purchased 9,876 ha (24,405 ac) as of December, 1997 (Szcodronski, pers comm). Counties and cities have also used REAP funds to purchase natural areas (e.g. Hitaga Sand Prairie was purchased by the Linn Co. Conservation Board). While proposed funding for REAP has been less than originally projected and not all REAP-funded land purchases are natural habitats, REAP remains an important source of state funding for land acquisition.

Under the Habitat Stamp Program, county conservation boards and the DNR acquired 9,594 ha (23,706 ac) and 27,487 ha (67,922 ac) respectively from 1980 to 1996. In addition, the Prairie Pothole Joint Venture, a cooperative agreement between many agencies and groups established to promote migratory waterfowl reproduction, resulted in the purchase of 6,585 ha (16,275 ac) by the state and 4,517 ha (11,161 ac) by the federal government by 1996 for wetland protection. Also, the US Fish and Wildlife Service (USFWS) had purchased 204 ha (505 ac) of algific talus slopes by 1996 in an ongoing effort to create a Driftless Area Refuge system (data from Daryl Howell, pers comm).

Private conservation groups also have contributed to the land acquisition effort. Since 1980, the Iowa Natural Heritage Foundation (INHF) has purchased or assisted in the acquisition of 15,525 ha (38,362 ac), however, not all of this land is natural habitat (Kyle Swanson, pers comm). In addition, The Nature Conservancy (TNC) has purchased 1,821 ha (4,500 ac) since 1980 (Jerry Selby pers com), and local groups and individuals also contributed to conservation of

natural habitats by direct purchases [e.g. 27 ha (67 ac) purchased by the Indian Creek Nature Center, Linn Co.]. TNC also strives to magnify conservation awareness with owners of land worthy of preservation through its registry program. By registering their land, land owners voluntarily agree to protect the natural resources and to inform TNC if the land is to change ownership or be developed, and to date, 10,117 ha (25,000 ac) have been placed in that program (Jerry Selby, pers comm).

In addition to the above programs, there has been a movement to restore native habitats (e.g. Thompson 1992). With this in mind, the USFWS purchased 2,064 ha (5100 ac) near Prairie City, Iowa, in 1990 and established the Walnut Creek National Wildlife Refuge with the goal of restoring tallgrass prairie and savanna. Groups like Trees Forever and countless schools, colleges, and universities have planted trees, prairies, and butterfly gardens in an attempt to provide native habitats within urban areas or restore tracts of land. REAP and the Iowa Department of Transportation also have protected, researched, and/or planted native prairie roadsides.

It is worthwhile to note that agencies are now attempting to preserve large tracts of land by purchasing small adjacent parcels over time, and that several different groups may purchase segments of a single larger area to accomplish a common larger goal. Examples would be the Loess Hills Pioneer State Forest which is taking shape as willing landowners sell their parcels to the state. Loess Hills ecosystems also are profiting by TNC's designation of the Loess Hills as part of its Last Great Places campaign and the subsequent purchase of several large adjacent parcels in the hills of Plymouth County. The TNC also is coordinating purchases across state boundaries in its Ecoregional Planning project, an effort that includes areas like the algific talus slopes of Iowa, Minnesota, Illinois, and Wisconsin. (Jerry Selby, pers comm). Such efforts are important if we are to preserve and maintain viable ecosystems rather than smaller ecosystem remnants.

It is important to remember that information about algific talus slopes was relatively new when Roosa (1981) discussed these challenges to conservation efforts, and that the ecology and locations of Iowa fens and savannas then was barely known, if at all. As the scientific community has become aware of these rare habitats, groups have made a concerted effort to quickly locate and preserve as many communities as possible, efforts that have been stimulated by Roosa's (1981) next challenge.

An inventory of our natural history base:

Roosa (1981) noted that information was not available for several taxonomic groups and was not current for others. While our knowledge of native taxa is still far from complete, the gathering of new information about Iowa's taxa is evidenced by summaries of groups (Odonata, terrestrial plants, aquatic plants, and fungi) in this symposium that were not represented in the 1980 symposium (Cruden and Gode 1998, Lewis 1998, Phillips 1998, Schlicht and Orwig 1998, and Tiffany and Knaphus 1998). Additionally, Roosa (1981) suggested that a checklist of Iowa vascular plants was needed, and this has been published (Eilers and Roosa 1994).

To survey and document Iowa's organisms, the Iowa Natural Areas Inventory (INAI) was established in 1981 by TNC, and the DNR took over funding and administering the program in 1983 as a staff group within the Division of Parks, Recreation and Preserves. Through the INAI and the Wildlife Diversity Program, the DNR has funded surveys of species and taxonomic groups. The Iowa Natural History Association (INHA) has also contributed to our knowledge through the work of individual members, natural history forays in conjunction with the DNR (Roosa 1977) (Table 1), symposia (see below), and research projects like the effort to develop a

Table 1. Locations of Iowa Natural History Forays^a.

| YEAR | LOCATION |
|------|--|
| 1977 | Fremont County |
| 1978 | Allamakee County |
| 1979 | Lee County |
| 1980 | Lyon County |
| 1981 | Plymouth and Woodbury Counties |
| 1982 | Monona and Harrison Counties |
| 1983 | Pottawattamie, Mills, and Fremont Counties |
| 1984 | Decatur and Ringgold Counties |
| 1985 | Hardin County |
| 1986 | Mitchell and Worth Counties |
| 1987 | Jackson and Clinton Counties |
| 1988 | Guthrie and Adair Counties |
| 1989 | O'Brien and Cherokee Counties |
| 1990 | Benton County |
| 1991 | Monroe and Mahaska Counties |
| 1992 | Louisa County |
| 1993 | Scott and Muscatine Counties |
| 1994 | Fayette County |
| 1995 | Delaware and Clayton Counties |
| 1996 | Dickinson County |
| 1997 | Walnut Creek National Wildlife Refuge ^b |

^aExcept for the first year and some specialized publications on selected groups (vascular plants), most of the data gathered during forays remain undocumented

^bThe 1998–2001 forays are scheduled for WCNWR

restoration plan of Horseshoe Bend National Wildlife Refuge in Louisa Co. for the USFWS. Unfortunately, participation in the forays has steadily decreased, partially because of increased commitments of potential participants as well as retirement of many of the original, most active members.

In addition, since 1987 the Leopold Center for Sustainable Agriculture has funded studies documenting interactions between agriculture and nature. There have also been a number of books and scientific papers published on Iowa's organisms and ecosystems which contributed to the goal of developing an inventory of biodiversity (cited below in "Publicity on Iowa's diminishing natural heritage").

Land-use legislation:

Roosa (1981) was concerned about environmental impacts of land use that extend beyond the boundaries of an individual's ownership, and this problem remains today. An example of a negative impact that seems to be increasing is accidental manure spills from hog lots. Other problems include pesticide drift and urban sprawl, which will be discussed below.

However, since Roosa's paper (1981), land use for conservation has been promoted through various tax incentive and subsidy programs. In 1985, the US Congress established the Conservation Reserve Program (CRP) which paid farmers to plant grass species on former crop land for a period of 10 years. By 1991, Iowans had enrolled more than 809,000 ha (2,000,000 ac) in CRP. These grassy areas have increased reproduction for some grassland birds and promoted soil conservation (Hughes et al. 1995, Bogenschutz et al. 1998, Dinsmore 1998). However, the 1995 Farm Bill excluded many of these lands from the present CRP, and it is predicted that most of the land originally entered in the CRP will revert to row crops (Bogenschutz et al. 1998). In addition to entering land in CRP, private land owners can also receive property tax exemptions for preserving

forested tracts in the Forest Reserve Program, and property tax exemptions through the Slough Bill apply to recreational lakes, rivers, streams, forest cover along streams, river and stream banks, and open prairies. Bishop et al. (1998) also documented similar programs for land owners to preserve wetlands such as the Wetlands Reserve Program (WRP).

Formation of an Iowa Biological Survey:

While an Iowa Biological Survey was not formally established, various state, private, and academic organizations have contributed to our knowledge base, and the INAI maintains a data base of rare species. Roosa (1981) suggested publications of survey data, and the DNR publications cited below in the "Publicity" section partially served this function. However, at the time of Roosa's (1981) address, the INAI consisted of 4 individuals plus Roosa, the ecologist. Today, three people share the responsibilities once performed by five, and the three individuals have several duties beyond surveying biota.

Clearly, more funding with more individuals focused exclusively on the task of studying our natural history would be an asset to our conservation efforts. However, a new technological initiative will increase our analysis of Iowa's biota and aid in preservation efforts. Data on distributions of organisms and communities now can be computerized in a geographical information system (GIS). These data can then be used to perform Gap Analysis, "a scientific method for identifying the degree to which native animal species and natural communities are represented in our present-day mix of conservation lands" (www.ag.iastate.edu/centers/cfwru/iowagap/whatisit.htm 1998). Coordinated by the Biological Resources Division of the US Geological Survey (USGS), data on organisms and their habitats will be analyzed by the Gap Analysis Program (GAP). From these data, correlations can be drawn for the purposes of management, conservation, or pure inquiry. Also, because this is a national effort, data from several states can be analyzed for large geographic areas which should enhance efficacy of conservation efforts. This program, coordinated in Iowa at Iowa State University, receives funding from many sources such as the US Department of Defense, the Environmental Protection Agency, USGS, businesses, universities, state agencies, tribes, and non-governmental organizations like TNC (www.ag.iastate.edu/centers/cfwru/iowagap/whatisit.htm 1998).

However, more effort to survey and coordinate our biota is needed. Recently, Minnesota began intensive documentation of natural habitats for each county, the County Biological Survey. Several of these county surveys have been published, and they provide an important source of information on the Minnesota's biodiversity. The Illinois Biological Survey has a long history of natural history studies and habitat assessment, and Missouri developed a plan for conservation of biodiversity (Nigh et al. 1992). Similar efforts in Iowa would be beneficial.

River Corridor Management Plans:

Some progress has been made toward achieving this toward this goal. In 1978, the state of Iowa established the Protected Waters Area program (PWA), a system for designating lakes, rivers, streams, and marshes along with surrounding land for preservation, protection, and enhancement of natural and cultural resources (Ott 1995). This plan was enacted into law by the Iowa legislature in 1984. As of 1995, 5 PWA's totaling 533 river km (315 mi) have been designated, and purchase of adjacent land has taken place. Also, the USGS began data collection and analysis of Iowa rivers in the early 1990s as part of the National Water Quality Assessment program (NAWQUA).

Efforts have also been made to protect the Des Moines River and Cedar River greenbelts and also develop them for recreation, and

numerous projects have addressed qualities of both the Missouri and Mississippi Rivers. Examples include the Upper Mississippi River System Environmental Management Program, Upper Mississippi River Conservation Committee, Upper Mississippi River Basin Association, Missouri River Fish and Wildlife Mitigation Plan, and Back to the River (Ott 1995).

Following the 1993 Midwest floods, several projects were initiated to take floodplain land out of agricultural use. One of the largest projects was the Iowa River Corridor Project jointly sponsored by the Natural Resource Conservation Service (NRCS) and the USFWS. To date, 3,845 ha (9500 ac) have been purchased along the Iowa River between Tama and the Amana Colonies, and when combined with existing public lands, there is almost 12,140 ha (30,000 ac) of protected wildlife corridor along the Iowa River in this stretch (David DeGeus, pers comm). The same public agencies are acquiring additional floodplain lands surrounding rivers in Louisa, Lucas, Van Buren, and Polk Cos (Roger Link, pers comm).

Publicity on Iowa's diminishing natural heritage:

Soon after the 1980 symposium, the INHF published *Iowa's Natural Heritage* (Cooper 1982), a compilation of short, definitive pieces on Iowa's natural history authored by various experts, and the opening of Iowa Hall in 1985 at the Museum of Natural History at the University of Iowa presented some of this information in displays and dioramas (Schrimper 1992). Additionally, two natural history series were produced by Iowa Public Television entitled "The Land Between Two Rivers."

Since 1980, numerous books and papers have publicized Iowa's natural history. However, it is important to state that several also updated our knowledge of taxonomic groups and native habitats as well, and, therefore, the following works were important to Roosa's (1981) category of "An inventory of our natural history base" (above). Over 60 papers on Iowa organisms have been published since 1980 in either *The Journal of the Iowa Academy of Science (JIAS)* or its predecessor *The Proceedings of the Iowa Academy of Science (PIAS)*. There have been a number of additional publications on Iowa's biota (e.g. Madson 1982, Dinsmore et al. 1984, Van der Linden and Farrar 1984, Madson 1985, Harlan et al. 1987, Christiansen and Baily 1988, Mutel 1989, Christiansen and Baily 1990 and 1991, Lannoo et al. 1993, Laubach et al. 1994, Mutel and Swander 1994, Jackson et al. 1996, Kent and Dinsmore 1996). Proceedings of two Iowa Academy of Science (IAS) symposia, one on the Iowa Driftless Area and one on the Loess Hills were published in three issues of the *PIAS* in 1984, 1985, and 1986, and the proceedings of a 1990 IAS symposium on fens was partially published in *JIAS*. Furthermore, a symposium on the History of Iowa Natural History was published in *JIAS*, 1990, and this issue spawned subsequent articles on the contributions of additional Iowa scientists who studied nature. The Iowa Association of Naturalists (Conservation Education Center, Box 53, Guthrie Center, IA. 50115) has published a series of booklets on Iowa's biological communities, an effort that was partially funded by a REAP grant, and books in preparation include one on Iowa's amphibians and reptiles, another on the Order Lepidoptera, and a guide to Iowa's prairie plants.

Information on Iowa's geology and hydrology is often central to our understanding of specialized habitats (e.g. fens, algific talus slopes), and geological topics have been covered in a variety of formats, among them publications by Anderson (1983), Prior (1991), and over 10 papers published in either the *PIAS* or *JIAS* since 1980. Also, since 1976, the DNR has published an annual volume highlighting geological research, *Iowa Geology*.

Additional books have focused on conservation issues (Dinsmore 1994, Lannoo 1996), and private and governmental groups have cir-

culated newsletters, sponsored talks, and conducted workshops. The DNR's magazine, *Iowa Conservationist*, regularly publishes articles about conservation, and REAP has brought together a variety of organizations that, in turn, have distributed information about natural resources to their members. In addition, the Iowa Fen Project jointly supported by Iowa State University Extension and the U.S. Environmental Protection Agency, educated Iowans about the unique importance of fens in the state.

An example of the benefits of publicizing Iowa's natural heritage is the awareness that has developed about the Loess Hills. Multiple publicity and educational efforts (the Loess Hills Prairie Seminar, books by Mutel (1989), designation of the Loess hills as one of TNC's "Last Great Places," and efforts of county conservation boards and other groups) have transformed the Loess Hills into a focal point for conservation efforts and nature-focused "ecotourism" that serves as a model for the remainder of the state.

Monograph series on taxonomic groups:

This has not been developed, although several definitive papers, pamphlets, and books have been published as cited above. In fairness, monographs may have been an unrealistic goal, and, in a sense, progress has been made towards the overall goal of documenting Iowa's biodiversity.

An expanded non-game and endangered species program:

The non-game program of the DNR is now known as the Wildlife Diversity program and the endangered species program is the INAI. Although funding and staffing could be increased, as noted, both have been active in conservation efforts and data acquisition. As examples, the annual frog vocalization survey mobilizes volunteers throughout the state, and re-introductions of Peregrine Falcons (*Falco peregrinus*), Trumpeter Swans (*Cygnus buccinator*), River Otters (*Lutra canadensis*), and Greater Prairie Chickens (*Tympanuchus cupido*) have received public interest and support.

Roosa (1981) noted that "non-consumptive resource users need a method to lend financial support to programs of this type," and several initiatives currently address his concern. Since 1995, Iowans can purchase special natural resource license plates for which a portion of the money is allocated to the REAP account. As of March, 1998, 62,000 such plates had been purchased (Kevin Szcodronski, pers comm), but the program is too new to analyze long-term trends. While some may have purchased the plates for their attractive looks without consideration of supporting conservation efforts, the plates do provide a constant reminder to Iowans of the value of natural resources.

Iowans also have contributed to non-game programs through donations on their state income taxes, the Chickadee Check-Off. Donations, however, are decreasing (DNR, pers comm). Currently, the Teaming with Wildlife initiative is a movement to add an additional sales surcharge to recreational equipment that would help fund non-game programs.

A coalition of concerned environmental organizations:

Roosa (1981) envisioned a coalition that would speak with a unified voice regarding environmental issues, and progress has been made toward this goal. In 1989, a Conservation Leadership Summit was held that again identified the need for an environmental coalition, and from that meeting, the Iowa Wildlife Federation and the DNR produced the *Iowa Environmental Network Greenbook*, a directory of environmental groups (Joe Wilkinson, pers comm). However, a coalition with unified objectives did not materialize until December, 1994, when the Iowa Environmental Council (IEC) formed with rep-

resentation from a broad spectrum of environmental groups and leaders. Currently, the IEC gathers and synthesizes information regarding environmental problems to produce unified public policy statements.

Also, the REAP legislation has unified environmental groups around some common goals. Additionally, several new statewide environmental organizations have formed since 1980 that focus on a specific ecosystem or group of organisms, and examples include Trees Forever, the Iowa Prairie Network, the Iowa Lepidoptera Project, and the Iowa Native Plant Society.

POTENTIAL THREATS TO BIODIVERSITY

Progress has been made toward accomplishing Roosa's (1981) vision and preserving crucial habitats to protect Iowa's biodiversity. However, there can still be threats to organisms even when within a preserve. Potentially, fragmentation of habitats, habitat destruction, management practices, climatic instability, competition from introduced species, and competition/predation/parasitism from generalist species can all individually or synergistically negatively impact native plants and animals.

Iowa's remaining natural areas are isolated fragments of habitat surrounded by an altered landscape. While past and present efforts to acquire and preserve these islands of habitat are laudable, basic biogeographical theory predicts that small fragments cannot support the diversity of organisms compared with larger, contiguous habitats (e.g. Wilcox 1980, Spellerberg 1991, Hubbell 1995). While Simberloff and Abele (1984) cautioned that numerous, smaller preserves might protect more biodiversity in some cases, the predominant philosophy is to acquire as much land as possible into single, large preserves. This view is supported by the need for peripheral habitats to "buffer" critical habitat from surrounding disturbed lands.

However, as Schlicht and Orwig (1998) noted, movement between habitats is limited for many insects, and the same could also be said about most organisms excluding birds. Along with allowing gene flow, migration to a new habitat is crucial following a major disturbance as is recolonization of the disturbed natural area. Both are less likely than in pre-settlement times when natural habitats were contiguous.

However, Mangel and Tier (1992) noted that even large preserves are susceptible to sudden and disastrous loss of species. Disturbances could come from a variety of sources such as management practices (Herkert 1994b, Lannoo 1996, Phillips 1998, Schlicht and Orwig 1998), accidental pesticide application, manure spills, soil erosion (Cruden and Gode 1998), or climatic perturbations (see below). For example, in May, 1996, herbicide drift from a helicopter applicator damaged 1033 black walnut (*Juglans nigra*) trees in Kent County Park, Johnson Co, Rod Dunlap pers comm), and herbicide was mistakenly applied to Anderson Prairie State Preserve, Emmet Co, in 1985 (Daryl Howell pers comm).

Continued habitat destruction in Iowa also limits preservation of native species. While loss of prairie habitat historically has been linked to the spread of agriculture (Smith 1991 and 1998), most feel that land in crops has remained relatively stable in Iowa in the last few decades while urban areas are expanding (Greater Des Moines Chamber of Commerce Federation 1998). However, precise data on these trends are lacking because of the different methods that have been used to measure non-agricultural and city land throughout history. As municipalities expand through urban sprawl (Lockeretz 1989, Cooper 1997), they destroy or surround natural areas in what was once a rural area (e.g. Rock Island Botanical Preserve, Linn Co).

However, habitat destruction outside of Iowa also can limit preservation of some of Iowa's organisms. Neotropical migrant grassland birds, such as Dickcissels (*Spiza americana*), have been declining

across the Midwest and Great Plains (Herkert 1994a and 1995, Jackson et al. 1996). While preservation of prairies and programs such as the CRP provide nesting habitat for grassland birds, loss of habitat on Dickcissel wintering grounds hinder preservation efforts in Iowa and surrounding states (Basili and Temple 1995).

Basili and Temple (1995) also noted that Dickcissels were impacted by eradication programs on the bird's wintering grounds because granivorous birds are considered pests to crops. While thousands of these perceived "pest" birds are purposefully killed by pesticide application, chemicals also may indirectly kill migrants as evidenced by the recent discovery of 20,000 dead Swainson's Hawks (*Buteo swainsoni*) in Argentina. The hawks apparently fed on grasshoppers poisoned with monocrotophos, an insecticide banned in the US since 1988 (O'Neill 1997).

Despite these problems, habitat preservation is key to our conservation efforts, and our natural areas and preserves were established as protected reservoirs for native flora and fauna with the intent that these would provide relatively stable havens into the future. This relative stability could be threatened by yet one more potential environmental problem, global warming or the greenhouse effect (e.g. Graedel and Crutzen 1993). If predictions are valid, rising temperatures could be disastrous for temperature-sensitive areas like the alfic talus slopes of northeastern Iowa (Iowa's Driftless Area. A Symposium. 1983. Proceedings of the Iowa Academy of Science. 91: 1-46).

A correlate of global warming is climatic instability. Studies by Karl et al. (1995) and Carlson and Todey (1997) indicated a climate that may become increasingly variable, and how organisms will respond to future climatic extremes and variability is unknown (Peters and Darling 1985, Dobson et al. 1989, Peters and Lovejoy 1992, Gates 1995, Takle and Mearns 1995a and b, Webb 1995, Forseth 1996, Wing 1996). However, despite evidence from other studies, Carlson and Todey (1997) did not link their analysis to global warming, and some studies question the concept of variability (e.g. Takle and Zhong 1991) or whether a variable climate over time is not part of normal fluctuations (e.g. Vaughan et al 1987).

Even if anthropogenic climatic alteration is discounted, extreme localized weather events can damage isolated preserves. As examples, the Wisconsin DNR documented the following climatic disturbances to several of its natural areas (Thomas Meyer, pers comm): 1) In 1993, 33.02 cm (13 in) of rain fell in a 12 hour period in the Baraboo Hills of southcentral Wisconsin. The resulting flood waters moved through the narrow gorges of two state natural areas, Parfrey's Glen and Pewit's Nest. Damage included scouring of native vegetation and destruction of rustic bridges and boardwalks. 2) In 1991, Platte Woods State Natural Area was damaged by a tornado which destroyed about 20% of the canopy trees. 3) In 1977, a huge downburst with extreme straight-line winds leveled 149.7 ha (370 ac) of old-growth forest in the Flambeau River Hardwood Forest Natural Area. The same storm toppled most of the trees in the 60.7 ha (150 ac) Lake of the Pines Conifer Hardwoods State Natural Area, and succession in both of these natural areas has since changed the forest composition. While such disturbances are to be expected (Connell 1978), localized perturbations to small, isolated preserves could hinder our preservation efforts if the original community is altered to the point where recovery is limited.

Competition with other organisms can also pose a threat to native species preservation and the maintenance of biodiversity. Much of this impact comes from introduced species. Phillips (1998) and Pitlo (1998) noted impact of Eurasian watermilfoil (*Myriophyllum spicatum*) and purple loosestrife (*Lythrum salicaria*) in aquatic systems. Other highly competitive introduced species include zebra mussels (*Dreissena polymorpha*), garlic mustard (*Alliaria petiolata*), bullfrogs (*Rana catesbeiana*), European starlings (*Sturnus vulgaris*), and carp (*Cyprinus*

carpio), and many more introduced plants and animals exist in the state. As documented by numerous studies, introduced species tend to aggressively outcompete native plants and animals, eventually dominating a community. Species introductions can also bring new diseases to an area, and this can be devastating as exemplified by the impacts of Dutch elm disease on American elm (*Ulmus americana*) trees and the chestnut blight on the American chestnut (*Castanea dentata*).

Often non-native species are first introduced to a natural area around the borders or in areas of disturbance (Christiansen 1992, Nuzzo 1991), a problem exacerbated by fragmentation of habitats and the resulting increase in the amount of edge. Typically, forests are fragmented as roads and houses are built in what was once a large woodland, however, prairies and other habitats are also susceptible to this edge effect (Christiansen 1992).

Even native species can reduce biodiversity. For birds, as habitats become more fragmented and disturbed, generalist species that are native, year-round residents tend to replace the area-sensitive specialists, most of which are neotropical migrants (Terborgh 1989). Brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) and nest predation are greatest around the edge of habitats (Johnson and Temple 1990, Robinson et al. 1995, Marini et al. 1996), and Brown-headed Cowbirds have been increasing, as have other generalists, in Iowa (Peterjohn 1991, Jackson et al. 1996). In another example, Jungst et al. (1998) noted the negative impacts of white-tailed deer (*Odocoileus virginianus*) herds on tree seedlings, songbirds, and wildflowers.

OUTLOOK FOR THE FUTURE

Given the diverse and numerous potential threats to organisms and ecosystems, it is easy to be pessimistic about the future of Iowa's biodiversity. While it is reassuring to note that progress has been made toward satisfying some of Roosa's (1981) "future challenges," many still exist today. Acquisition of natural habitats and buffers for existing preserves is still a priority; increased research is needed to better define many taxonomic groups, especially the microorganisms; the issues of land use and property rights are contentious; increased funding and personnel need to be directed toward researching, surveying, and documenting our natural history; many rivers and streams remain unprotected and without management plans; more people need to embrace conservation as an important issue and to view our natural resources as essential to life and worthy of protection; and environmental issues should be a central component in decision making. The threats of urban sprawl, introduced species, habitat destruction and fragmentation both here and abroad, international cooperation with conservation efforts, and the increase in both density of generalist species as well as number of individuals within generalist species can be added to our list of present-day concerns, along with the uncertainty of climatic fluctuations.

Can the downward trends in the abundance and diversity of our native species cited by the authors be reversed? The work of restoration ecologists gives hope that some of the damage to natural areas can be partially reversed. However, merely planting a prairie or flooding a once existent wetland does not replenish a once diverse ecosystem that included everything from microorganisms to large vertebrates. As an example, research has shown that while restored wetlands tended to attract waterfowl, the associated upland bird community was less diverse than that of existing wetlands because of the lack of surrounding natural vegetation (VanRees-Siewart and Dinsmore 1996).

It is unrealistic to assume that we can recreate the total diversity that once proliferated in Iowa; however, natural areas, communities, and organisms remain that are worthy of preservation. A most en-

couraging prospect for preservation comes from the interest and knowledge demonstrated at this symposium. While much attention has been correctly directed toward preservation in the tropics and specialized North American ecosystems, it is important that each state become actively involved in documenting and preserving biodiversity. Although Iowa's scientific community has demonstrated continued interest, expertise, and concern, it is clear that public policy and attitudes must radically change if we are to protect Iowa's remaining natural resources.

ACKNOWLEDGEMENTS

I thank the many people who assisted me in data collection including: L. Applegate, J. Bowles, R. Dunlap, D. DeGeus, K. Faux, D. Howell, R. Link, T. Meyers, J. Pease, L. Scarth, J. Selby, M. Suhr, K. Swanson, K. Szcodronski, and J. Wilkinson. Also, Sr. P. Fox, J. Grove, D. Howell, K. Lang, C. Mutel, J. Pearson, T. Rosburg, and M. J. Stanton provided helpful criticisms of the paper. Finally, I thank the authors who contributed to the symposium and made time to publish their presentations, the INHA for providing partial publication costs of the symposium, and Connie Mutel, who cheerfully assisted in all aspects of the symposium.

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