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John A. Pearson
Iowa Department of Natural Resources

Mark J. Leoschke
Iowa Department of Natural Resources

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Floristic Composition and Conservation Status of Fens in Iowa[a]

JOHN A. PEARSON and MARK J. LEOSCHKE[b]

Preserves and Ecological Services Bureau, Iowa Department of Natural Resources, Des Moines, Iowa 50319

Over 200 extant fens of varying condition were documented during an extensive inventory conducted in Iowa between 1986 and 1991. Approximately half of the extant fens support endangered, threatened, special concern, or other rare plant species. Approximately 25 fens are outstanding conservation prospects with intact vegetation, high species richness, and rare species. Nearly 40% of all potential fen sites have been destroyed by cultivation or drainage; another 30% remain unknown due to lack of a field visit, but most appear on aerial photographs to be very small, disturbed fragments. In addition to their traditionally recognized range in northwest Iowa, fens were found to be numerous and widespread in eastern Iowa. Most (95%) of the extant fens occurred on privare lands; these were variously affected by grazing (65%), cropfield edge effects (33%), potential expansion of woody plants (20%), drainage by tile lines or ditches (10%), excavation for ponds (2%), and mining of nearby sand and gravel deposits (2%).

Over 225 species of vascular plants were identified on fens statewide during this inventory, of which 134 taxa occurred on at least five sites. *Carex stricta* was the most common graminoid among sites and was usually dominant within fens; other common species included *Eupatorium maculatum, E. perfoliatum, Pycnanthemum virginianum, Aster umbellatus, A. puniceus, Helianthus grosseserratus, Asclepias incarnata, Lobelia siphilitica, Pedicularis lanceolata*, and *Helenium autumnale*. A large number of cosmopolitan species were shared between traditionally recognized fens in northwest Iowa and newly recognized fens (formerly called "hanging bogs") in eastern Iowa. Eastern fens are distinguished by the presence or greater prevalance of *Chelone glabra, Heuchera richardsonii, Lythrum alatum, Onoclea sensibilis, Oxypolis rigidior, Salix candida, Saxifraga pensylvanica, Spiraea alba, Solidago riddellii*, and *Thelypteris palustris*: western fens are distinguished by the presence or greater prevalance of *Berula erecta, Lobelia kalmii*, and *Scirpus americanus*. Zonation of vegetation is common in western fens, but uncommon in eastern fens.

INDEX DESCRIPTORS: fens, floristics, plant community, vegetarion, conservation

Fens are small, boggy, spring-fed wetlands which often harbor rare plant species. In Iowa, the flora or vegetation of specific fens has been described in detail by Anderson (1943), Holte and Thorne (1962), Eickstaedt (1964), Holte (1966), van der Valk (1975), and Nekola and Lammers (1989). Early regional studies described the flora of "bogs" (many of which can be retrospectively classified as fens) in northwest and north-central Iowa (Pammel 1909, Wolden 1926). Other regional studies by Shimek (1915) and Hayden (1943) focused on northwest Iowa and were broad-based botanical studies which treated fens briefly and incidentally. Hence, to date, there has been no published description of the floristic composition and variation of Iowa fens from a statewide perspective; in fact, only two sites in northwest Iowa — Silver Lake Fen and the Excelsior Fen complex, both in Dickinson County — figure prominently in most of the above studies.

Despite a popular sense that fens are rare and valuable remnants of Iowa's natural heritage (Moats 1981, Cooper 1982, Howe et al. 1983, Leoschke and Pearson 1988), no previous statewide inventory has been conducted to determine the number, condition, and degree of protection — in short, the conservation status — of remaining sites. There have been some regional inventories conducted with the purpose of identifying fens for conservation, paralleling efforts for prairies by Hayden (1946), White (1981), and Schennum (1986). During a general inventory for natural areas in Black Hawk County conducted in 1980-82, Duritsa (1983) discovered two fens which she broadly classified as "wet prairie". She noted the usefulness of mapped units of Palms muck (the organic soil series underlying three known sites) for future inventory by listing several sites that remained unvisited at the conclusion of her study; follow-up visits to these sites by botanist Scott Zager in 1986 resulted in the discovery of additional fens. As part of a 1983 inventory targeted specifically at fens in Emmet and Dickinson counties, Laushman and Huston (1984) utilized county soil surveys (specifically noting symbols for seeps and wet spots) and aerial photographs to identify potential fens, screened candidate areas with a low-level airplane flight, and visited selected sites, but no new fens were discovered. They also described fens discovered earlier by Bob Moats, a conservation officer with the Iowa Department of Natural Resources based in Emmet County. In 1984, Schennum (1984, 1986) encountered several fens while surveying prairie remnants identified from aerial photographs. Schennum (1984) also found fens while investigating wetlands enrolled in the "Slough Bill" tax-relief program (Iowa Code 427.1(36)) and described fens found earlier by Bob Moats. Beginning about 1984, Jeff Nekola utilized county soil maps to identify potential fens on units of organic soil, resulting in the discovery of numerous fens, especially in eastern Iowa (Nekola 1984-86, Nekola 1988, Nekola and Lammers (1989); additionally he, too, described fens discovered earlier by Bob Moats (Nekola 1984-86).

There are two general and sometimes conflicting definitions of fens in ecological literature, one based on water chemistry and the other based on the origin of the water. Although both definitions agree that fens are characterized by a combination of organic soils and a saturated (wet but not flooded) water regime, the term "fen" has been traditionally restricted in application by most authors in Iowa to wetlands in the northwest part of the state (specifically the "Lakes District" of Dickinson and Emmet counties) with calcareous or alkaline water. For example, in his study of the Excelsior Fens in northwest Iowa, Holte (1966) stated that "alkaline peat is a major feature in differentiating a fen from a bog, which by definition is underlain by acid peat....certain calcicolous plants are peculiar to a fen habitat". The emphasis on an alkaline habitat was also reflected in his list of "calcicolous" plants, including several rare plants of wet, calcareous habitats. The *de facto* definition of a fen as a calcareous or alkaline wetland has also been used elsewhere in the Midwest (e.g., Curtis 1959, Reed 1985, Orzell and Kurz 1986, Eggers and Reed 1987).

The other major definition of a fen, commonly used in international ecological literature, is based on the minerotrophic origin of water in the wetland, that is, from seepage through adjacent mineral substrates (Moore and Bellamy 1974, Gore 1983, Crum and Planisek 1988). Under this broad definition, water in fens can be alkaline, circumneutral, or even acidic depending on the nature of the surrounding or underlying substrate. (A companion definition distinguishes bogs as wetlands whose sole source of water is precipitation, i.e., an ombrotrophic origin.) Because all of the fens in northwest Iowa studied by previous authors arise from seepage, they would be classified as true fens (specifically as "rich" fens, denoting their high nutrient level) under this definition. Significantly, however, this definition includes

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[b]Present address: SEC Donohue Inc., 7200 Hemlock Lane North, Suite 300, Maple Grove, Minnesota 55369

sites with non-alkaline water which would not satisfy the other definition. In Iowa, wetlands of this nature are known primarily from the eastern part of the state and were previously classified as "hanging bogs" by Lammers and van der Valk (1978). They described hanging bogs as "geologically similar to the fens of northwestern Iowa....Like fens, they are usually situated part way up a slope, where ground water seeps out of the hillside. The soil reaction of a hanging bog is not nearly so alkaline as that of a fen; it is often neutral to slightly acidic." In the first detailed study of the flora of this type of wetland in Iowa, Nekola and Lammers (1989) described a relatively undisturbed remnant (the Brayton-Horsley site) and termed it a "spring fen".

In this study, we adopted the definition of a fen as any seepage-based wetland with organic soil, but restricted our scope of concern to sites dominated by herbaceous vegetation, thereby excluding "forested fens" (sensu Nelson 1985) exemplified in Iowa by the Hanging Bog State Preserve (Glenn-Lewin 1981a) and by calcareous seeps in Dolliver State Park (Johnson-Groh et al. 1987). Our objectives for conducting this study were: 1) to determine the number, distribution, and condition of fens in Iowa, with special concern for identifying sites with outstanding botanical value and 2) to describe the vegetation of Iowa fens, noting the species composition of plant communities and describing possible differences between the traditionally recognized fens of northwest Iowa and the newly recognized fens of eastern Iowa (prompted in part by Lammers and van der Valk's (1978) comment that their vegetation is quite different). A third objective, to document the distribution of rare vascular plant species in fens, will be treated in a separate paper (Leoschke and Pearson, in preparation).

STUDY AREA AND METHODS

We conducted our inventory in 38 counties, spanning five landform regions (specifically the Des Moines Lobe, Iowan Surface, Northwest Plains, Paleozoic Plateau, and Southern Drift Plain sensu Prior 1991) (Figure 1). We chose these counties because they met at least one of the two following criteria: 1) modern soil surveys indicated that suitable organic soils were present or 2) local leads alerted us to the presence of fens or fen-like areas. We used soil surveys because some organic soils develop on seepage sites (Buol et al. 1973) and it would therefore be logical to expect that fens (as seepy, organic wetlands) might be depicted on soil maps. In this regard, we were encouraged by earlier successes in identifying fens with county soil surveys by Duritsa (1983) and especially by the efforts of Nekola (1984-86, 1988). In 23 counties, the soil survey was our primary source of potential inventory sites. Local leads (obtained from naturalists, herbarium specimen labels, and historical documents) were our primary source for 15 others, particularly those in which no modern soil survey was available or in which the existing survey did not depict organic soils. (The paradox of fens existing in a county with no organic soils reflects a mapping convention of the USDA Soil Conservation Service to recognize only

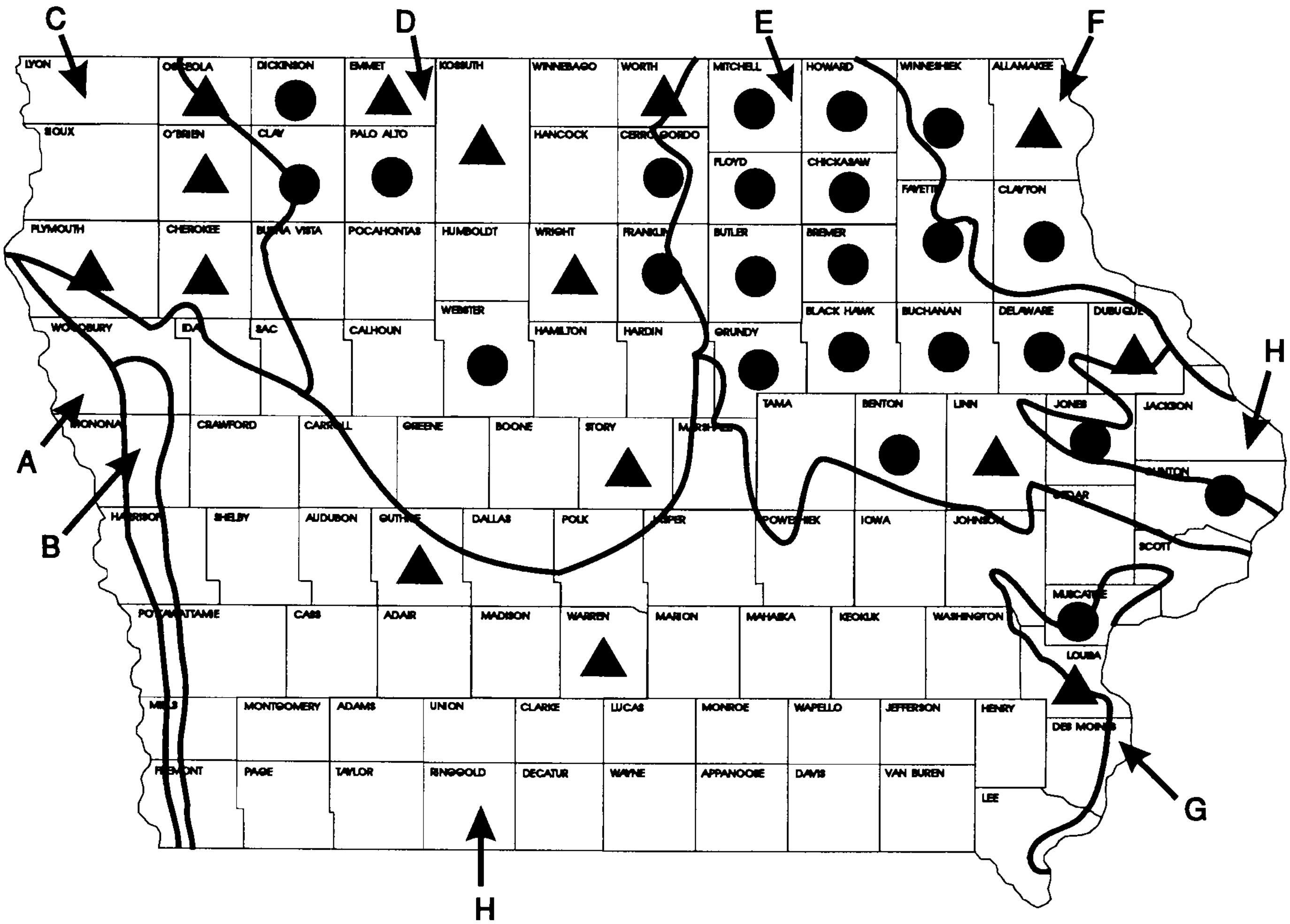

Fig. 1. Counties which were inventoried for fens by using soil maps (circles) and by following local leads (triangles).1 Landform regions adapted from Prior (1991): A, Missouri Alluvial Plain; B, Loess Hills; C, Northwest Plains; D, Des Moines Lobe; E, Iowan Surface; F, Paleozoic Plateau; G, Mississippi Alluvial Plain; H, Southern Drift Plain.

soil series which comprise a significant portion of the total land area in a county [Kermit Voy, personal communication]; fens in the affected counties were in fact small, isolated sites.)

Our procedure for using soil surveys to identify potential fens consisted of 1) identifying suitable organic soil sites with the use of soil maps and aerial photographs and 2) inspecting extant sites with field visits. Modern (post-1965) county soil surveys published by the USDA Soil Conservation Service provide detailed maps (1:15840 scale) of soils in most of the 99 counties in Iowa. Organic soils (histosols) have been mapped in 36 counties. We used county soil surveys to identify areas of histosols which were suitable sites for fens. "Suitable" histosols were defined as those mapped in locations other than basins occupied by former lakes or by contemporary pothole marshes. Basins were rejected because they are subject to flooding and ponding and not merely saturation; moreover, surficial seeps and springs (features which are often found in fens) are generally absent or poorly developed. Lakebeds and potholes could be recognized on soil map sheets by their large size, flat topography, or occurrence in closed basins. Based on our perusal of all available, modern soil surveys, it was evident that histosols in some counties (especially those located in the central portion of the Des Moines Lobe landform region) occurred predominantly or entirely in closed basins. Counties rejected from the soil survey-based part of our inventory for this reason included Boone, Cedar, Hamilton, Hancock, Hardin, Johnson, Kossuth, Sac, Story, Winnebago, and Worth, thereby narrowing our potential inventory by this approach to 25 counties. We did not initiate soil-based inventories of Emmet or Linn counties because they had already been examined by Bob Moats (personal communication; Schennum 1984) and Nekola (1984-86), respectively. Hence, we ultimately conducted inventories based on soil maps in 23 counties (Table 1).

Table 1. Source of county soil maps used in fen inventory.

County	*Source*
Benton	Brown and Highland 1980
Black Hawk	Fouts and Highland 1978
Bremer	Buckner 1967
Buchanan	Fouts and Wisner 1982
Butler	Buckner 1982
Cerro Gordo	DeWitt 1981
Chickasaw	advance soil map sheets
Clay	Fisher 1969
Clayton	Kuehl 1982
Clinton	Boeckman and Sabata 1981
Delaware	Wisner 1986
Dickinson	Dankert 1983
Fayette	Kuehl and Highland 1978
Floyd	advance soil map sheets
Franklin	Voy 1980
Grundy	Andrews 1977
Howard	Buckner and Highland 1974
Jones	advance soil map sheets
Mitchell	Voy and Highland 1975
Muscatine	advance soil map sheets
Palo Alto	Jones 1977
Webster	Koppen 1975
Winneshiek	Kittleson and Dideriksen 1968

Two formally named series of histosols were commonly represented in most of the county soil surveys used in this study: Palms muck and Houghton muck. Alternatively, some county soil surveys used prosaic names such as "muck" or "peaty muck", often prefaced with adjectives such as "deep" or "shallow". Palms muck was the most frequently encountered series; it is described by the Soil Conservation Service (citations in Table 1) as a loamy, mixed, euic, mesic Terric Medisaprist consisting of shallow muck with mineral substrate within 100 cm of the surface. Houghton muck was encountered less frequently; it is a euic, mesic Typic Medisaprist consisting entirely of deep muck (at least 150 cm in depth). Caution about the identity of hisotosol map units is advised because several areas mapped as Palms muck have, upon closer examination, been identified as Houghton muck (Kermit Voy, Richard Baker, Art Bettis; personal communication).

In addition to regular soil map units, "spot symbols" were very useful for identifying potential fens on county soil maps. Spot symbols denoted areas of soil less than 2 acres (0.8 hectare) in size. A wide variety of symbols were used among the county soil surveys in Table 1 to depict spots of organic soil, which were also variously named "muck", "peaty muck", "mucky seepy land", "conical mounds of peat or muck", or similar terms; we referred to them collectively as "muck spots". Muck spots were especially useful for our inventory in western Iowa, even more predictive of potential fens than regular soil map units in this region.

For the counties chosen for inventory, we visually scanned the soil survey maps and highlighted occurrences of potential fens (non-basin histosol units and muck spots) on the map sheets with a colored pencil. The location of each potential fen was recorded by section (square mile) within a township. We sketched a template representing the location and scaled image of the potential fens (which had earlier been highlighted on the soil maps) onto recent (1979) black-and-white aerial photographs (1:7920 scale, obtained from the Agricultural Stabilization and Conservation Service [ASCS]). Each potential fen was then interpreted to be either "extant" or "destroyed". A site was classified as destroyed if no trace of natural vegetation could be seen within the template. Conversely, if any trace of natural vegetation remained within the template, it was classified as extant. Natural vegetation was usually easily recognized on the photographs as dark, grainy, irregularly shaped patches contrasting sharply with white (cropland) or gray (pasture), rectangular agricultural land. Because our inventory occurred between 1986 and 1991, the photographs represented conditions 7-11 years in the past and, on infrequent occasions, caused us to identify a potential fen as extant when it was in fact destroyed, resulting in a field visit to an unrewarding site; their correct status noted at that time.

Our ideal goal was to visit all extant sites, but logistical constraints forced us to prioritize our effort. Accordingly, extant sites were classified as 1) high-priority, representing sites which appeared to be relatively "whole" or intact (i.e., natural vegetation appeared to fill the template) and 2) low-priority, representing relatively tiny fragments (typically a narrow, linear "sliver" along a ditch in a fen which was mostly destroyed). In many counties, we were able to visit most extant sites, but in others only high-priority sites were visited. We conducted site visits only after obtaining the permission of landowners.

Upon our arrival in the field, a potential fen was quickly inspected and classified as a herbaceous fen, as an "other" kind of wetland, or destroyed. Herbaceous fens were plant communities whose vegetation was dominated by grasses, sedges, and forbs; moreover, we sought some confirming evidence (obvious or subtle) of surficial features of groundwater discharge such as seeps, springs, or a quaking substrate. Other wetlands included forested fens and other natural vegetation which lacked any evident association with surficial discharge features. Sites which had been recently (i.e., since 1979) drained or cultivated were updated as "destroyed". After classifying the site in the field, we spent no additional time on forested fens, non-fens, or destroyed sites. On herbaceous fens, however, we usually spent an additional 1-2 hours compiling a plant species list and noting land use surrounding the fen. A significant limitation on our ability to compile a truly comprehensive species list was our relatively short tenure on a site coupled with the fact that we generally visited most sites only once. This undoubtedly resulted in recording only a subset of the actual number of species present in a fen due to overlooking of species which were inconspicuous by virtue of their growth habit or seasonality. We acknowledge that our floristic composition data are therefore conservative and account mainly for conspicuous species and locally abundant species. A strength of our approach, however, is that unlike previous studies which intensively catalogued the flora of single sites (Eickstaedt 1964, Holte 1966, Nekola and Lammers 1989), it provides the first extensive view of fen plant communities in the state.

Taxonomy follows Eilers and Roosa (in preparation), which in turn is based on Kartesz and Kartesz (1980).

RESULTS AND DISCUSSION

Conservation Status of Fens

Over 1000 potential fens were evaluated during the inventory (Table 2). Based on interpretation of aerial photographs or field visits, nearly 40% (394) were determined to have been completely destroyed. Another 30% (319) technically remain "unknown" because we were unable to visit them in the field; however, most of these were classified as low-priority sites because they appeared on aerial photographs to be tiny fragments in sites which had been incompletely destroyed (typically "slivers" persisting on the edges of narrow drainageways in cropfields). Of the 331 potential fens that were extant and visited, 119 turned out to be non-target, "other" wetlands (forested fens, sedge meadows, and wet prairies), but over 200 extant herbaceous fens were encountered (Table 2). This statistic must be tempered with our determination that only about half of the extant fens had significant botanical value (i.e., they contained at least one Endangered, Threatened, or Special Concern plant species [Roosa et al. 1986, 1989]). In

Table 2. Results of fen inventory by county. Fens divided into three groups: OUT, outstanding sites with intact vegetation, high species richness, and at least one rare plant species; SIG, botanically significant sites with at least one rare species (i.e., Endangered, Threatened, or Special Concern: Roosa et al. 1989); ALL, total of all extant fens. OTHER includes extant forested fens and non-fen wetlands. UNKNOWN contains all unvisited sites. DESTROYED sites are cultivated or completely drained. TOTAL is sum of all extant fens, other wetlands, unknown sites, and destroyed sites. Dash (-) indicates no observation.

	FENS						
COUNTY	OUT	SIG	ALL	OTHER	UNKNOWN	DESTROYED	TOTAL
Allamakee	1	1	1	-	-	-	1
Benton	-	1	3	-	-	-	3
Black Hawk	1	6	9	0	5	3	17
Bremer	1	5	15	5	1	35	56
Buchanan	2	5	15	12	8	50	85
Butler	2	6	23	6	13	36	78
Cerro Gordo	4	8	11	8	20	4	43
Cherokee	-	2	4	1	-	-	5
Chickasaw	3	9	19	8	27	23	77
Clay	3	6	9	3	1	3	16
Clayton	-	2	2	0	5	5	12
Clinton	-	3	3	2	2	41	48
Delaware	-	3	6	0	5	16	27
Dickinson	4	11	22	22	6	11	61
Dubuque	-	-	1	-	-	-	1
Emmet	1	6	9	0	6	2	17
Fayette	1	9	11	5	57	35	108
Floyd	1	3	3	4	2	8	17
Franklin	-	2	2	-	-	-	2
Grundy	1	2	3	0	18	16	37
Guthrie	-	-	1	-	2	-	3
Howard	1	3	16	10	36	54	116
Jones	-	-	1	3	2	3	9
Kossuth	-	-	1	-	-	-	1
Linn	-	3	3	4	65	16	88
Louisa	-	-	1	-	-	-	1
Mitchell	-	3	5	6	20	24	55
Muscatine	-	-	1	8	1	1	11
O'Brien	-	-	1	-	-	-	1
Osceola	-	1	1	-	-	-	1
Palo Alto	-	-	0	0	0	3	3
Plymouth	-	-	1	-	-	-	1
Story	-	-	1	1	-	-	2
Warren	-	-	1	-	-	-	1
Webster	-	-	1	2	2	2	7
Winneshiek	-	1	4	9	15	3	31
Worth	-	1	1	-	-	-	1
Wright	-	-	1	-	-	-	1
SUM	26	102	212	119	319	394	1044

turn, only about 25 of these were truly outstanding (i.e., they were intact sites with a high species richness) (Table 2). Nonetheless, the existence of over 100 botanically significant fens greatly revises the impression of extreme rarity promoted by the familiarity of most Iowa naturalists with only three sites (namely Silver Lake Fen, Excelsior Fens, and Brayton-Horsley Fen).

Eight counties contained more than ten extant fens each (Table 2). Most of them (Bremer, Buchanan, Butler, Chickasaw, Fayette, and Howard) were located in the northeastern quarter of the state in the Iowan Surface landform region (sensu Prior 1991). Only one of them (Dickinson County) was located in the "Lakes Region" of Iowa in the Des Moines Lobe landform region, where true fens were traditionally perceived to occur (Lammers and van der Valk 1978). The remaining county (Cerro Gordo) straddled the boundary between the Iowan Surface and Des Moines Lobe landform regions. It would appear, therefore, that the "hanging bog" type of fen (sensu Lammers and van der Valk 1978) is more numerous and more widely distributed than the fens traditionally recognized in northwest Iowa. A similar pattern was observed even when only botanically significant or outstanding fens were considered (Table 2).

Over 95% of the extant fens were privately owned. Seven botanically significant fens have been formally protected by conservation agencies through fee acquisition or conservation easement. Brief individual descriptions of the protected sites appear in Appendix 1. Several land uses collectively affected the existence and condition of fens, including grazing, cultivation of adjacent cropfields, drainage, excavation for ponds, and mining for sand and gravel. Additionally, we noted in many fens that expansion of woody vegetation was a potential threat to herbaceous plant communities. Although we did not study these factors in a controlled manner, we repeatedly observed their effects during the field phase of our inventory and have provided the following qualitative accounts.

Grazing. Grazing was the single most common land use encountered during our inventory, with at least 65% of the remaining fens located in pastures. This statistic may be an underestimate because some areas which were idle during our inventory had been pastures previously and might be grazed again in the future. Grazing appeared to affect fens in two general ways: 1) by modifying the vegetational structure of the plant community through selective utilization of plant species and 2) by altering the physical structure of the wetland by trampling.

Selective grazing of palatable grasses and forbs appeared to increase the relative abundance of *Carex stricta* and *Helianthus grosseserratus*, both of which possess coarse, scabrous foliage probably of low palatability to cattle. We also noted that other composites (particularly *Aster umbellatus*, *Eupatorium maculatum*, and *E. perfoliatum*) were abundant on grazed fens. At the Excelsior Fen complex, Holte (1966) attributed the presence of *Asclepias syriaca*, *Achillea millefolium*, *Ambrosia artemisiifolia*, *Hordeum jubatum*, *Setaria viridis*, *Verbena hastata*, and other ruderal species to intensive cattle grazing. In fens of northeastern Illinois, Moran (1981) noted that *Aster puniceus* and *Solidago gigantea* were especially frequent in grazed areas.

We noted that heavily grazed fens were extremely hummocky, often exhibiting pedestals crowned by coarse sedges and surrounded by trenches (up to 1 m deep in extreme cases). Hummocky terrain in grazed fens was also noted by Moran (1981) in Illinois. We interpret this as the result of differential compaction of soil occupied and protected by coarse sedges and soil between sedges. Although the dominant sedge in most Iowa fens (*Carex stricta*) naturally forms tussocks, grazing appears to accentuate the hummocky aspect of fens greatly. Once established, the extremely hummocky terrain of grazed fens evidently persists for many years even when cattle are removed. In parts of the Brayton-Horsley Fen, for example, pronounced pedestals were still evident approximately 35 years after the cessation of grazing. Similarly, we observed pedestals in the Cedar Hills Sand Prairie fen, where grazing had been absent for about 25 years, but also noted that some pedestals were collapsing as the crowning sedges died.

Cropfield edge effects. Approximately 33% of the extant fens were associated with cropfields and variously exhibited problems associated with field "edge effects" including runoff, weed infestation, and herbicide drift. We typically observed that tall ruderal species such as *Ambrosia trifida*, *Urtica dioica*, *Lactuca canadensis*, *Asclepias syriaca*, *Oenothera biennis*, and *Pastinaca sativa* had invaded the disturbed cropfield-fen edge; this circumstance may facilitate a stereotypic view among landowners of fens as "weed patches". In contrast, an extreme example of possible herbicide drift was provided by a small fen within 10 m of the edge of a cornfield in Dickinson County: it contained a typical suite of monocot species, but only a single dicot species, a circumstance which we interpreted as the result of drift onto the fen of broad-leaf herbicide applied to the cornfield.

Drainage. Drainage (with subsequent cultivation for crops) was presumably a factor in the demise of many of the destroyed fens encountered in our inventory. Drainage by ditching was noted by Moran (1981) as a source of disturbance in fens of northeastern Illinois. In Iowa, we encountered both ditches and buried tile lines as drainage techniques. Drainage affected at least 10% of the remaining fens; this statistic may be an underestimate because evidence of buried lines is often difficult to detect visually. By rapidly conducting water away from the fen, ditches and drain tiles effectively lower the local water table. Depending on the depth of the water table drop, a fen responds to drainage by first shrinking in size, secondly by changes in water chemistry, or ultimately by desiccation and mineralization of organic matter (van Diggelen et al. 1991). In the soil survey for Fayette County, Kuehl and Highland (1978) noted that Palms muck soils "settle considerably after they are drained", probably reflecting the actions of dehydration and oxidation of organic matter.

Although row crops can be cultivated on drained histosols, the USDA Soil Conservation Service (citations in Table 1) warns that drainage of certain muck soils in Iowa often requires special equipment and may be difficult to achieve. In deep or strongly flowing fens, attempts at drainage may fail completely and be fiscally disastrous for the farmer. The owner of a 4-hectare (10-acre) fen, for example, informed us that he had spent $10,000 to install drainage tiles to no avail because it was discovered (after the fact) that subsurface flow of spring water was much stronger than expected and that organic matter quickly clogged the lines. Moreover, even a large, powerful tractor became deeply mired while preparing the site. During our inventory, we also observed other instances of "doubly ruinous" drainage attempts which disturbed the natural vegetation of fens and also failed to grow crops.

Excavation for ponds. We encountered several potential fens in which natural vegetation had been eliminated by excavation for ponds. About 2% of the fens existed as remnants around the periphery of incompletely excavated units of organic soil. The ponds had been excavated by landowners for a variety of purposes, including the watering of livestock, creation of wildlife habitat (particularly for waterfowl), and as a fishery (notably for trout [*Salmo* spp.]). Certain muck soils in Iowa are attractive sites for ponds because excavations fill rapidly with water from seepage (see soil survey citations in Table 1). Excavation of ponds in fen-supporting histosols obviously destroys or reduces the size of fens. From a fen preservation perspective, excavation of ponds is thus a potential threat to remaining sites.

Mining. Approximately 2% of the remaining fens were located on land owned by mining companies or adjacent to quarries mined for sand or gravel. In most cases, these fens had not been directly disturbed by mining activities. One had been deliberately set aside by the Estherville Sand and Gravel Company, a conservation effort that was heralded in an industry trade magazine (Anonymous 1989). In the absence of deliberate conservation, however, mining could conceivably impact fens by 1) direct destruction through excavation or earthmoving or 2) indirect destruction via disruption of the surrounding hydrological system. With regard to the latter point, critical distances and depths for avoiding risk to fens from adjacent mining operations are not known. A complicating factor is that fens in Iowa exist in a variety of geological settings (Thompson et al. 1992).

Woody plant expansion. We noted that woody plant expansion was a potential management problem in 20% of the remaining fens due to the presence of an established tall shrub or tree cover. In these sites, further growth of a woody canopy could conceivably cast shade onto a significant portion of the fen and potentially degrade the light regime for shade-intolerant plants. Woody plant expansion is widely recognized as a threat to prairie communities (e.g., Curtis 1959, Mutel 1989, McClain and Anderson 1990) and the same concern can be projected onto fens. We commonly observed woody plant cover in fens (especially in eastern Iowa) that far exceeded the cover in Silver Lake Fen that aroused the concern of Carroll et al. (1984). The most common stand-forming woody species in our inventory were *Ulmus rubra, Cornus amomum,* and tall *Salix* spp. (especially *S. bebbii* and *S. discolor*) (Table 3). In several fens in Indiana, McGrath (1988) documented a recent (post-1940), progressive increase in shade cover from invading shrubs, especially *Cornus amomum* and *C. racemosa.* Shrub invasion of fens has also been reported in Ohio (Smith 1988), Illinois (Wilhelm 1978, Moran 1981, Schennum 1983, Stoynoff and Hess 1986), and Wisconsin (Lovely 1983, Warners 1989, Carpenter 1990a).

Recommendations have been made for the control of woody plant expansion in fens and similar communities by prescribed burning (Wilhelm 1978, Kohring 1982, Schennum 1983, McGrath 1988, Skinner 1988, Warners 1989, Rooney 1990, Carpenter 1990a) and cutting (Armstrong 1982, Lovely 1983, Smith 1988). Some studies have shown that burning does not necessarily reduce shrub cover (Reuter 1986) while others have indicated that it has complex effects which appear to be dependent in part on the degree to which a fen has been altered hydrologically (Kohring 1982, Warners 1989, Carpenter 1990a). Fens in Iowa which have been burned for management purposes include Rowley Fen, Brayton-Horsley Fen, and the Cedar Hills Sand Prairie fen. Research on the effects of fire on woody plants (and potentially sensitive groups such as rare plants, mosses, and invertebrates) in fens is needed.

Floristic Composition of Fens

Over 225 species of vascular plants were detected on fens during our inventory. Of these, 134 occurred in at least five out of a statewide sample of 99 fens (Table 3). *Carex stricta* and *Eupatorium maculatum* were the most commonly encountered graminoid and forb species, respectively, among fens and were also locally abundant in most fens; in fact, *Carex stricta* was typically dominant. Other commonly encountered (>50% presence) herbaceous species were *Scirpus acutus, Calamagrostis canadensis, Pycnanthemum virginianum, Aster puniceus, A. umbellatus, Eupatorium perfoliatum, Helianthus grosseserratus, Asclepias incarnata, Lobelia siphilitica, Pedicularis lanceolata, Viola nephrophylla,* and *Helenium autumnale; Solidago* spp. (particularly *S. canadensis* and *S. gigantea*) commonly occurred on disturbed sites. The only common woody species were *Salix* spp. (especially *S. bebbii* and *S. discolor*). In addition to being common among fens, all of these species are common in Iowa as a whole and are widely distributed among other types of wetlands (Lammers and van der Valk 1977, 1978; Eilers and Roosa, in preparation).

The importance of *Carex stricta* both within and among sites distinguishes most fens in Iowa from most fens in adjacent states. In Wisconsin, Curtis (1959) identified *Calamagrostis canadensis, Spartina*

Table 3. Floristic composition of fens based on statewide frequency of occurrence of vascular taxa which were recorded five or more times among sample of 99 fens. Taxa arranged in descending order of frequency (number of fens) within major growth-forms. Asterisk (*) indicates species not previously attributed to fens or bogs by Lammers and van der Valk (1977, 1978). Capital letter denotes current official status of species in Iowa: S, Special Concern; T, Threatened; E, Endangered (Roosa et al. 1989). Lower case letter denotes geographic distribution in state: e, unique to eastern Iowa or at least twice as frequent in eastern fens; w, unique to western Iowa or at least twice as frequent in western fens (see text for details).

		GRAMINOIDS[a]			*SHRUBS*[b]
		Carex stricta (99)		e	Salix spp. (55)
		Scirpus acutus (69)	*	e	Cornus amomum (37)
		Calamagrostis canadensis (56)		e	Spiraea alba (35)
		Carex spp. (54)	*	e	Salix candida (25)
		Muhlenbergia mexicana (44)	*	e	Sambucus canadensis (16)
		Carex hystericina (36)		e	Ribes americanum (11)
		Muhlenbergia glomerata (36)	*	e	Viburnum lentago (10)
		Spartina pectinata (31)	*		Amorpha fruticosa (9)
	S	Eriophorum angustifolium (29)		Te	Betula pumila (8)
*		Glyceria striata (22)		Te	Salix pedicellaris (5)
*		Scirpus atrovirens (21)			
*		Andropogon gerardii (18)			
		Juncus spp. (18)			*TREES*
		Carex lasiocarpa (14)	*	e	Ulmus rubra (44)
		Eleocharis spp. (14)	*	e	Populus tremuloides (23)
	w	Scirpus americanus (13)	*		Acer negundo (16)
		Phragmites australis (8)	*		Acer saccharinum (16)
	T	Rhynchospora capillacea (8)	*		Populus deltoides (12)
*		Elymus canadensis (5)	*		Salix amygdaloides (12)
	E	Scleria verticillata (5)	*	e	Juniperus virginiana (9)
			*		Fraxinus pennsylvanica (8)
		Ruderal graminoids	*		Prunus americana (5)
*		Agrostis gigantea (28)			
*		Phalaris arundinacea (27)			*LIANAS*
*		Poa pratensis (20)	*		Parthenocissus quinquefolius (19)
*		Hordeum jubatum (8)	*		Vitis riparia (7)
*		Setaria viridis (6)	*		Toxicodendron radicans (5)

Table 3. (continued)

		FORBS
*		Eupatorium maculatum (80)
*		Pycnanthemum virginianum (78)
		Aster puniceus (75)
*		Eupatorium perfoliatum (74)
		Helianthus grosseserratus (69)
*		Asclepias incarnata (62)
*		Lobelia siphilitica (61)
		Pedicularis lanceolata (61)
		Viola nephrophylla (59)
*		Helenium autumnale (54)
		Aster umbellatus (51)
	e	Thelypteris palustris (49)
		Typha latifolia (46)
		Lysimachia quadriflora (45)
*	e	Fragaria virginiana (44)
		Lycopus americanus (42)
*		Polygonum amphibium (42)
*	e	Geum aleppicum (41)
*		Thalictrum dasycarpum (38)
*		Bidens coronata (37)
		Rumex orbiculatus (37)
		Epilobium leptophyllum (34)
	e	Onoclea sensibilis (34)
*	e	Oxypolis rigidior (32)
*	e	Solidago riddellii (31)
		Caltha palustris (28)
	e	Chelone glabra (28)
	e	Lythum alatum (28)
	e	Saxifraga pensylvanica (28)
		Pilea fontana (27)
*		Equisetum arvense (25)
		Parnassia glauca (25)
*	e	Rudbeckia hirta (24)
*		Impatiens capensis (23)
*		Stachys palustris (23)
	e	Gentiana andrewsii (21)
*	e	Phlox maculata (21)
*		Zizea aurea (20)
*		Monarda fistulosa (17)
*		Sagittaria latifolia (17)
*		Euthamia graminifolia (16)
		Gentianopsis crinita (16)
	Sw	Lobelia kalmii (16)
*	e	Triadenum fraseri (15)
		Typha angustifolia (15)
*	e	Cirsium muticum (14)
	T	Gentianopsis procera (14)
		Agalinus tenuifolia (13)
		Galium obtusum (13)
		Cicuta bulbifera (12)
*	e	Veronicastrum virginianum (12)
*		Heuchera richardsonii (11)
*		Lemna minor (11)
*		Lilium michiganense (11)
*	e	Potentilla simplex (11)
		Scutellaria galericulata (11)
*	Se	Valeriana edulis (11)
*		Anemone canadensis (10)
*		Campanula apaninoides (10)
	e	Dryopteris cristata (10)
		Iris shrevei (10)
*	e	Polemonium reptans (10)
*		Ratibida prinnata (10)
	T	Triglochin palustre (10)
		Cardamine bulbosa (9)
*		Heliopsis helianthoides (9)
*		Lathyrus palustris (8)
		Stellaria longifolia (8)
*		Apios americana (7)
*		Mimulus ringens (7)
*		Senecio aureus (7)
*		Smilicina stellata (7)
	Ew	Berula erecta (5)
		Liparis loeselii (5)
		Ruderal forbs[c]
*		Solidago spp. (77)
*		Verbena hastata (46)
*		Cirsium spp. (29)
*		Oenothera biennis (28)
*		Achillea millefolium (27)
*		Lactuca canadensis (21)
*		Ambrosia trifida (18)
*		Asclepias syrica (18)
*		Ambrosia artemisiifolia (15)
*		Apocyanum cannabinum (9)
*		Urtica dioica (7)
*		Oxalis stricta (5)
*		Pastinaca sativa (5)

[a]*Carex* spp. include *C. interior, C. prairea,* and other fine-stemmed sedges.
[b]*Salix* spp. include *S. bebbii, S. discolor,* and others.
[c]*Solidago* spp. include *S. canadensis, S. gigantea,* and others.

pectinata, Bromus ciliatus, and *Andropogon gerardii* as the most prevalent graminoids in fens; *Carex stricta* was an important species only in his "southern sedge meadow" community-type. Reed (1985) noted that some fens in southeastern Wisconsin were dominated by *Carex stricta* while others were dominated by low prairie species such as *Spartina pectinata* and *Andropogon gerardii.* Moran (1981) determined that *Andropogon gerardii* and *Schizachyrium scoparium* were the dominant species in most fens of northeastern Illinois, although *Carex stricta* was noted to be dominant in one "atypical" site. At another site in northeastern Illinois, Stoynoff and Hess (1986) identified both prairie grasses and *Carex stricta* as dominants. In Missouri, two general types of fens have been described: "prairie fens" dominated by *Andropogon gerardii, Spartina pectinata* and *Sorghastrum nutans* and other fens dominated by a variety of sedges (*Carex interior, C. lurida, C. suberecta,* and *C. hystericina*) (Nelson 1985, Orzell and Kurz 1986). Curtis (1959) indicated that the vegetation of fens is very similar to that of sedge meadows and wet prairies (similarity index values of 59% and 54%, respectively), suggesting that they form a continuum of closely related communities. The Iowa fens may thus represent a transitional community-type near the sedge meadow segment of the continuum.

In Wisconsin, Carpenter (1990a) determined that *Carex stricta* was dominant in zones within fens that were associated with a fluctuating water table. Accordingly, the dominance of *Carex stricta* in most Iowa fens suggests that they are subject to a fluctuating water table. Conversely, the absence of *Carex stricta* in Silver Lake Fen and the Excelsior Fens (Eickstaedt 1964, Holte 1966, van der Valk 1975) suggests the presence of a non-fluctuating or constant water table. This hypothesis is supported by the findings of Thompson et al. (1992) that the Silver Lake and Excelsior fens possess uniquely artesian water regimes with relatively constant water tables; all other Iowa fens observed by them were non-artesian systems with relatively variable water tables. This comparison, however, is confounded with pronounced differences in water chemistry between the Silver Lake/Excelsior fens and other fens in the state (Thompson et al. 1991, Thompson, in preparation).

Several vascular plant species have been identified as indicators of fens. Although lists of indicator plants overlap broadly, different authors have also identified different taxa as indicative or representative of fens. In defining a fen for his intensive study of the Excelsior Fen complex, Holte (1966) identified "certain calcicolous plants [which] are peculiar to fens", namely *Liparis loeselii, Lobelia kalmii, Parnassia glauca, Rhynchospora capillacea, Triglochin maritimum,* and *T. palustre.* In addition to some of the above species, Eggers and Reed (1987) listed several others as "representative of calcareous fens" in Minnesota and Wisconsin, including *Cirsium muticum, Cypripedium candidum, Gentianopsis procera, Muhlenbergia glomerata, Salix candida, Spiranthes cernua,* and *Valeriana edulis.* Other species in Iowa occurring primarily in fens include *Berula erecta, Betula pumila, Eriophorum angustifolium, Galium labradoricum, Gentianopsis crinita, Menyanthes trifoliata, Mimulus glabratus, Platanthera hyperborea, Salix pedicellaris, Scleria verticillata, Spiranthes romanzoffiana,* and *S. lucida* (Roosa et al. 1989; Leoschke and Pearson, in preparation). All of the above species are uncommon in Iowa (Eilers and Roosa, in preparation) and most are (or were at the beginning of our inventory) officially listed as Endangered, Threatened, or of Special Concern under state law (Roosa et al. 1986, 1989). Collectively, they occurred in about half of the fens in our inventory (the officially listed species alone occurred on 102 of 212 fens, Table 2), but individually each was encountered relatively rarely. For example, the most common of the above species, *Muhlenbergia glomerata, Eriophorum angustifolium,* and *Parnassia glauca,* were detected on 36%, 29%, and 25% of the fens sampled, respectively (Table 3).

In addition to many of the species listed above, Curtis (1959) identified numerous species as "modal" in fens of Wisconsin, including *Asclepias incarnata, Calamagrostis canadensis, Caltha palustris, Campanula aparinoides, Eupatorium perfoliatum, Iris shrevei, Lycopus americanus, Pedicularis lanceolata, Solidago riddellii, Thalictrum dasycarpum, Lobelia siphilitica,* and *Stellaria longifolia.* Although all of these species occur in Iowa fens (Table 3), most of them are also common in other types of wetlands in the state (Lammers and van der Valk 1977, 1978; Eilers and Roosa, in preparation) and are therefore (with the possible exception of *Solidago riddellii*) not reliable indicators of fens here.

Over half of the species found on Iowa fens by our study were not attributed to fens or bogs on the annotated wetland plant checklist by Lammers and van der Valk (1977, 1978), who published the only previous statewide account of the Iowa fen flora (Table 3). Similarly, many of the species listed by Nekola and Lammers (1989) in the Brayton-Horsley Fen were new additions to the previously recognized fen flora of Iowa. In addition to reflecting a more mature base of knowledge, our seemingly large update may be partially explained by two artifacts associated with comparison of our list with the previous list: 1) the previous list apparently represented an ideal fen flora which excluded most woody and ruderal species and 2) the previous list evidently presumed a smaller degree of overlap between the flora of fens and sedge meadows (termed "wet meadows" by Lammers and van der Valk 1978). An "ideal" view of the fen flora was facilitated in the 1970's by the fact that only two fen sites located about 5 km (3 miles) apart in northwest Iowa had been studied in detail, one of which was Silver Lake Fen, a pristine site protected from disturbances which affect nearly all other fens in the state. The other site was the Excelsior Fen complex; this site was grazed, but was not exposed to other disturbances. Reflecting regional land use and phytogeographical patterns, problems associated with cropfield edges and woody plant expansion are especially prevalent in eastern Iowa, but in the 1970's the hanging bogs and sedge meadows of eastern Iowa were considered to be distinct from fens and no published literature described them (Lammers and van der Valk 1978).

Although we treated both the fens that were traditionally recognized in northwest Iowa and the hanging bogs of eastern Iowa as fens in this inventory, their vegetation was noted to be different by Lammers and van der Valk (1978). To document the degree to which the flora of the "western" and "eastern" fens differed, we calculated their floristic overlap with the Jaccard Similarity Index (Mueller-Dombois and Ellenberg 1974). (For this exercise, we defined "western" fens as those occurring in Dickinson, Emmet, Clay, Palo Alto, and Osceola counties on the Des Moines Lobe in northwestern Iowa; "eastern" fens were those in the northeastern quarter of Iowa). Of the 134 most common plant taxa of fens in the state, 108 of them occurred in both eastern and western fens, representing a floristic overlap of 80%. According to Mueller-Dombois and Ellenberg (1974), values of Jaccard's Index over 25% indicate that two floras belong to the same plant association. All graminoid species and most forbs (79%) were shared between the two types. The lowest similarity in composition was for the tree (67%) and shrub (50%) components. These values must be interpreted with caution because rarer species not considered in the analysis may be restricted to one of the types. Nonetheless, the large number of cosmopolitan species in both fen types indicates that eastern and western fens are fundamentally similar in composition. Moreover, many of the species common to both types were also locally abundant in individual fens (e.g., *Carex stricta, Eupatorium maculatum, Pedicularis lanceolata*), a circumstance which promotes homogeneity of vegetation among sites.

Despite their basic floristic similarity, however, some important differences in flora and vegetation do exist between eastern and western fens. Among the 20% of plant species not shared by the two fen types are non-ruderal species such as *Betula pumila, Chelone glabra, Dryopteris cristata, Heuchera richardsonii, Onoclea sensibilis, Salix candida, S. pedicellaris, Saxifraga pensylvanica, Spiraea alba, Thelypteris palustris, Triadenum fraseri,* and *Valeriana edulis* which appear to be restricted to eastern Iowa; conversely, *Berula erecta* appears to be restricted to western Iowa (Table 3). Some of these (e.g., *Onoclea* and *Thelypteris*) are widely distributed among and locally abundant in eastern fens. Perusal of range descriptions for these species in Iowa (Eilers and Roosa, in preparation) suggests that this pattern reflects the general distribution of the species in the state and is not unique to fen habitats; possible exceptions include *Populus tremuloides* and *Rudbeckia hirta,* which we recorded only in eastern fens despite their statewide distribution. A weakness of this presence/absence argument is that it may be based partly on ignorance of the true occurrence of a species in both regions. For example, "fen indicator" species such as *Triglochin maritimum, T. palustre,* and *Rhynchospora capillacea* were once considered to be restricted to the fens of northwest Iowa, but are now known to occur in eastern Iowa as well (Leoschke and Pearson, in preparation).

Another pattern which distinguishes eastern and western fens in the state is the relative frequency of occurrence among sites of species which are present in both regions. In a comparison of 25 eastern and 25 western fens (representing nearly all western fens and a corresponding number of typical eastern sites), we determined that *Cornus amomum, Fragaria virginiana, Geum aleppicum, Lythrum alatum, Oxypolis rigidior, Solidago riddellii,* and *Ulmus rubra* were at least twice as frequent among eastern sites (Table 3). Conversely, *Lobelia kalmii* and *Scirpus americanus* were at least twice as frequent among western fens.

Applying a variety of multivariate ordinations (including Bray-Curtis, TWINSPAN, and DECORANA) to our floristic data, Carpenter (1990b) concluded that "geography, especially longitude, is the most important factor" related to differences among Iowa fens. His analyses indicated that some species (especially *Lobelia kalmii, Rhynchospora capillacea, Scleria verticillata, Scirpus americanus, Triglochin palustris,* and *T. maritimum*) "preferred" western fens and that others (especially *Betula pumila, Chelone glabra, Dryopteris cristata, Heuchera richardsonii, Salix pedicellaris, Saxifraga pensylvanica,* and *Thelypteris palustris*) "preferred" eastern fens. "Preference", of course, reflects the unique or disproportionate occurrence of a species between the two types.

Another factor which distinguishes eastern and western fens is the greater prevalence of well-developed zonation of vegetation among western fens. In his studies of Silver Lake Fen and the Excelsior Fens, van der Valk (1975, 1976) described three concentric zones of vegetation: a "discharge zone" near the center of the fen with tall herbaceous vegetation, a "sedge mat zone" with short vegetation, and a "border zone" of tall vegetation in the periphery of the fen. During our inventory, we observed many western fens with distinct sedge mat zones but very few eastern fens with this feature. Although there were notable exceptions, zonation appeared to be absent or weakly developed in most eastern fens, with sites typically consisting of an extensive border zone dominated by *Carex stricta* and, on occasion, a small, weakly differentiated discharge zone populated by *Typha* spp., *Impatiens capensis, Cardamine bulbosa, Epilobium leptophyllum,* and other species.

We also encountered several western fens which did not exhibit a distinct sedge mat zone. Similarly, van der Valk (1976) noted that small fens in the Excelsior Fen complex were completely covered with border/discharge vegetation. He interpreted the presence of a sedge mat zone as an indication that the peat or muck of a fen was deep enough to isolate the rhizosphere from contact with underlying mineral substrate; conversely, the absence of a sedge mat zone indicated that the influence of a mineral substrate extended throughout a fen, a circumstance typical of shallow fens or small sites with a high edge:interior ratio. A problem with this explanation, however, is our observation of large, deep fens in eastern Iowa that did not exhibit zonation; perhaps disturbance, water table fluctuation, or water chemistry (Thompson et al. 1992; Thompson, in preparation) also influence the development of a sedge mat zone.

Conservation Outlook

Fens are an important natural resource in Iowa as examples of native vegetation and as habitat for rare plant species. Our inventory collectively encountered over 200 native species in fens, including several which were officially endangered, threatened, or of special concern. Considering that the entire native flora of Iowa consists of about 1500 species (Eilers and Roosa, in preparation), fens provide habitat for over 10% of the native flora. Assuming an average size of about 2 hectares (5 acres), the ~200 remaining fens (of any condition) comprise less than 0.01% of the Iowa landscape, mostly in the northern part of the state. Fens thus provide an opportunity for the conservation of native plants that is disproportionately large (by orders of magnitude) relative to their size and number.

Conservation of fens in Iowa can logically proceed in two complementary directions: 1) acquisition or protection of key sites by conservation agencies and 2) improved management of fens on private agricultural lands. Due to constraints of budgets and personnel, conservation agencies will likely to be able to protect and manage only a relatively small number of sites. If, for example, protection of a typical fen would necessitate the purchase of a 40-acre tract (arbitrarily assuming an average price of $500/acre), then some 8000 acres costing $4 million would be required to acquire all 200 remaining fens; given the small budgets and staffs of conservation agencies, this is probably not a realistic option (for perspective, the entire state REAP [Resource Enhancement and Protection] fund allocation for 1992 is less than $10 million). More realistically, the best 25 fens might be acquired at a cost of $0.5 million for 1000 acres. With this approach, however, the remaining 175 fens (including 75 botanically significant sites) would remain privately owned, underscoring the need for improved management in the private sector.

Improved management of fens on private agricultural land could conceivably involve several actions: fencing to protect fens from cattle, plugging or re-routing of drainage tile lines,and planting of buffer strips between fens and cropfields. However, all of these actions could potentially have negative effects on the productivity of farms: fencing might deny cattle access to a water source, plugging of tiles could decrease drainage of surrounding cropfields, and buffer strips would require the idling of some cropland. These effects could be mitigated by developing alternative water sources for cattle, re-configuring tile lines to drain cropfields without draining fens, and purchase of cropland to replace acreage withdrawn for buffer strips. All of these mitigations cost money, but who should pay? Solutions for the management and restoration of fens in Iowa will require both technical and fiscal innovations, a challenge faced by the conservation of all natural resources.

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APPENDIX 1. Descriptions of protected fens in Iowa.

Silver Lake Fen is the best known of all Iowa fens. It was acquired by the Iowa Department of Natural Resources in 1941 and dedicated as a state preserve in 1972. It is a complex of three fens in Dickinson County. Although mostly contained on state property, it extends slightly onto adjacent private land, which has been protected by a conservation easement held jointly by the DNR and The Nature Conservancy since 1985. The private land was formerly grazed. Carroll et al. (1984) expressed concern over the possible negative effects of potential expansion of woody species (especially *Fraxinus pennsylvanica*) and tall, clonal herbs (*Typha* spp. and *Phragmites australis*) on orchid species here. The vascular flora and vegetation of Silver Lake Fen have been studied in detail by Anderson (1943), Conard (1952), Holte and Thorne (1962), Eickstaedt (1964), Holte (1966), van der Valk (1975, 1976), and Carroll et al. (1984).

The *Brayton-Horsley Fen* in Bremer County was informally protected for many years by its owners and has been formally protected with a conservation easement by The Nature Conservancy since 1982. This fen was part of a pasture that was last grazed by cattle in the 1950's (John Brayton, personal communication). Woody plant expansion is a potential problem. The fen has been burned occasionally as part of a management plan. The flora of this fen has been described in detail by Nekola and Lammers (1989). (Note: this site is privately owned; permission from the landowners is required to visit the fen.)

The *Cedar Hills Sand Prairie* in Black Hawk County was purchased and dedicated as a state preserve in 1985 by The Nature Conservancy (TNC). Studies of the flora (Crum 1972) and vegetation (Glenn-Lewin 1981b) in the preserve described a large swale, part of which (underlain by Palms muck) we recognize as a fen. Prior to acquisition by TNC, the preserve (including the fen) was a pasture, last grazed by cattle about 1965 (Crum 1972). Woody plant expansion is a potential problem in some places. This fen has been periodically burned as part of the management plan for the surrounding prairie.

The *Rowley Fen* was acquired by the Buchanan County Conservation Board in 1984 and was recognized as a significant site at that time by Dave Wendling and Jeff Nekola. It is part of a former pasture last grazed in 1983, but cattle seemingly avoided the fen itself (possibly due to a combination of unsound footing and a light stocking rate). This site has been burned as part of the CCB's management plan.

Now protected as the *Fen Valley Wildlife Management Area.*, a complex of nine fens near Gillett Grove in Clay County was discovered in 1987 during our inventory and subsequently purchased by The Nature Conservancy (which then conveyed title to the Iowa Department of Natural Resources). It is the second largest fen complex in Iowa, behind only the Excelsior Fens in nearby Dickinson County (Holte and Thorne 1962, Holte 1966). Prior to protection, it was part of a native grass pasture grazed as recently as 1990.

The *Korey Halbur Fen* in Dickinson County was acquired in 1990 by the Iowa Department of Natural Resources and is now part of the Spring Run Wildlife Management Area. It was evidently first visited by Bohumil Shimek (who collected rare plants here in 1918) but was subsequently overlooked by Iowa naturalists. This site contains a complex of fens and fen-like marshes located along Spring Run Creek near the shore of Lower Gar Lake. It was part of a pasture which was grazed until 1990. Expansion by woody vegetation is a potential problem in some places.

The *Boehmler Fen* was discovered in 1989 by naturalist Joel Hanes of Mason City. It is now protected by a conservation easement obtained by the Iowa Natural Heritage Foundation and transferred to the Franklin County Conservation Board. It was last grazed about 1979 (Ethen Perkins, personal communication). Woody plant expansion is a potential problem. (Note: this site is privately owned; permission from the landowner is required to visit the fen.

In addition to the fens encountered during our inventory, another publicly owned fen is the "sphagnum bog" occupying the west end of Dead Man's Lake in Pilot Knob State Preserve. (The preserve is located in Pilot Knob State Park, which has been owned by the Iowa Department of Natural Resources since 1924; the preserve itself was dedicated in 1968). Although described as a bog by Grant and Thorne (1955), Smith and Bovbjerg (1958), Smith (1962), and Watson (1989) because of its acidic water (pH of 5.6) and lack of obvious springs or seeps, this site can be considered to be a "poor fen" (a contraction of "nutrient-poor fen") because the vegetation is influenced by water which has been in contact with underlying mineral substrate (Diana Horton, personal communication). The Pilot Knob site is located in a small closed basin in Hancock County (a county which was excluded from our inventory) and represents an exception to our general perception that basins are unlikely settings for fens in Iowa.