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A Literature Review and Survey of the Status of Iowa's Terrestrial Flora

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A survey of Iowa's floristic literature and herbarium resources indicates that while there is not uniform coverage of plant groups and regions, a great deal is known about the Iowa flora. Taxonomic and floristic studies are ongoing, despite evidence of a decreased number of researchers with expertise and interest in Iowa's flora and changing emphases in academic research. Current knowledge is sufficient for the production of an Iowa Flora, and an Iowa Flora committee to initiate this project is proposed.

Destruction or disturbance of most of the natural habitats in Iowa has resulted in the loss of both diversity and abundance of our native flora. Approximately 13% of the total species of Iowa vascular plants are currently listed by the Department of Natural Resources as sufficiently rare to warrant special consideration, and of these, 37 species are presumed extirpated. Factors that contribute to species decline and rarity are largely the result of direct and indirect human impacts. Further studies and monitoring, along with publication of completed studies, that result in an increased understanding of the significance of these factors on maintenance of Iowa's plant diversity are needed. Other efforts underway or proposed to slow the decline of our native plants include increasing public awareness of the plight of our native flora, involving our colleagues and the public in collaborative Iowa floristics projects, and preserving remaining natural areas that are otherwise endangered by human activities.

INDEX DESCRIPTORS: Iowa flora, rare plants, endangered species, weeds, floristics, herbarium.

Iowa's flora and the need for publication of a statewide manual of the vascular plants have been discussed in numerous papers, many of which were published in the *Proceedings/Journal of the Iowa Academy of Science.* (In this paper, "flora" will refer to the plant life of a given region, while "manual" will be used when referring to a published listing that includes descriptions and keys for identification of the vascular plants of an area.) These publications and the state's herbarium resources provide the foundation for current and future research.

The Iowa flora is dynamic. Most of the state's flora now obvious to the casual observer is the result of agronomic or horticultural activity. However, such a cursory view reveals only a small fragment of Iowa's total plant diversity, with a far greater number of species occurring naturally in the state. Until the mid-19th century, the indigenous peoples and early settlers in Iowa were far more cognizant of and reliant on the native species than are today's residents. Yet Iowa's flora was not static even in pre-settlement times, with natural and anthropogenic fluctuations in the occurrence and distribution of species and in numbers, size, and density of populations. Obviously many factors have contributed to the changes in the past and present floristic composition, including natural succession, intentional or unintentional introductions of new species, habitat disturbance or loss, herbivory and other animal-mediated impacts, disease and, on a longer time scale, climatic, edaphic, and geologic changes.

Some of Iowa's native plant species are common, perhaps even more so now than in the past. However, the majority of species of Iowa's native flora have been unable to withstand the impact of tremendous changes in the landscape in post-settlement Iowa; these species are in decline, with some extirpated from the state's flora. If such impacts continue, many species will further decline in population size and number, and some will be irretrievably lost.

STATUS OF OUR KNOWLEDGE

Floristic Studies

Radford (1986) defined floristics as "the study of plant species diversity in relation to habitat diversity within an area." Field study of the flora of an area and collection of specimens are fundamental components of floristics. Beyond a simple list of species present in an area, floristic studies also provide observations of the relationships between the species and community distribution and habitat, information about species biology, and estimates of diversity and abundance of species within the area. A compilation of these floristic studies of areas or regions, along with tabulation of the resulting voucher specimens, provide clues to the spatial and temporal distribution of Iowa's plants and give some indication of the changes occurring in the flora through time. For example, floristic studies provide the evidence for increasing abundance of an introduced weed or rarity of an endangered native species. Such studies allow the making of informed decisions regarding management and protection of a species, habitat type, or natural area. The habitat descriptions and listed indicator species can be used in the determination of hydrologic, geologic and other features, and floristic data can serve as "ground-truthing" when compared with data obtained from remote-sensing techniques. Beyond the sciences, floristic studies contribute information to activities as diverse as selecting native plant species for landscaping, finding appropriate vegetation to support animal species, developing land use plans, and cataloging the poisonous plants in an area.

Several papers have summarized the status of knowledge of the Iowa flora. One of the first was Gilly's (1947) compilation from 114 early floristic and revisionary papers on Iowa's vascular plants. He concluded that there were 11 counties for which the flora was reasonably well known, while the floras of Adams, Audubon, and Montgomery counties were extremely poorly known. As for taxonomic revisions, he stated that only 37 families (approximately ¼ of the

Table 1. References listed in Eilers (1975).

DECADE	CO./REGION[a]	< CO.[b]	CHECKL. = IA.[c]	FAM./GROUP[d]	MISC.	TOTAL
<1850	—	—	—	—	3	3
1851–1860	—	—	—	—	1	1
1861–1870	—	—	—	—	—	0
1871–1880	—	1	4	—	—	5
1881–1890	1	1	4	3	1	10
1891–1900	8	7	2	11	3	31
1901–1910	11	1	1	17	1	31
1911–1920	5	2	—	10	3	20
1921–1930	5	1	—	14	4	24
1931–1940	6	5	3	11	3	28
1941–1950	5	1	2	15	3	26
1951–1960	14	—	2	17	8	41
1961–1970	4	—	—	10	4	18
1971–1975	1	—	1	—	1	3
Total	60	19	19	108	35	241

[a]Floristic study of area of at least one county, but not of entire state
[b]Floristic study of area smaller than one county
[c]Checklist of species of entire state
[d]Taxonomic study of family, genus, or group of species

total) and an additional 25 genera had been more or less fully studied in Iowa.

Only seven years later, Thorne (1954) presented a more optimistic view of the status of Iowa floristics, reporting that since his arrival in Iowa (ca. 1949), he and his students "have undertaken to fill in some of the worst gaps in our botanical knowledge of the state." Yet in the 1954 paper he conceded that "certain counties and sections of Iowa still are much in need of botanical exploration and thorough collecting."

Eilers (1975) next published a summary of floristic knowledge. He provided a historical overview, noting that the first definitive recording of Iowa plants was a listing of 11 species from the Spirit Lake vicinity during the Nicollet Expedition of 1839. He listed the previous attempts at providing a checklist of Iowa's vascular flora, the first of which was by Charles Bessey in 1871. Eilers recounted the contributions of naturalists such as J.C. Arthur, T.H. Macbride, L.H. Pammel, B. Shimek, A. Hayden, and H.S. Conard. Eilers' closing comments included the statement, "It is clear that Iowa has been adequately botanized since Gilly's 1947 paper." While he mentioned a number of families and genera needing careful taxonomic study, he concluded that "a great deal of work has been published on the flora of Iowa and we now have an adequate floristic survey of the state."

The year 1950 has been chosen by botanists studying the Iowa flora (e.g., Roosa 1981) as the transitional year between historical and modern studies. Because Ada Hayden died in 1950, and that date also approximates the arrival of Robert Thorne at the University of Iowa, the selection of that year has merit. A perusal of the research interests of the state's professional botanists, especially within academia, within this modern period suggests that research in plant systematics and ecology has shifted from a parochial, field-oriented golden-age of floristic and taxonomic studies to a more lab-oriented, less Iowa-centered focus. However, a tabulation of the references cited in Eilers' (1975) paper clearly shows that floristic and taxonomic studies were certainly not depauperate in the decades since 1950 (Table 1). Similarly, and including more recent publications, a tabulation by decade of the "Selected References" from Eilers and Roosa (1994) indicates the trend continuing at least through the 1980s (Table 2). While it is true that these two samples are biased in being weighted for recent studies that might have duplicated an earlier, and therefore excluded, work, they reveal that progress of floristic and taxonomic studies in the state is ongoing.

The studies by Thorne and his students in the 1950s to mid-1960s are fundamental in the modern study of Iowa's flora (e.g., Fay 1953; Van Bruggen 1958; Davidson 1959; Carter 1960; Cooperrider 1962; Hartley 1966; Eilers 1971). Of the regional flotistic studies that have been done since 1950, all but two (Monson 1959; Novacek et al. 1985) were done under Thorne's direction. Map 1 in Eilers and Roosa (1994) pictorially summarizes the floristic surveys of Iowa's counties and regions. More recent studies not shown on the map include Wilson's (1992) floristic survey of Page County and the update by Cady (unpubl. data) of Wagenknecht's (1954) survey of the Washington County flora. The study of species of a particular habitat type is exemplified by that of Rosburg (1997), which provides site-specific distributions and habitats for a number of southern Loess Hills prairie species.

Taxonomic and Distributional Studies of Particular Species or Plant Groups

While there have been attempts to monitor the status of weeds and the rarest plants, usually only dramatic changes in the relative abundance and distribution of Iowa's plant species have been noted or reported. These fluctuations and the necessarily disparate coverage because of the researchers' interests and location leave in question the current status of most of Iowa's plant species.

A notable exception, however, is Peck's study of the Iowa pteridophytes. Although no longer an Iowa resident, Peck has assembled a network of professional and amateur fern enthusiasts who have helped document the occurrence and distribution of the state's pteridophyte taxa. These efforts have resulted in a series of publications that make pteridophyte distribution the best known of any group of Iowa's plants (Peck 1976a, 1980, 1983, 1989; Peck et al. 1989; Peck et al. 1997).

Studies of individual species of vascular plants and plant groups continue, with examples being the several reports of new findings of

Table 2. References listed in Eilers and Roosa (1994).[a]

DECADE	CO./REGION[b]	< CO.[c]	CHECKL. = IA.[d]	FAM./GROUP[e]	MISC.	TOTAL
pre-1850	—	—	—	—	1	1
1851–1860	—	—	—	—	1	1
1861–1870	—	—	—	—	—	0
1871–1880	—	—	4	—	—	4
1881–1890	—	—	3	—	—	3
1891–1900	2	1	—	—	1	4
1901–1910	1	—	1	—	2	4
1911–1920	1	1	1	—	1	4
1921–1930	—	1	—	—	1 (1)	2 (1)
1931–1940	1	1	2	—	3	7
1941–1950	4	—	1	2	7 (3)	14 (3)
1951–1960	9	2	2	4 (2)	9 (2)	26 (4)
1961–1970	4 (1)	3	—	3 (6)	4 (4)	14 (11)
1971–1980	5	4	—	4 (17)	9 (1)	22 (18)
1981–1990	9	4	—	3 (21)	17 (4)	33 (25)
1991–1994	2	1	1	1 (1)	4 (4)	9 (5)
Total	38 (1)	18	15	17 (47)	59 (19)	147 (67)

[a]Numbers in parentheses are additional non-Iowa or non-taxonomic references
[b]Floristic study of area of at least one county, but not of entire state
[c]Floristic study of area smaller than one county
[d]Checklist of species of entire state
[e]Taxonomic study of family, genus, or group of species

rare species by Nekola (1990) and Wilson (1992, 1993). Roosa et al. (1989; revised by Pearson in 1994 (unpubl.)) provided general information about the distribution patterns of Iowa's endangered and threatened vascular plants. Lammers and van der Valk (1977, 1978) listed Iowa's wetland and aquatic plants and provided county-level distribution maps.

Taxonomic revisions of Iowa's angiosperm (flowering plant) taxa are also completed or underway. Some of these revisions are limited to taxa as they occur within Iowa, while others cover a larger region or all of the taxa within a family or genus throughout their range. The flowering plant families and suprafamilial or subfamilial taxa that have been treated on a statewide basis since 1950 include the Apiaceae (as Umbelliferae, Crawford 1970), tribes Senecioneae, Cynareae and Cichorieae of the Asteraceae (Davidson 1953), Liliaceae (Coleman 1950), Orchidaceae (Niemann 1986), Poaceae (Pohl 1966), Polemoniales (Kwang 1951), Salicaceae (Spence 1959), and Scrophulariaceae (Coffey 1966). Similar studies of genera or subgeneric taxa include those of *Asclepias* (Asclepiadaceae; Nicolson and Russell 1955), the *Carex brevior* (Dewey) Mackenz. ex Lunell group (*Carex* sect. *Ovales* in part; Cyperaceae; Zager 1991), *Elymus* (Poaceae; Gabel 1984), *Rubus* (Rosaceae; Widrlechner 1998), and *Setaria* (Poaceae; Pohl 1951).

Regional and National Floristic Manuals

The kinds of studies cited in the previous sections have provided data for several recent regional and national manuals of the flora that cover all or part of Iowa. In chronological order, the first of these is *Flora of the Great Plains* (Great Plains Flora Association 1986), which provides good coverage of the western two tiers of Iowa's counties that were included by the "Flora Committee" within the Great Plains region. This manual also serves adequately for the identification and description of plants in the western half of the state. Iowa is supposedly included within the range of Gleason and Cronquist's (1991) *Manual of Vascular Plants of the Northeastern U.S.*; however, because Iowa lies at the western edge of the range, the coverage, especially from central to western Iowa, is nominal. Attempts are underway to provide the first comprehensive floristic manual for the North American continent north of Mexico, and the first three volumes of *Flora of North America* have been published. Once this project is completed, it will provide coverage of all of the species in Iowa. But in a work covering such a large area, detailed information is lost and identification can be difficult because the keys that include a large number of taxa can be so cumbersome to use.

Herbarium Resources

The documentation of Iowa's flora by collecting specimens for herbaria began at least as early as the 1840s by Charles C. Parry. The most recent edition of *Index Herbariorum* [IH 1990] (Holmgren et al. 1990), a directory of the world's herbaria, listed 10 Iowa herbaria, with combined holdings of nearly 690,000 specimens. It is difficult to estimate how many of these are from Iowa and how many additional Iowa specimens can be found in herbaria not listed (e.g., the Coe College Herbarium) or in herbaria beyond Iowa's borders (e.g., the Missouri Botanical Garden Herbarium). The state's oldest and largest herbaria are the Ada Hayden Herbarium at Iowa State University (founded 1870, IH 1990 total 410,000 specimens) and the Herbarium of the University of Iowa (founded 1870, IH 1990 total 202,000 specimens). The University of Northern Iowa (IH 1990 total 34,000 specimens) also houses significant holdings, especially of relatively recent collections.

Production of a Manual of Iowa's Flora

Iowa does not yet have its own state manual (a published listing of the native and naturalized taxa of vascular plants including keys and morphological descriptions). However, the recent publication of Eilers and Roosa's (1994) *The Vascular Plants of Iowa: An Annotated Checklist and Natural History* is an important step toward production of such a manual. The checklist provides a listing of all of Iowa's known native and naturalized species, including such information as

major synonyms, abundance and distribution, and habitat for each species.

The need for a comprehensive Iowa manual has long been recognized. Without available keys for identification and morphological descriptions to confirm the identity of Iowa's plants, researchers and plant enthusiasts must rely on manuals of other states or regions. As mentioned earlier, the incomplete coverage of Iowa's taxa and the complexity of regional keys often make the identification of Iowa's plants difficult. Identification is the fundamental first step in studying, understanding, and documenting Iowa's flora.

Two components are critical for successfully accomplishing the production of a manual of Iowa's flora—an adequate information base and at least one person with the expertise, time, will, and funding to complete the task. Regarding the first component, Gilly (1947) was probably correct in his assessment that "the obvious conclusion ... is that no adequate flora of the state of Iowa can be prepared in the near future." However, Thorne (1954) soon stated, "In summary, our knowledge of the flora of Iowa, though still incomplete, is fast reaching the point where a manual of the vascular plants of Iowa should be prepared. The time to begin work on the *Flora of Iowa* has arrived." Over 20 years later, that work had not begun, and Eilers (1975) commented, "I estimate that it would take a taxonomist familiar with Iowa plants at least a year of concentrated effort to produce an accurate checklist of the vascular plants of the state, and probably five years or more to publish a manual of the Iowa vascular flora."

More than 40 years have passed since Thorne proclaimed that the time had come to produce a manual of Iowa's flora. As herbarium specimens and publications have continued to accrue since Thorne's time, an even larger information base is available today. The reason that there is yet no statewide manual of the flora may lie in the second factor cited above: to produce such a compilation requires at least one person with the expertise, time, will, and funding to accomplish the task. Shifting emphases in today's academic departments and state and private organizations has led to a reduced number of field- and herbarium-oriented plant taxonomists. This lack of available expertise for such studies has become so critical within the national and international systematics community that "the taxonomic impediment" has become a catchword (cf. Systematics Agenda 2000 1994; Savage 1995; Simpson and Cracraft 1995). Yet, as seen in examples given above, work on floristic projects continues. It is possible, however, that the production of an Iowa manual cannot be completed by one person. Despite such examples as Voss' (1972, 1985, 1996) three-volume *Michigan Flora,* the days of single-authored state or regional manuals may be drawing to a close. Whether single- or multi-authored, the production of a statewide floristic manual will require the support and collaboration of many in Iowa's botanical systematics community. Such issues as funding, space allocation, availability of collections, databases, literature, and other documentation, and other needs must be addressed. Because of these unanswered questions, an Iowa Flora committee should be formed and charged with assessing the potential need and direction for the production of a manual of the Iowa flora.

IOWA'S PLANTS

Some of Iowa's native species are quite common, and several have increased their range during the state's recorded history. *Toxicodendron radicans* (L.) Kuntze (poison ivy), *Juniperus virginiana* L. (eastern red cedar), and *Rhus glabra* L. (smooth sumac) provide examples of species that have benefited from disturbance that created opportunities for spread. *Juglans nigra* L. (black walnut) and *Panicum virgatum* L. (switchgrass) are examples of "desirable" species commonly planted or cultivated, resulting in increasing numbers of individuals or populations in the state. Typical forest tree species, such as *Quercus* spp. (especially the "white oaks"), *Ostrya virginiana* (P. Miller) K. Koch (hop hornbeam), and *Acer* spp. (maples and box elder), may be more abundant than in the past because they have spread into former prairie areas. Disturbance and fire suppression have enabled the forest species to invade these areas.

Eilers and Roosa (1994) listed numerous species as common in Iowa (in at least one area of the state). Such a lengthy list of common species is misleading unless their methodology is considered; their data were "derived mostly from specimens in the major herbaria in Iowa" (Eilers and Roosa 1994). Their list, then, did not attempt to distinguish historical from present distributions, and they rarely commented on trends of changing frequencies and distributions of the species through time.

Rarity

Roosa et al. (1989) cited 264 of Iowa's rarest native vascular plant species in their listing of the state's endangered and threatened plants. Each species was assigned to one of four categories—presumed extirpated, endangered, threatened, and special concern. These 264 species represent approximately 13% of Iowa's total flora of 1958 species (Eilers and Roosa 1994); 37 of the 264 (nearly 2% of the total flora) are presumed extirpated. Several of these species are at the edge of their range or require specific habitats such as algific slopes (see Pusateri et al. 1993 for examples and discussion of such species from Iowa's Driftless Area); these have been rare throughout Iowa's known history. Others have become rare largely because of human (i.e., post-settlement) impacts. Five species that are rare both in Iowa and throughout their entire range are also on the federally endangered plant list; an additional 10 species are candidates for inclusion (Drewry 1993; U.S. Fish and Wildlife Service 1993). These are listed in Table 3.

The causes of rarity, and also the declining abundance of native species that are still too numerous to be considered rare, are myriad and complex. In a 1994 symposium on California's rare plants, Fiedler (1995) gave four reasons for a huge jump in the number of listed threatened and endangered species in that state during a six year period. These reasons, along with parallels for Iowa's flora, are:

1) taxonomic changes and nomenclatural shuffling. An example for Iowa is the recent splitting of *Platanthera leucophaea* (Nutt.) Lindley (prairie fringed orchid) into an eastern (*P. leucophaea* s. str.) and western (*P. praeclara* Sheviak and Bowles) species (Sheviak and Bowles 1986; see Table 4 for additional examples of rare to reasonably common species recently reported for Iowa).
2) new plants being discovered in the state that had been overlooked in the past. See Table 4 for reports of previously overlooked species and those whose range has recently extended into Iowa, that are not included in Eilers and Roosa (1994).
3) description of species new to science. *Botrychium campestre* Wagner and Farrar (prairie moonwort) was first discovered in the Loess Hills in 1982—not only as a new species in Iowa's flora, but as a species new to science (Wagner and Wagner 1986).
4) the acceleration of habitat loss and other threats. The loss especially of prairie (Smith 1981, in prep.) and wetland (Bishop 1981, in prep.) habitats is clearly demonstrated in the papers from the 1980 and 1997 symposia on Iowa's declining flora and fauna, of which this paper is a part.

Some attempts have been made to mitigate losses of these habitats by restoration. State and federal aid through initiatives such as the Conservation Reserve Program and the Wetland Reserve Program has provided support for private landowners to restore lost prairie and wetland habitat. While restorations may meet several goals of

Table 3. Federally listed endangered or threatened plant species (category 1) and those proposed as candidates for listing (category 2) that occur in Iowa. (Drewry 1993; Roosa et al. 1989).

SPECIES (COMMON NAME)	FEDERAL STATUS	STATUS IN IA
Category 1		
Aconitum noveboracense A. Gray (Norrhern wild monkshood)	Threatened	Threatened
Asclepias meadii Torr. ex Gary (Mead's milkweed)	Threatened	Endangered
Lespedeza leptostachya Engelm. (Prairie bush-clover)	Threatened	Threatened
Platanthera leucophaea (Nutt.) Lindley (Eastern prairie fringed orchid)	Threatened	Endangered
Platanthera praeclara Sheviak & Bowles (Western prairie fringed orchid)	Threatened	Endangered
Category 2		STATUS IN IA
Agalinis (Tomanthera) skinneriana (Wood) Britton (Purple or pale false-foxglove)		Endangered
Aster furcatus Burgess (Forked aster)		Endangered
Chrysosplenium iowense Rydb. (Golden saxifrage)		Threatened
Cirsium hillii (Canby) Fern.		Not listed
Eleocharis wolfii Gray (Wolf's spike rush)		Special concern
Juglans cinerea L. (Butternut)		Not listed
Poa paludigena Fern. & Wieg. (Bog or marsh bluegrass)		Endangered
Scirpus hallii A. Gray (bulrush)		Presumed extirpated
Talinum rugospermum Holz. (Rough-seeded fame flower)		Endangered
Tomanthera auriculata (Michx.) Raf. (Auriculate false-foxglove)		Not listed

these programs, e.g. by improving water quality and providing wildlife habitat and migratory/movement corridors, restorations typically fall short of natural systems in maintaining plant species diversity. For example, Galatowitsch (1993) compared the vegetation and seedbank composition of restored and natural wetlands in northern Iowa and found significant differences in species composition. In particular, 37 wet prairie and sedge meadow species (including the typical *Carex* spp.) were not found in the restored wetlands included in the study (Galatowitsch 1993).

In addition to habitat loss, many other factors contribute to the decline of Iowa's native plants. Disturbance of remaining habitat by direct or indirect human activities has been a major contributor. Destruction or modification of buffer areas adjacent to remaining natural areas increases the risk of pollutants, encroachment of weedy species (discussed in greater detail below), and loss of necessary pollinators or other beneficial biotic interactions. Increased urbanization and road building have fragmented formerly contiguous areas. Cessation of naturally occurring phenomena such as fire and periodic flooding greatly impacts species composition, even within preserves and other natural habitats.

These factors vary in their effects on individual species and populations because of differences in species biology. Breeding systems and other reproductive strategies vary among plant species, and some species require a minimum population size or proximity of other populations for reproductive success. Further pressures on population size and the distribution of Iowa's rarest plant species may lead to extirpation if the numbers of individuals or populations fall below the threshold necessary for maintaining viability.

Weeds

An interest in weeds in the state has paralleled the development of the state's agriculture. Pammel and King (1926) provided an extensive survey of the weeds of Iowa, including species descriptions, distribution maps, control, and summary chapters on general weed characteristics. The listed species, a number of which are native to Iowa, are those of agronomic importance. Pohl (1959) reported three weedy grasses as new introductions to the Iowa flora. One of these, *Miscanthus sacchariflorus* (Maxim.) Hackel (plume grass), has become a conspicuous and aggressive inhabitant of roadside ditches in many areas in the state.

Competition of native plants with aggressive, weedy species was mentioned above as a factor causing declining abundance and rarity of native plant species, but it seems that only in recent years has concern for such competition been expressed. Eilers (pers. comm. in Stuckey and Barkley 1993) states that 434 vascular plant species found in Iowa are nonindigenous, comprising 22.3% of the total flora. Several weedy species that are increasing and require control in terrestrial (including nonaquatic wetland) habitats are listed in table 5. It is interesting to note that a significant number of the species on the list are thought to be native to Iowa. The cessation of prairie fires, overgrazing by cattle and deer, other disturbances creating openings in native vegetation, introduction of more aggressive genotypes (perhaps the case in *Phalaris arundinacea* L.—reed canary grass, cf. Swink and Wilhelm 1994), and other factors are thought to have increased the dominance of these native species. The majority of weedy species, however, are introduced. Introductions may be intentional (e.g. those escaped from cultivation) or accidental, occurring for example through use of non-local fill material or through dispersal of propagules by vehicles or footwear.

Disease

Plant parasitic fungi, viruses, insects, and other disease- or injury-causing agents are naturally present in native plant populations, and plant species are typically well adapted to dealing with these natural agents. However, several plant parasitic fungi have had catastrophic effects on populations of native plant species. The introduced fungal pathogen *Ophiostoma ulmi* (Buisman) Nannf., which causes Dutch elm disease (elm wilt), has devastated both native and cultivated elms (*Ulmus* spp.). Tiffany and Knaphus (1998) give further details about the history of spread of Dutch elm disease in Iowa. Young individuals of *Ulmus americana* L. (American elm) that may have developed a resistance to the disease are frequently found; further monitoring is needed to confirm this resistance. Furthermore, hybrids between the native *Ulmus rubra* Muhl. (red elm) and the introduced, more disease-

Table 4. A list of species and hybrids reported in Iowa since 1994 or otherwise not included in Eilers and Roosa (1994).

SPECIES	FAMILY	REFERENCE
Range extension:		
Heterotheca latifolia Buckl.	Asteraceae	Lammers 1998
Liatris lanceolata (Greene) Kittel	"	Wilson 1993
Vernonia arkansana	"	Wilson 1992
Alnus glutinosa (L.) Gaertn.	Betulaceae	FNA[a] 3 (Furlow)
Lonicera japonica Thunb.	Caprifoliaceae	Wilson 1992
L. maackii Maxim.	"	Herb. spec.[a] (ISC[a], Lewis)
Ceratophyllum echinatum A. Gray	Ceratophyllaceae	FNA 3 (Les)
Carex austrina Mackenz.	Cyperaceae	FNA mss.[a] (Ball)
Carex echinata Murray	"	FNA mss. (Reznicek)
Carex intumescens Rudge	"	Herb. spec. (ISC, Norris)
Euphorbia × *pseudovirgata* (Schur) Soo	Euphorbiaceae	Wilson 1993
Carya glabra (Miller) Sweet	Juglandaceae	FNA 3 (Stone)
Hemerocallis lilioasphodelus L.	Liliaceae	Herb. spec. (ISC, Albertson, etc.)
Nothoscordum bivalve (L.) Britt.[b]	"	Herb. spec. (ISC, Hitchcock, etc.)
Broussonetia papyrifera (L.) Vent.	Moraceae	FNA 3 (Wunderlin)
Corydalis flavula (Raf.) DC.	Papaveraceae	FNA 3 (Stern)
Papaver rhoeas L.	"	FNA 3 (Kiger and Murray)
Duchesnea indica (Andr.) Focke	Rosaceae	Herb spec. (ISC, Pope, etc.)
Verbena × *illicita* Moldenke	Verbenaceae	Wilson 1993
V. × *perriana* Moldenke	"	"
Taxonomic revision:		
Sagittaria australis (J.G. Smith) J.K. Small	Alismataceae	Haynes, herb. ann.[a] (ISC)
Acorus americana (Raf.) Raf.	Araceae	FNA mss. (Thompson)
Gymnocarpium jessoense (Koidz.) Koidz.	Aspleniaceae	Peck et al. 1997
G. × *brittonianum* (Sarvela) Pryer & Haufler	"	"
G. × *intermedium* Sarvela	"	"
Aster urophyllus Lindley	Asteraceae	A. Jones, herb. ann. (ISC)
Carex mesochorea Mackenz.	Cyperaceae	S. Jones, herb. ann. (ISC)
Elymus glabriflorus (Vasey) Scribn. & Ball	Poaceae	Campbell, herb. ann. (ISC)
E. submuticus (Hook.) Smyth	"	Campbell, herb. ann. (ISC)
Heteranthera multiflora (Grisebach) C.N. Horn	Pontederiaceae	Horn, herb. ann. (ISC)
Ranunculus hispidus Michx. (var. *caricetorum*)	Ranunculaceae	FNA 3 (Whittemore)
Rubus ablatus L.H. Bailey	Rosaceae	Widrlechner 1998
R. aboriginum Rydb.	"	"
R. alumnus L.H. Bailey	"	"
R. cauliflorus L.H. Bailey	"	"
R. celer L.H. Bailey	"	"
R. curtipes L.H. Bailey	"	"
R. enslenii Tratt.	"	"
R. frondosus Bigelow	"	"
R. fulleri L.H. Bailey	"	"
R. leviculus L.H. Bailey	"	"
R. meracus L.H. Bailey	"	"
R. missouricus L.H. Bailey[b]	"	"
R. × *neglectus* Peck	"	"
R. parvifolius L.	"	"
R. plicatifolius Blanch.	"	"
R. recurvans Blanch.	"	"
R. roribaccus (L.H. Bailey) Rydb.	"	"
R. rosa L.H. Bailey	"	"
R. satis L.H. Bailey	"	"
R. semisetosus Blanch.[b]	"	"
R. steelei L.H. Bailey	"	"
R. stipulatus L.H. Bailey[b]	"	"
R. wisconsinensis L.H. Bailey	"	"

[a]Abbreviations and format: FNA—Flora of North America, with volume number if published (Flora of North America Editorial Committee 1993, 1997) or "mss." if unpubl., followed by author of treatment. Herb. spec.—herbarium specimen, followed by herbarium acronym and collector. ISC—Ada Hayden Herbarium, Iowa State University. Herb. ann.—herbarium annotation, preceded by name of person making the determination
[b]Species included in list of "Excluded Species" in Eilers and Roosa (1994)

Table 5. A partial list of common and aggressive weeds of Iowa's natural areas.[a]

SPECIES (COMMON NAME)	HABITAT AFFECTED	LISTED AS NOXIOUS?	NATIVE?
Alliaria petiolata (Bieb.) Cav. & Grande (Garlic mustard)	Woodlands	N	N
Bromus inermis Leyss. (Smooth brome)	Prairies	N	N
Cirsium arvensis (L.) Scop. (Canada thistle)	Prairies	Y	N
Coronilla (Securigera) varia L. (Crown vetch)	Prairies	N	N
Euphorbia esula L. (Leafy spurge)	Prairies	Y	N
E. × pseudovirgata (Schur) Soo (Leafy spurge)	Prairies	N	N
Juniperus virginiana L. (Eastern red cedar)	Prairies	N	Y
Lonicera tatarica L. (Tartarian honeysuckle)	Woodlands	N	N
Lotus corniculatus L. (Bird's-foot trefoil)	Prairies	N	N
Lythrum salicaria L. (Purple loosestrife)	Wetlands	N	N
Melilotus alba Medicus (White sweet clover)	Prairies	N	N
Melilotus officinalis (L.) Pallas (Yellow sweet clover)	Prairies	N	N
Phalaris arundinacea L. (Reed canary grass)	Wetlands	N	Y/N
Poa pratensis L. (Kentucky bluegrass)	Prairies	N	N
Rhamnus cathartica L. (Common buckthorn)	Woodlands	Y	N
Rhus glabra L. (Smooth sumac)	Prairies	N	Y
Ribes missouriense Nutt. ex T. & G. (Wild gooseberry)	Grazed woodlands	N	Y
Rosa multiflora Thunb. ex Murr. (Multiflora rose)	Prairies	Y	N
Trifolium pratense L. (Red clover)	Prairies	N	N
Zanthoxylem americanum P. Miller (Prickly ash)	Grazed woodlands	N	Y

[a]List compiled from Eilers and Roosa (1994); several articles in the Newsletter of the Iowa Native Plant Society; W. R. Norris and others, pers. comm.; pers. obs.

resistant *U. pumila* L. (Siberian elm) are often found; again, field studies are needed to document whether these hybrids are becoming more prevalent than either red or American elm.

Juglans cinerea L. (butternut), once a common native tree in eastern and north-central Iowa (Eilers and Roosa 1994), has largely been eliminated by butternut canker caused by the fungus *Sirococcus clavigignenti-juglandacearum* Nair, Kostichka & Kuntz. The tremendous loss of butternut trees in the United States and the high percentage of infection in remaining trees has prompted the listing of the species as a Category 2 (candidate for inclusion) Endangered and Threatened Plant (Drewry 1993). While the disease's toll on Iowa's butternuts has not been quantitatively assessed, field studies indicate that living, uninfected, mature butternuts are now rare. Ostry et al. (1994) provide descriptive information about butternut canker, including how to identify the symptoms and recognize diseased trees.

Iowa's native and cultivated red oaks have been greatly affected by oak wilt, caused by the fungus *Ceratocystis fagacearum* (T.W. Bretz) J. Hunt. The "red oak" species (the common ones in Iowa being *Quercus borealis* Michx.f., *Q. ellipsoidalis* E.J. Hill, and *Q. velutina* Lam.) are quickly killed by oak wilt, whereas white oak (*Q. alba* L.), bur oak (*Q. macrocarpa* Michx.), and others of the "white oak" group can survive and reproduce for several to many years following infection, often showing only crown dieback (Dietz and Young 1948).

Kernel smut, caused by the fungus *Sphacelotheca occidentalis* (Seym.) Clint., was first collected in Iowa on its host *Andropogon gerardii* Vitman (big bluestem) in 1978 (Snetselaar and Tiffany 1991). Snetselaar and Tiffany (1991) report that while not immediately lethal, kernel smut reduces both vigor and ability to reproduce. Tiffany et al. (1990) report that the disease is frequently found on restored prairies planted with big bluestem varieties from Nebraska stock, yet the introduced stands do not seem to be as badly affected as native populations infected by the fungus.

The effects of many other plant pathogens are little known. For example, ash yellows is a disease caused by mycoplasma-like organisms, and all four of Iowa's native species of *Fraxinus* have been reported as hosts (Pokorny and Sinclair 1994). The disease is known from urban plantings across the state. Although also reported in native ash populations, the effect of this disease on native populations is unknown.

Non-vascular Plant Groups

The bryophytes make up another significant component of Iowa's terrestrial plants. Since Conard's intensive studies up to the 1940s, coverage of the bryophytes has been rather spotty. Peck (1978) updated Conard's work, providing dot maps and current names of the taxa. He has also compiled a bibliography of Iowa bryophytes (Peck 1976b). A more recent survey of the liverworts has been done by Zehr (unpubl. data). Studies of mosses or bryophytes in general since Peck's 1976 bibliography include those by Carvey et al. (1977), O'Keefe (1980), O'Keefe and Farrar (1983), van der Linden et al. (1985), and Johnson-Groh (1987). Horton is an editor and author for the future bryophyte volume of the *Flora of North America North of Mexico* (unpubl.). A summary of the literature on Iowa's fungi, lichens, and myxomycetes is contained within this symposium (Tiffany and Knaphus 1998).

Need for Further Studies

The floristic composition, at least at the level of a checklist of species, of several of Iowa's regions and counties is comparatively well known. These include the counties of the state's major universities (i.e., Black Hawk, Johnson, and Story) and adjacent counties (e.g., Iowa and Muscatine). Those counties with floras associated with significant geologic features (e.g., the counties of the Loess Hills, lakes region, and Paleozoic Plateau (driftless area), also Boone, Hardin, and Webster cos.; cf. Prior 1991) are also more likely to have been surveyed. Although the vascular plants of Page County were intensively studied by Wilson (1992), and Fremont, Guthrie, Lee,

Mahaska, and Marion counties were included in natural history forays (albeit less thoroughly covered than Page Co.), the floras of the counties of the Southern Iowa Drift Plain in the southern one-third of Iowa remain the most poorly known.

Many floristic studies of areas smaller than a county have been done; however, similar surveys of many of Iowa's natural areas, including state parks and preserves, are needed. As Eilers (1969) aptly stated, "New and exciting information comes to light nearly every time an intensive floristic study is made of even a small area .... This kind of 'pioneering' effort has to be completed before we can know the ranges of distribution of the species accurately. Also, careful studies of this nature can bring to light patterns of variation within species that are so important to know in order to understand the population structure and patterns of evolution within species complexes."

Studies of the species biology of Iowa's rare and more common native plant species and introduced weeds, the role of these species as indicators of specific habitats, their distribution, and changes in their population status are critically needed. Massey and Whitson (1980) assert that knowledge of species biology may be the crucial factor in efforts to aid the long-term preservation of rare species. Kuchenreuther's (1996) paper on the life history of *Aconitum noveboracense* A. Gray provides a desirable model for such studies. Careful observation of both species and habitats can yield surprising results, such as the splitting of *Platanthera praeclara* from *P. leucophaea* and the discovery of *Botrychium campestre* previously cited. Field researchers have traditionally avoided such complex groups as the hawthorns (*Crataegus*) and those as difficult to recognize and identify as the sedges (*Carex*), resulting in a lack of knowledge of their status and distribution in the state. Both data and specimens need to be collected for these groups, as has been done for *Rubus* (Widrlechner 1998), another genus that frustrates most field researchers. The fact that many floristic studies remain unpublished presents another difficulty. It is a formidable task to find needed information when it is dispersed in theses and dissertations or only in personal field notes, and this situation may lead to unnecessary duplication of studies.

As cited earlier, the knowledge of Iowa's pteridophytes sets an example for studies of families and higher groups. With such baseline data about Iowa's ferns, further research into their ecological requirements, modes of reproduction and dispersal, hybridization, and similar detailed studies can more easily be accomplished, as illustrated by Rutz and Farrar (1984), Farrar (1985), and Peck et al. (1990). Unfortunately, no other Iowa plant group is similarly covered by publications, voucher specimens in herbaria, field records, and networks of researchers.

Studies of the frequency of occurrence of individuals (population size) and populations are necessary to determine trends of abundance of the state's plant species. An attempt to present a list of Iowa's steady to increasing species for this paper was abandoned when it became apparent that data on such trends were insufficient. While Norris and Rosburg (unpubl. data) have conducted frequency studies of plant genera in forests of the Paleozoic Plateau, such data are lacking for most regions and habitat types.

Revisionary and monographic studies of many of Iowa's plant groups are sorely needed. As noted earlier, Widrlechner's (1998) revision of Iowa's *Rubus* has greatly increased our knowledge of the relationships and distribution of the species in this large and complex genus. Studies outside of the state have been done for many groups, but such treatments need to be applied to Iowa taxa. For example, Jones has studied the large and complex composite genus *Aster* (e.g., Jones 1989). Although she has examined and annotated some of Iowa's herbarium specimens, many more specimens in the genus need to be annotated using her published works. Similar efforts are also needed in numerous other genera, including *Cornus, Euphorbia, Polygonum, Ranunculus, Crataegus, Salix, Viola, Sagittaria, Carex, Eleocharis, Juncus, Agropyron, Dichanthelium, Poa* and *Potamogeton.*

Has there been a shift in the kind and number of researchers who are studying Iowa's flora? There is a general perception that research in floristics and alpha taxonomy based on field-oriented studies may no longer be in vogue, and that academic and governmental positions for individuals with this expertise are rare. Several of Iowa's leading field botanists in academia have recently retired and been replaced by botanists with other research interests. Furthermore, several botanical positions have been lost in the state's Department of Natural Resources by attrition and fiscal reductions. I know of no current Iowa researchers in floristics who are faculty members of Iowa's colleges or universities and who cite Iowa floristic or taxonomic studies as their primary research interest. In the past, C.E. Bessey, L.H. Pammel, B. Shimek, A. Hayden, R.F. Thorne, L.J. Eilers, and others likely claimed such an interest. However, Iowa's current researchers list pteridology, bryology, plant ecology, horticulture, etc. as their primary area of interest, or they are graduate students, herbarium curators, employees of governmental or private organizations, etc. Many of the authors of recent publications cited in this paper are no longer Iowa residents, including Lammers, Nekola, Peck, and Wilson. Yet, the contributions of these researchers are immense, and their ongoing work is key to furthering our knowledge of Iowa's flora. Their efforts should be encouraged and others should be urged to join their ranks.

Taxonomists answering basic questions of biology and colleagues doing so-called "high-tech," laboratory-oriented, molecular or biochemical studies should develop collaborative projects that may better demonstrate the role of basic taxonomy in the scientific community. An example of such collaboration is the study by Klier et al. (1991) of hybridization between two of Iowa's *Cypripedium* species. Public understanding of biological research may increase with improved collaboration and interaction between professional botanists and native plant enthusiasts, perhaps resulting in increased funding and support. The observations and contributions of amateur plant enthusiasts provide an important, and often underutilized, source of information for the botanical community. In conclusion, all of us must work together to convince the general public, from landowners to policy makers, of the value in preserving what remains of Iowa's biological heritage!

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