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More than a Century of Change in the Ames, Iowa Flora (1859–2000)

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We compared two floras compiled in Ames, Iowa: (1) an "historic" flora based on two published floras (1871, 1890) and on 1450 herbarium voucher specimens of plants collected in Ames between 1859 and 1899, and (2) a "current" flora compiled by us during recent fieldwork (1990–2000). Our goals were to determine 1) long-term changes in composition (i.e., the proportion of native species) over time, 2) long-term changes in the abundance of individual plant species over time, and 3) the extent of gains and losses of native and non-native plant species. We found that the proportion of native species declined over time from 83.5% to 71.2%. Native taxa had a greater tendency to decrease in abundance and a lesser tendency to increase in abundance than did non-native taxa ($p \leq 0.001$). Furthermore, historically uncommon plant taxa (regardless of origin) were more prone to extirpation from the flora than were more abundant taxa ($p \leq 0.001$). Of the 277 plant species that likely entered the Ames flora after 1899, 160 of them (57.8%) are non-native including eleven aggressive invasive species: garlic mustard (*Alliaria petiolata* (Bieb.) Cav. & Grande), Japanese barberry (*Berberis thunbergii* DC.), crown vetch (*Coronilla varia* L.), leafy spurge (*Euphorbia esula* L.), Amur honeysuckle (*Lonicera maackii* (Rupr.) Herder), purple loosestrife (*Lythrum salicaria* L.), Osage orange (*Maclura pomifera* (Raf. ex. Sarg.) Schneider), white mulberry (*Morus alba* L.), European buckthorn (*Rhamnus cathartica* L.), multiflora rose (*Rosa multiflora* Thunb. ex Murray) and Siberian elm (*Ulmus pumila* L.). We argue that more floristic inventory work is needed to facilitate continued analysis of human impact on the Iowa flora.

INDEX DESCRIPTORS: plant communities, urban flora, Story County, floristic study, vegetation change, conservation, human impact, introduced species.

The Iowa flora has always been dynamic, characterized by long-term fluctuations in the occurrence and distribution of species due to climatic, edaphic and geological factors (Lewis 1998). This flora has likewise experienced many short-term changes in composition due to natural events which include succession, natural disturbance, disease and herbivory (Lewis 1998). However, rates of floristic change in Iowa have probably accelerated since the time of European settlement due to the massive destruction and fragmentation of Iowa's natural habitats (Bishop et al. 1998, Jungst et al. 1998, Phillips 1998, Smith 1998) and the introduction of aggressive, non-native plant species and diseases (Lewis 1998). Many botanists in Iowa believe that a large number of native plant species in this state have suffered population declines and reduced distributions in the wake of these human impacts.

Nevertheless, direct comparisons of modern and past floras for any region in Iowa are rare, limited primarily by the paucity of historic data (see Phillips 1998 for a notable exception). For instance, fewer than twenty regions in Iowa (i.e., counties, cities, etc.) had floras published by 1900 (Eilers 1975). However, when detailed floristic knowledge *is* available for a region from two widely separated points in time, one may analyze the nature of change for a variety of parameters (composition, origin, abundance, etc.). Likewise, one may compare the characteristics of "lost" and "gained" species in temporally separated floras compiled for a given area to gain insight into extirpation and invasion processes (Robinson et al. 1994, Drayton and Primack 1996, Shaffer et al. 1998).

A unique opportunity exists for such a study of the Ames, Iowa flora. Baseline data documenting this city's flora from the latter half of the 19th century (1859–1899) exist from two published accounts (Bessey 1871, 1890) and from over 1400 plant specimens collected in Ames prior to 1900 (Ada Hayden Herbarium (ISC), Iowa State University). Collectively, these sources provide a relatively thorough baseline for the pre-1900 Ames flora. Likewise, we compiled a modern plant list for Ames between 1990 and 2000 (Norris et al. 2001), thus permitting an analysis of floristic change in Ames between the late 19th Century and the last decade of the 20th Century. In this paper, we present preliminary results of these analyses.

THE STUDY AREA

Ames (1995 population: 48,691) is located in Story County in central Iowa. The boundary of our recent (1990–2000) plant inventory represents a 3.2 km (=2 mi) extension of the Ames city limits, which corresponds to the city's planning and zoning jurisdiction. The area lies within the following coordinates: 41°57′40″ to 42°05′30″N latitude and 93°31′40″ to 93°43′30″W longitude. Although most of the area thus circumscribed (23,700 ha = 58,560 ac) lies within Story County, a very small portion on the west extends into Boone County (see fig. 1 in Norris et al. 2001 for map of the inventory boundary).

Although most of Story County was covered by prairie vegetation at the time of settlement by Europeans (Anderson 1996), most of this historic vegetation was drained, plowed, and replaced by crop

Table 1. Assignments of changes in abundance for plant taxa assigned abundance codes by Hitchcock (1890) and Norris et al. (2001). Note that taxa described as "Not Uncommon" by Hitchcock (1890) are omitted here because the meaning of this abundance category is ambiguous.

Hitchock (1890) Code	Norris et al. (2001) Code	Assignment
Infrequent, scarce or rare	infrequent or rare	no change
Infrequent, scarce or rare	frequent or common	increase
Abundant, common or frequent	infrequent or rare	decrease
Abundant, common or frequent	frequent or common	no change

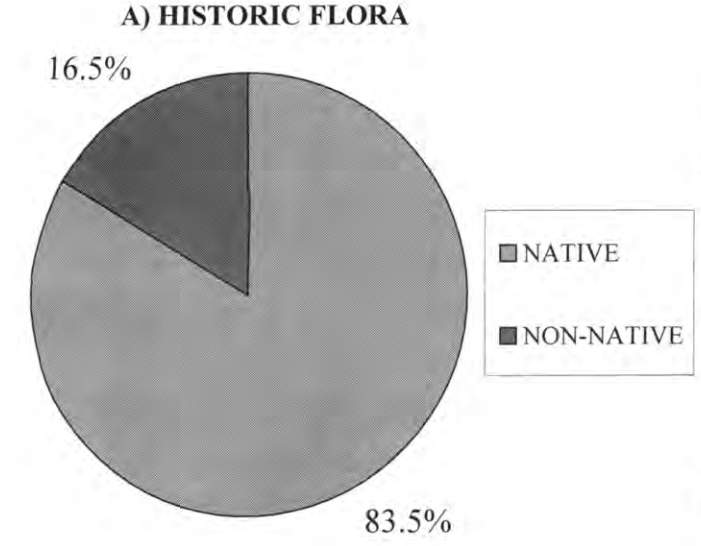

Fig. 1. Proportions of the a) historic (1859–1899) and b) current (1990–2000) Ames floras that are native and non-native.

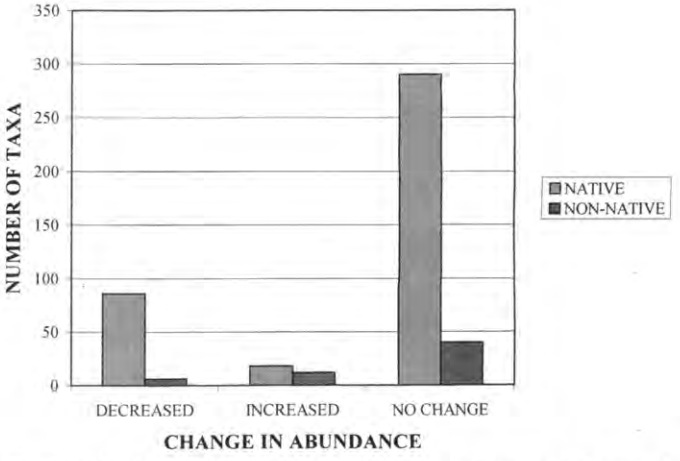

Fig. 2. Numbers of native and non-native taxa that have decreased, increased or not changed in abundance between the historic (1859–1899) and current (1990–2000) inventories of the Ames flora.

fields. Increased urbanization has led to further loss of the historic vegetation. Nevertheless, several remnants of prairie vegetation still exist in Ames. Wetland habitats were also historically common in Ames (Anderson 1996), but only a few wetland tracts currently exist within the inventory boundary. Significant amounts of forest vegetation currently occur in Ames along streams and rivers. Upland forests are dominated by oak species (*Quercus alba* L., *Q. borealis* Michx. f. var. *maxima* (Marsh) Ashe, *Q. macrocarpa* Michx.) and black maple (*Acer nigrum* Michx. f.); bottomland forests have silver maple (*Acer saccharinum* L.), boxelder (*Acer negundo* L.), elm (*Ulmus americana* L., *U. rubra* Muhl.), black walnut (*Juglans nigra* L.) and/or hackberry (*Celtis occidentalis* L.) dominant in their canopies.

Detailed descriptions of these natural habitats in Ames are given by Joens (1978), Norris (1995), Norris and Farrar (1999) and Norris et al. (2001).

METHODS

Documentation of the Historic Ames Flora (1859–1899)

The historic flora of Ames, Iowa has been well studied by botanists associated with the Botany Department at Iowa State University, which is located in Ames. One of the first professors in this department, Charles Bessey, published a flora of Iowa in 1871 in which he listed 452 taxa as occurring in Ames at that time. Less than 20 years later, Albert Hitchcock (1890) published a checklist of the Ames flora (ca. 700 taxa) based on his fieldwork in the city during the 1880s. In his published flora, Hitchcock (1890) assigned an abundance code (common, abundant, frequent, not uncommon, infrequent, scarce, rare) to most taxa listed. These published accounts are supplemented by approximately 1450 herbarium voucher specimens of plants collected in Ames between 1859 and 1899 (deposited in the Ada Hayden Herbarium (ISC), Iowa State University, Ames, IA). These vouchers and the floras published by Bessey (1871) and Hitchcock (1890) have allowed us to reconstruct the late 19th Century flora of Ames.

Table 2. Species that declined in abundance between the late 1880s (Hitchcock 1890) and the current inventory (Norris et al. 2001). Abundance codes assigned to plants in the first inventory are defined in Hitchcock's published flora of Ames (1890); abundance codes assigned to taxa in the current inventory are defined in the text. OR = origin; N = native species; * = non-native species.

OR	Family	Species	Historic Abundance (Hitchcock 1890)	Current Abundance (Norris et al. 2001)
		PTERIDOPHYTES		
N	Adiantaceae	*Adiantum pedatum* L.	abundant	infrequent
N	Aspleniaceae	*Athyrium felix-femina* (L.) Roth var. *angustum* (Willd.) Moore	abundant	infrequent
		DICOTS		
N	Apiaceae	*Eryngium yuccifolium* Michx.	abundant	infrequent
N	Apiaceae	*Oxypolis rigidior* (L.) Raf.	abundant	infrequent
N	Apiaceae	*Sium suave* Walter	frequent	rare
N	Apiaceae	*Taenidia integerrima* (L.) Drude	abundant	rare
N	Apocynaceae	*Apocynum androsaemifolium* L.	frequent	rare
N	Asclepiadaceae	*Asclepias sullivantii* Engelm.	frequent	rare
N	Asclepiadaceae	*Asclepias tuberosa* L. ssp. *interior* Woodson	abundant	rare
N	Asteraceae	*Antennaria plantaginifolia* (L.) Richardson	common	infrequent
*	Asteraceae	*Artemisia biennis* Willd.	frequent	infrequent
N	Asteraceae	*Aster azureus* Lindley	frequent	infrequent
N	Asteraceae	*Aster lanceolatus* Willd.	common	infrequent
N	Asteraceae	*Cacalia plantaginea* (Raf.) Shinners	frequent	infrequent
N	Asteraceae	*Echinacea pallida* Nutt.	abundant	infrequent
N	Asteraceae	*Erigeron philadelphicus* L.	abundant	infrequent
N	Asteraceae	*Eupatorium perfoliatum* L.	common	infrequent
N	Asteraceae	*Euthamia graminifolia* (L.) Nutt. ex Cass.	abundant	infrequent
N	Asteraceae	*Helenium autumnale* L.	common	infrequent
N	Asteraceae	*Helianthus rigidus* (Cas.) Desf.	frequent	infrequent
N	Asteraceae	*Liatris aspera* Michx.	abundant	infrequent
N	Asteraceae	*Liatris pycnostachya* Michx.	abundant	infrequent
N	Asteraceae	*Rudbeckia subtomentosa* Pursh	frequent	rare
N	Asteraceae	*Solidago flexicaulis* L.	frequent	infrequent
N	Asteraceae	*Solidago missouriensis* Nutt.	common	rare
N	Asteraceae	*Verbesina alternifolia* (L.) Britton	frequent	rare
N	Asteraceae	*Vernonia fasciculata* Michx.	common	infrequent
N	Betulaceae	*Corylus americana* Walter	abundant	infrequent
*	Boraginaceae	*Lappula echinata* Gilib.	frequent	infrequent
N	Boraginaceae	*Lithospermum canescens* (Michx.) Lehm.	frequent	infrequent
N	Boraginaceae	*Lithospermum incisum* Lehm.	frequent	rare
N	Brassicaceae	*Cardamine bulbosa* (Schreber) BSP.	frequent	infrequent
*	Brassicaceae	*Erysimum cheiranthoides* L.	common	infrequent
N	Brassicaceae	*Iodanthus pinnatifidus* (Michx.) Steudel	frequent	rare
*	Brassicaceae	*Sinapis arvensis* L.	common	rare
N	Campanulaceae	*Lobelia spicata* Lam.	frequent	infrequent
N	Caprifoliaceae	*Triosteum perfoliatum* L.	abundant	infrequent
N	Caryophyllaceae	*Paronychia canadensis* (L.) Wood	frequent	rare
N	Caryophyllaceae	*Silene stellata* (L.) Aiton	common	infrequent
N	Convolvulaceae	*Cuscuta cephalanthii* Engelm.	frequent	rare
N	Cucurbitaceae	*Echinocystis lobata* (Michx.) T. & G.	frequent	rare
N	Euphorbiaceae	*Acalypha virginica* L.	abundant	rare
N	Euphorbiaceae	*Euphorbia glyptosperma* Engelm.	common	infrequent
N	Fabaceae	*Amorpha canescens* Pursh	common	infrequent
N	Fabaceae	*Amorpha fruticosa* L.	frequent	infrequent
N	Fabaceae	*Astragalus canadensis* L.	frequent	infrequent
N	Fabaceae	*Baptisia lactea* (Raf.) Thieret	frequent	infrequent
N	Fabaceae	*Dalea candida* Willd.	abundant	infrequent
N	Fabaceae	*Desmodium glutinosum* (Muhl. ex Willd.) Wood	common	infrequent

Table 2. Continued.

OR	Family	Species	Historic Abundance (Hitchcock (1890))	Current Abundance (Norris et al. 2001)
N	Fabaceae	*Pediomelum argophyllum* (Pursh) Grimes	abundant	rare
N	Lamiaceae	*Physostegia virginiana* (L.) Bentham	frequent	rare
N	Lamiaceae	*Scutellaria leonardii* Epling	frequent	infrequent
N	Linaceae	*Linum sulcatum* Riddell	frequent	rare
N	Menispermaceae	*Menispermum canadense* L.	frequent	rare
N	Oxalidaceae	*Oxalis violacea* L.	frequent	rare
N	Polygonaceae	*Polygonum ramosissimum* Michx.	frequent	rare
N	Polygonaceae	*Rumex verticillatus* L.	abundant	rare
N	Primulaceae	*Lysimachia hybrida* Michx.	abundant	rare
N	Primulaceae	*Lysimachia quadriflora* Sims	frequent	infrequent
N	Ranunculaceae	*Caltha palustris* L.	frequent	rare
N	Ranunculaceae	*Clematis pitcheri* T. & G.	frequent	infrequent
N	Ranunculaceae	*Clematis virginiana* L.	frequent	infrequent
N	Rhamnaceae	*Ceanothus americanus* L. var. *pitcheri* T. & G.	abundant	rare
N	Rosaceae	*Crataegus punctata* Jacq.	frequent	infrequent
N	Rosaceae	*Malus ioensis* (Wood) Britton	frequent	infrequent
N	Rosaceae	*Potentilla arguta* Pursh	abundant	infrequent
N	Salicaceae	*Salix discolor* Muhl.	common	infrequent
N	Saxifragaceae	*Heuchera richardsonii* L. var. *hirsuticaulis* (Wheelock) Rosend., Butters & Lak.	frequent	infrequent
N	Saxifragaceae	*Penthorum sedoides* L.	common	infrequent
N	Scrophulariaceae	*Agalinis tenuifolia* (Vahl) Raf.	abundant	infrequent
N	Scrophulariaceae	*Pedicularis canadensis* L.	abundant	infrequent
*	Scrophulariaceae	*Verbascum blattaria* L.	abundant	rare
		MONOCOTS		
N	Alismataceae	*Alisma plantago-aquatica* L.	abundant	infrequent
N	Alismataceae	*Sagittaria brevirostra* Mack. & Bush	abundant	infrequent
N	Commelinaceae	*Tradescantia bracteata* Small	frequent	infrequent
N	Cyperaceae	*Carex conjuncta* Boott	common	infrequent
N	Cyperaceae	*Carex sparganioides* Muhl. ex Willd.	common	infrequent
N	Cyperaceae	*Carex stricta* Lam.	common	infrequent
N	Cyperaceae	*Cyperus erythrorhizos* Muhl.	abundant	rare
N	Cyperaceae	*Cyperus filiculmis* Vahl.	frequent	rare
N	Liliaceae	*Hypoxis hirsuta* (L.) Cov.	common	rare
N	Liliaceae	*Uvularia grandiflora* Small	abundant	infrequent
N	Poaceae	*Bouteloua curtipendula* (Michx.) Torrey	common	infrequent
N	Poaceae	*Brachyeletrum erectum* (Schreber) Beauv.	frequent	rare
N	Poaceae	*Bromus pubescens* Muhl. ex Willd.	abundant	rare
N	Poaceae	*Diarrhena americana* Beauv. var. *obovata* Gl.	frequent	infrequent
N	Poaceae	*Dichanthelium latifolium* (L.) Gould & Clark	frequent	rare
N	Poaceae	*Koeleria macrantha* (Ledeb.) Schultes	abundant	infrequent
N	Poaceae	*Phragmites australis* (Cav.) Trin. ex Steudel	frequent	infrequent
N	Poaceae	*Poa palustris* L.	frequent	rare
*	Poaceae	*Setaria italica* (L.) Beauv.	abundant	infrequent
N	Poaceae	*Sporobolus heterolepis* (Gray) Gray	abundant	infrequent

Recent Inventory of the Ames Flora (1990–2000)

The most recent inventory of the Ames flora was initiated in 1991 by the Ames City Planning Office (Norris 1995, Norris and Farrar 1999), which wished to obtain detailed information about the location and natural quality of all forests, prairies and wetlands occurring on land within their jurisdiction. Norris conducted fieldwork (more than 1000 hours) for this initial inventory between 1991 and 1994 and summarized his findings in a report submitted to the City of Ames (Norris 1994).

In his initial inventory, Norris compiled a list of 493 vascular plant species encountered in surveys of Ames forests, prairies and wetlands (Norris 1995) based on sight observations of numerous common plant species as well as field collections of difficult-to-identify species (*Carex* spp., *Polygonum* spp., etc.). Non-native species on this list were restricted to plants observed 1) to have spread from

Table 3. Species that increased in abundance between the late 1880s (Hitchcock 1890) and the current inventory (Norris et al. 2001). In the historic flora, the abundance codes "infrequent," "rare," and "scarce" are defined by Hitchcock (1890); the abundance code "low" is defined in the text. Abundance codes assigned to taxa in the current inventory (Norris et al. 2001) are defined in the text. OR = origin; N = native species; * = non-native species.

OR	Family	Species	Historic Abundance (Hitchcock 1890)	Current Abundance (Norris et al. 2001)
		PTERIDOPHYTES		
N	Ophioglossaceae	*Botrychium virginianum* (L.) Sw.	scarce	common
		DICOTS		
N	Apiaceae	*Chaerophyllum procumbens* (L.) Crantz	infrequent	frequent
*	Asteraceae	*Cirsium vulgare* (Savi) Tenore	infrequent	common
N	Asteraceae	*Helianthus annuus* L.	infrequent	frequent
*	Brassicaceae	*Barbarea vulgaris* R. Br.	infrequent	common
N	Brassicaceae	*Descurainia pinnata* (Walter) Britton var. *brachycarpa* (Richardson) Fern.	infrequent	frequent
*	Brassicaceae	*Hesperis matronalis* L.	low	frequent
N	Campanulaceae	*Lobelia inflata* L.	low	frequent
*	Caryophyllaceae	*Saponaria officinalis* L.	rare	common
*	Caryophyllaceae	*Stellaria media* (L.) Vill.	scarce	common
N	Ceratophyllaceae	*Ceratophyllum demersum* L.	scarce	frequent
N	Chenopodiaceae	*Chenopodium hybridum* L.	infrequent	frequent
N	Cornaceae	*Cornus alternifolia* L. f.	rare	frequent
*	Fabaceae	*Medicago sativa* L.	low	frequent
*	Fabaceae	*Melilotus alba* Medicus	infrequent	common
*	Fabaceae	*Melilotus officinalis* (L.) Pallas	infrequent	common
N	Lamiaceae	*Agastache nepetoides* (L.) Kuntze	infrequent	frequent
*	Lamiaceae	*Leonurus cardiaca* L.	low	common
N	Lythraceae	*Ammania coccinea* Rottb.	scarce	frequent
*	Malvaceae	*Abutilon theophrasti* Medicus	infrequent	common
N	Oleaceae	*Fraxinus americana* L.	rare	frequent
*	Polygonaceae	*Rumex acetosella* L.	infrequent	frequent
*	Scrophulariaceae	*Veronica arvensis* L.	rare	common
N	Ulmaceae	*Celtis occidentalis* L.	infrequent	common
N	Urticaceae	*Urtica dioica* L.	infrequent	frequent
		MONOCOTS		
N	Cyperaceae	*Scirpus fluviatilis* (Torrey) Gray	infrequent	frequent
N	Cyperaceae	*Scirpus pendulus* Muhl.	scarce	frequent
N	Lemnaceae	*Lemna minor* L.	infrequent	common
N	Lemnaceae	*Lemna trisulca* L.	scarce	frequent
N	Poaceae	*Phalaris arundinacea* L.	infrequent	common

their point of introduction and 2) to be successfully reproducing in Ames (thus excluding many escaped crop and ornamental species).

Lewis, Pope, Thompson and Widrlechner joined the project after 1995. They contributed several observations of taxa in Ames since 1990 and conducted additional fieldwork (more than 1000 hours) to document the Ames flora through December 2000. During this phase of the inventory, the authors expanded the realm of survey to include disturbed habitats such as roadsides, old fields, sandbars, construction sites and railroad rights-of-way. This fieldwork resulted in discovery of an additional 423 taxa not encountered by Norris during his initial inventory. The final plant list for Ames (1990–2000) totals 916 taxa (native and naturalized) (Norris et al. 2001).

Based on our observations while conducting fieldwork, we assigned an abundance code (common, frequent, infrequent, rare) to each taxon we encountered during the recent inventory. Definitions for these codes, which appear below, are adapted from those given by Eilers and Roosa (1994):

Common: widely distributed and often found growing in large quantities in several different habitats.
Frequent: widespread but not abundant and usually found in only one type of habitat.
Infrequent: not widespread and often not found in places where it might be expected to occur.
Rare: found in only one or a few places.

Compilation of Plant Species Lists

We compiled separate lists of taxa documented from the "historic" (1859–1899) and "current" (1990–2000) floras of Ames. Each list includes all native and non-native taxa documented from the given

Table 4. Plant taxa documented in the historic flora (1859–1899) but not encountered during the recent (1990–2000) inventory. Abundance codes assigned to these taxa, when available, are from Hitchcock (1890) or are defined in the text. OR = origin; N = native species; * = non-native species.

OR	Family	Species	Historic Abundance (Hitchcock 1890)[1]
		PTERIDOPHYTES	
N	Aspleniaceae	*Onoclea sensibilis* L.	not uncommon
N	Dennstaedtiaceae	*Pteridium aquilinum* (L.) var. *latiusculum* (Desv.) Underw. ex Heller	scarce
N	Osmundaceae	*Osmunda claytoniana* L.	scarce
		DICOTS	
N	Apiaceae	*Angelica atropurpurea* L.	
*	Apiaceae	*Conioselinum chinense* (L.) BSP.	
N	Apiaceae	*Polytaenia nuttallii* DC.	scarce
N	Asclepiadaceae	*Asclepias ovalifolia* Decne.	scarce
N	Asclepiadaceae	*Asclepias purpurascens* L.	not uncommon
*	Asteraceae	*Anthemis arvensis* L.	
*	Asteraceae	*Anthemis nobilis* L.	
N	Asteraceae	*Artemesia dracunculus* L.	not uncommon
N	Asteraceae	*Artemisia serrata* Nutt.	infrequent
N	Asteraceae	*Aster oblongifolius* Nutt.	infrequent
N	Asteraceae	*Aster pubentior* Cronq.	infrequent
N	Asteraceae	*Aster puniceus* L.	not uncommon
N	Asteraceae	*Aster umbellatus* Miller	not uncommon
N	Asteraceae	*Aster* × *amethystinus* Nutt.	scarce
N	Asteraceae	*Boltonia asteroides* (L.) L'Her.	frequent
*	Asteraceae	*Centaurea cyanus* L.	
N	Asteraceae	*Dyossodia papposa* (Vent.) A.S. Hitchc.	frequent
N	Asteraceae	*Eupatorium maculatum* L.	frequent
N	Asteraceae	*Helianthus decapetalus* L.	scarce
N	Asteraceae	*Hieracium longipilum* Torrey	infrequent
N	Asteraceae	*Lactuca biennis* (Moench) Fern.	not uncommon
N	Asteraceae	*Liatris cylindracea* Michx.	frequent
N	Asteraceae	*Prenanthes aspera* Michx.	infrequent
N	Asteraceae	*Senecio aureus* L.	not uncommon
N	Asteraceae	*Senecio pauperculus* Michx.	
N	Boraginaceae	*Lithospermum latifolium* Michx.	scarce
*	Brassicaceae	*Camelina sativa* (L.) Crantz	scarce
N	Brassicaceae	*Draba reptans* (Lam.) Fern.	infrequent
*	Brassicaceae	*Sinapis alba* L.	low
N	Campanulaceae	*Lobelia cardinalis* L.	frequent
N	Capparidaceae	*Polanisia dodecandra* (L.) DC.	abundant
*	Caryophyllaceae	*Agrostemma githago* L.	scarce
*	Caryophyllaceae	*Cerastium glomeratum* Thuill.	
*	Caryophyllaceae	*Spergula arvensis* L.	
N	Caryophyllaceae	*Stellaria longifolia* Muhl ex Willd.	not uncommon
*	Caryophyllaceae	*Vaccaria pyrimidata* Medicus	rare
*	Chenopodiaceae	*Chenopodium botrys* L.	low
N	Chenopodiaceae	*Chenopodium foggii* H. A. Wahl	
N	Chenopodiaceae	*Cenopodium missouriensis* Aellen	
*	Chenopodiaceae	*Chenopodium urbicum* L.	infrequent
N	Chenopodiaceae	*Cycloloma atriplicifolium* (Sprengel) Coulter	
N	Convolvulaceae	*Cuscuta coryli* Engelm.	infrequent
N	Convolvulaceae	*Cuscuta glomerata* Choisy	not uncommon
N	Convolvulaceae	*Cuscuta gronovii* Willd.	frequent
N	Cornaceae	*Cornus rugosa* Lam.	rare
N	Euphorbiaceae	*Euphorbia marginata* Pursh	
N	Euphorbiaceae	*Euphorbia missurica* Raf.	low
*	Euphorbiaceae	*Euphorbia serpyllifolia* Pers.	
N	Fabaceae	*Dalea leporina* (Aiton) Bullock	infrequent
N	Fabaceae	*Dalea villosa* (Nutt.) Sprengel	low
N	Fabaceae	*Desmodium cuspidatum* (Muhl. ex Willd.) Louden	

Table 4. Continued.

OR	Family	Species	Historic Abundance (Hitchcock 1890)[1]
N	Fabaceae	*Desmodium paniculatum* (L.) DC.	abundant
N	Fabaceae	*Desmodium sessilifolium* (Torr.) T. & G.	abundant
N	Fabaceae	*Lathyrus venosus* Muhl. ex Willd.	infrequent
N	Fabaceae	*Lotus purshianus* Clem. & Clem.	
*	Fabaceae	*Trifolium arvense* L.	
*	Fabaceae	*Trifolium aureum* L.	low
N	Gentianaceae	*Gentiana* × *billingtonii* Farw.	
N	Gentianaceae	*Gentianopsis crinita* (Froelich) Ma.	rare
N	Haloragidaceae	*Proserpinaca palustris* L.	scarce
N	Lamiaceae	*Blephilia hirsuta* Benth.	
N	Lamiaceae	*Scutellaria galericulata* L.	rare
N	Malvaceae	*Callirhoe involucrata* (Nutt. ex T. & G.) Gray	
*	Malvaceae	*Malva sylvestris* L.	low
N	Nymphaeaceae	*Nuphar luteum* (L.) Smith	
N	Nymphaeaceae	*Nymphaea tuberosa* Paine	
N	Onagraceae	*Epilobium ciliatum* Raf.	frequent
N	Onagraceae	*Epilobium leptophyllum* Raf.	scarce
N	Onagraceae	*Gaura parviflora* Douglas	
N	Onagraceae	*Ludwigia polycarpa* Short & Peter	frequent
N	Orobanchaceae	*Orobanche uniflora* L.	low
N	Plantaginaceae	*Plantago aristata* Michx.	
N	Polemoniaceae	*Phlox maculata* L.	scarce
N	Polygalaceae	*Polygala incarnata* L.	infrequent
N	Polygalaceae	*Polygala sanguinea* L.	frequent
N	Polygalaceae	*Polygala senega* L.	frequent
N	Polygonaceae	*Polygonum amphibium* L. var. *stipulaceum* (Coleman) Fern.	scarce
*	Polygonaceae	*Polygonum orientale* L.	
N	Polygonaceae	*Rumex orbiculatus* Gray	
N	Ranunculaceae	*Actaea pachypoda* Ell.	scarce
N	Ranunculaceae	*Anemone caroliniana* Walter	infrequent
N	Ranunculaceae	*Pulsatilla patens* (L.) P. Miller ssp. *multifida* (Pritz.) Zemels	rare
N	Ranuculaceae	*Ranunculus cymbalaria* Pursh	scarce
N	Rhamnaceae	*Ceanothus herbaceus* Raf. var. *pubescens* (T. & G.) Shinners	scarce
*	Rosaceae	*Agrimonia eupatoria* L.	abundant
N	Rosaceae	*Agrimonia striata* Michx.	
N	Rosaceae	*Amelanchier humilis* Wieg.	
N	Rosaceae	*Geum laciniatum* Murray	frequent
N	Rosaceae	*Potentilla rivalis* Nutt.	infrequent
N	Rosaceae	*Prunus pensylvanica* L.f.	not uncommon
N	Rubiaceae	*Cephalanthus occidentalis* L.	infrequent
N	Rubiaceae	*Galium tinctorium* L.	common
N	Rubiaceae	*Galium trifidum* L.	common
N	Salicaceae	*Populus tremuloides* Michx.	infrequent
N	Salicaceae	*Salix humilis* Marsh.	frequent
N	Salicaceae	*Salix petiolaris* Smith	
N	Saxifragaceae	*Mitella diphylla* L.	
N	Saxifragaceae	*Parnassia glauca* Raf.	
N	Scrophulariaceae	*Agalinis purpurea* (L.) Pennell	
N	Scrophulariaceae	*Castilleja sessiliflora* Pursh	rare
*	Solanaceae	*Physalis hispida* (Waterfall) Cronq.	frequent
*	Solanaceae	*Physalis pubescens* L. var. *integrifolia* (Dunal) Waterfall	not uncommon
N	Verbenaceae	*Verbena* × *perriana* Moldenke	
N	Violaceae	*Viola pedata* L.	frequent
		MONOCOTS	
N	Alismataceae	*Sagittaria graminea* Michx.	infrequent
N	Alismataceae	*Sagittaria rigida* Pursh	scarce
N	Cyperaceae	*Carex lasiocarpa* Ehrh. var. *americana* Fern.	abundant
N	Cyperaceae	*Carex muskingumensis* Schwein	frequent

Table 4. Continued.

OR	Family	Species	Historic Abundance (Hitchcock 1890)[1]
N	Cyperaceae	*Cyperus diandrus* Torrey	scarce
N	Cyperaceae	*Cyperus schweinitzii* Torrey	frequent
N	Cyperaceae	*Eleocharis acicularis* (L.) R. & S.	common
N	Cyperaceae	*Eriophorum angustifolium* Honck.	frequent
N	Cyperaceae	*Scirpus americanus* Pers.	scarce
N	Hydrocharitaceae	*Elodea canadensis* Michx.	infrequent
N	Juncaginaceae	*Triglochin maritimum* L.	low
N	Liliaceae	*Lilium philadelphicum* L. var. *andinum* (Nutt.) Ker-Gawl.	not uncommon
N	Liliaceae	*Maianthemum canadense* Desf.	low
N	Liliaceae	*Trillium cernuum* L.	
N	Liliaceae	*Trillium flexipes* Raf.	
N	Orchidaceae	*Cypripedium calceolus* L. var. *pubescens* (Willd.) Correll	infrequent
N	Orchidaceae	*Cypripedium candidum* Muhl. ex Willd.	not uncommon
N	Orchidaceae	*Cypripedium reginae* Walter	rare
N	Orchidaceae	*Malaxis unifolia* Michx.	
N	Orchidaceae	*Platanthera hookeri* (Torrey ex Gray) Lindley	
N	Orchidaceae	*Platanthera hyperborea* (L.) R. Br. var. *huronensis* (Nutt.) Luer	
N	Orchidaceae	*Platanthera praeclara* Sheviak & Bowles	infrequent
N	Poaceae	*Agroypyron trachycaulum* (Link) Malte	
N	Poaceae	*Agrostis hyemalis* (Walter) BSP. var. *tenuis* (Tuckerman) Gl.	common
*	Poaceae	*Anthoxanthum odoratum* L.	
N	Poaceae	*Aristida basiramea* Engelm. ex Vasey	
N	Poaceae	*Aristida longespica* Poiret	infrequent
*	Poaceae	*Arrhenatherum elatius* (L.) Presl	
*	Poaceae	*Bromus catharticus* Vahl	
*	Poaceae	*Bromus commutatus* Schrader	
N	Poaceae	*Bromus kalmii* Gray	infrequent
*	Poaceae	*Bromus secalinus* L.	scarce
N	Poaceae	*Calamovilfa longifolia* (Hooker) Scribner	infrequent
N	Poaceae	*Dichanthelium depauperatum* (Muhl.) Gould	
N	Poaceae	*Dichanthelium perlongum* (Nash) Freckm.	
N	Poaceae	*Festuca octoflora* Walter var. *tenella* (Willd.) Fern.	frequent
N	Poaceae	*Festua paradoxa* Desv.	rare
N	Poaceae	*Hierochloe odorata* (L.) Beauv.	
*	Poaceae	*Holcus lanatus* L.	
*	Poaceae	*Lolium temulentum* L.	
N	Poaceae	*Muhlenbergia sobolifera* (Muhl. ex Willd.) Trin.	infrequent
N	Poaceae	*Muhlenbergia sylvatica* (Torrey) Torrey ex Gray	frequent
N	Poaceae	*Poa languida* A.S. Hitchc.	
*	Poaceae	*Sorghum halepense* (L.) Pers.	
N	Poaceae	*Stipa viridula* Trin.	
N	Poaceae	*Zizania aquatica* L.	scarce
N	Pontederiaceae	*Heteranthera dubia* (Jacq.) MacM.	
N	Pontederiaceae	*Pontederia cordata* L.	scarce
N	Potamogetonaceae	*Potamogeton gramineus* L.	infrequent
N	Potamogetonaceae	*Potamogeton illinoensis* Morong	infrequent

[1]Blanks indicate no abundance code available from Hitchcock (1890)

time period. Crop species with no tendency to persist (e.g., *Zea mays* L.) and ornamental species not demonstrated to spread from their point of introduction (e.g., *Syringa vulgaris* L.) were excluded from these lists. Nomenclature for all taxa previously reported in Iowa follows Eilers and Roosa (1994) except for *Rubus* L., which follows Widrlechner (1998). Nomenclature for taxa previously unreported in Iowa follows Gleason and Cronquist (1991), the Great Plains Flora Association (1986), and/or Swink and Wilhelm (1994), with a few exceptions (e.g., *Digitaria bicornis* (Lam.) R.& S., *Poa pratensis* subsp. *angustifolia* (L.) Lej.) for which expert determinations were followed.

To allow further analysis, we categorized all taxa as "native" or "non-native". The latter category includes taxa not native to North America (e.g., *Cerastium vulgatum* L.), taxa native to North America but not to Iowa (e.g., *Catalpa speciosa* Walter) and taxa native to Iowa but introduced in Story County (e.g., *Pinus strobus* L.). We consulted Eilers and Roosa (1994) to determine the origin of all taxa previously

reported from Iowa; for those taxa previously unreported from Iowa, we referred to other standard floristic references (Gleason and Cronquist 1991, the Great Plains Flora Association 1986, Swink and Wilhelm 1994).

Both the current and historic plant lists documenting the Ames flora are based on exhaustive fieldwork conducted over many years. Thus, we are confident that these lists capture the vast majority of plant species occurring in Ames during each time period. However, no botanical inventory results in discovery of every plant species; thus, we acknowledge that our compiled plant lists probably omit a few overlooked taxa.

Analyses of Floristic Change

Our analyses were conducted in three phases. In the first phase, we compared the overall composition of the historic and current floras. Next, we analyzed tendencies of plant species to increase, decrease, or not change in abundance between the two inventories. Finally, we analyzed attributes of "lost" (i.e., documented in Ames prior to 1900 but not encountered by us) and "gained" (i.e., encountered during the current inventory bur not documented in Ames prior to 1900) taxa.

Comparison of Overall Composition. We compared the proportion of native and non-native species between the two floras using a chi-square test of independence with continuity correction (Scheffler 1980). The potential problems of nomenclatural and taxonomic change between the two floras, the veracity of locality information, etc. are discussed in Norris et al. (2001).

Origin of Declining and Increasing Taxa. In the second phase of analysis, we examined tendencies of native and non-native taxa to increase, decline or not change in abundance between the two inventories. For this analysis, we included all taxa encountered during our inventory for which Hitchcock (1890) had assigned an abundance code. In Hitchcock's flora, most taxa were explicitly assigned one of seven abundance codes (common, abundant, frequent, not uncommon, infrequent, scarce, rare) reflecting their frequency of occurrence in Ames during the 1880s. In cases where Hitchcock (1890) recognized two taxa that today are treated as a single taxon, his more frequent abundance code was used for comparisons between the historical and modern datasets. Rarely, Hitchcock omitted the abundance code for a given taxon but provided enough anecdotal information (e.g., "known from a single location", "a few specimens collected from along the railroad", etc.) to allow abundance to be inferred. In these instances, we assigned the abundance code "low" to the taxa in question.

We characterized the abundance of each taxon as having *increased, decreased* or *not changed* between the two inventories as described in Table 1. Then, we calculated the proportions of native and non-native taxa that had increased, decreased or not changed in abundance. Finally, we tested whether the proportions of taxa that had increased, decreased or not changed in abundance were independent of origin (i.e., native versus non-native) by using a chi-square test of independence.

Attributes of "Lost" and "Gained" Taxa. In this final phase of analysis, we examined several attributes of "lost" and "gained" taxa. First, we wanted to know whether the tendency of a taxon to disappear from the flora is independent of origin (i.e., native versus non-native). We categorized all taxa in the historic flora as "persistent" or "lost" relative to the current flora. Then, we tested whether the relative frequencies of "persistent" and "lost" taxa are independent of origin (i.e., native versus non-native) by using a chi-square test of independence with continuity correction. Similarly, we categorized all taxa in the current flora as "persistent" or newly "gained" relative to the historic flora, and tested whether the relative frequencies of "persistent" and "gained" taxa in the current flora are independent of origin with the same statistical test.

Next, we wanted to determine whether the tendency of taxa to be "lost" from the Ames flora is influenced by historic abundance. We first categorized all taxa in the historic flora as "persistent" (i.e., taxa documented in both historic and current floras) or "lost" (i.e., documented in the historic flora but not the current flora). We then tallied the number of "persistent" and "lost" taxa (separately) in each of Hitchcock's (1890) seven abundance categories. Finally, we tested whether the tendency of taxa to drop out of the flora is independent of historic abundance by using a chi-square test of independence.

Finally, we wanted to test whether the tendency of taxa to be newly "gained" to the Ames flora is independent of modern abundance. First, we categorized all taxa in the current flora as "persistent" (defined above) or newly "gained" (i.e., documented from the current flora but not the historic flora). Then, we tallied the number of "persistent" and "gained" taxa (separately) in each of our four abundance categories (Norris et al. 2001). Finally, we tested whether recent entry to the Ames flora is independent of modern abundance patterns by using a chi-square test of independence.

RESULTS

Comparison of Overall Composition

The historic flora had a higher proportion of native species than does the current flora ($\chi^2 = 36.0$, df = 1, $p \leq 0.001$). The historic flora documented by published floras and herbarium voucher specimens totals 796 taxa; of these, 665 taxa (83.5%) are native. Of the 916 taxa encountered during the current inventory, 652 taxa (71.2%) are native. This represents a decline of 12.3% in proportion of native taxa between the two floras (Figs. 1a, 1b).

Changes in Abundance

Native taxa had a greater tendency to decline in abundance and a lesser tendency to increase in abundance than did non-native species ($\chi^2 = 23.2$, df = 2, $p \leq 0.001$) (Tables 2 and 3). Of the 394 native taxa considered in this analysis, 86 (21.8%) declined, 18 (4.6%) increased and 290 (73.6%) did not change in abundance. Of the 58 non-native taxa analyzed for change in abundance over the same time period, 6 (10.3%) declined, 12 (20.7%) increased, and 40 (69.0%) did not change (Fig. 2).

Attributes of "Lost" and "Gained" Taxa

We detected no significant difference in the tendencies of native and non-native species to be "lost" from the flora ($\chi^2 = 0.033$, df = 1, $p \leq 0.86$); 130 of 665 (19.5%) native taxa and 27 of 131 (20.6%) non-native taxa have evidentally become extirpated (Fig. 3). The taxa "lost" between the historic and current Ames floras are listed in Table 4. On the other hand, non-native species had a much higher tendency than native species to enter the flora ($\chi^2 = 160.1$, df = 1, $p \leq 0.001$); 160 of 264 (60.7%) non-native taxa are recent additions to the Ames flora, while only 117 of 652 (17.9%) native taxa have entered the Ames flora since 1900 (Fig. 4). The taxa "gained" by the Ames flora since 1900 are lisred in Table 5.

Less abundant taxa in the historic flora had a greater tendency to disappear from the Ames flora than did more abundant taxa ($\chi^2 = 97.7$, df = 6, $p \leq 0.001$) (Fig. 5). For example, 57.3% of the analyzed taxa "lost" from the Ames flora (55 of 96) were "infrequent," "scarce," or "rare" in the 1880s, although these three categories comprise only 17.0% (84 of 495) of the persistent taxa included in our analysis. Conversely, only 29.2% of the "lost" taxa (28 of 96) were "abundant," "common," or "frequent" in the 1880s, but

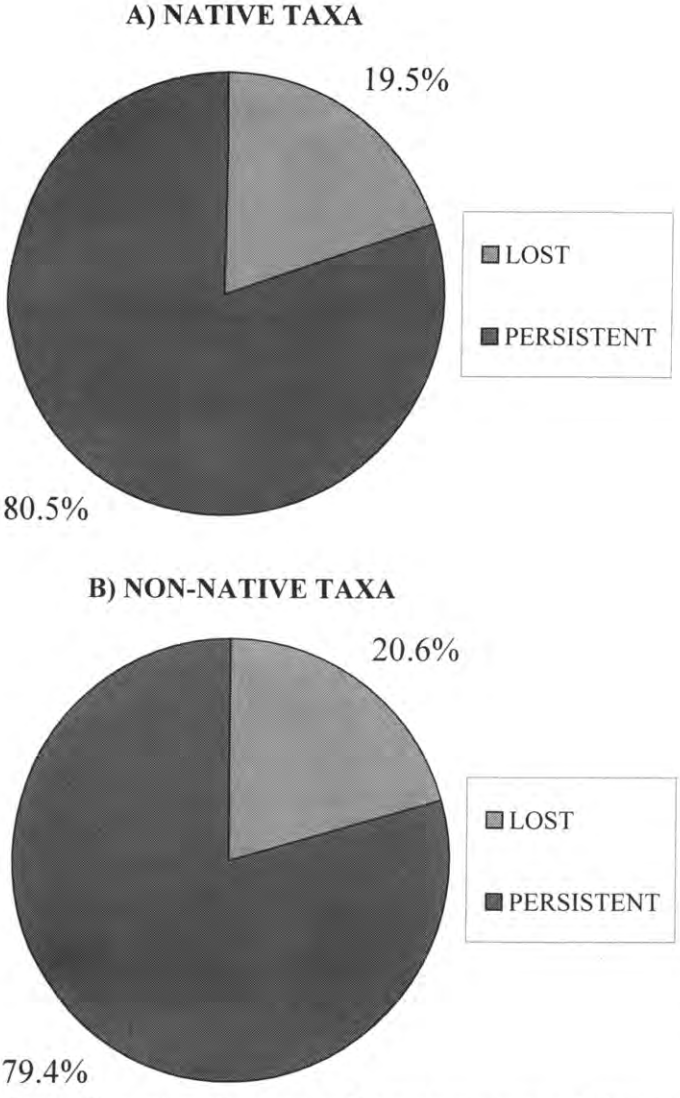

Fig. 3. Proportions of a) native and b) non-native taxa in the historic (1859–1899) Ames flora that are "lost" and "persistent." See text for definitions of "lost" and "persistent" taxa.

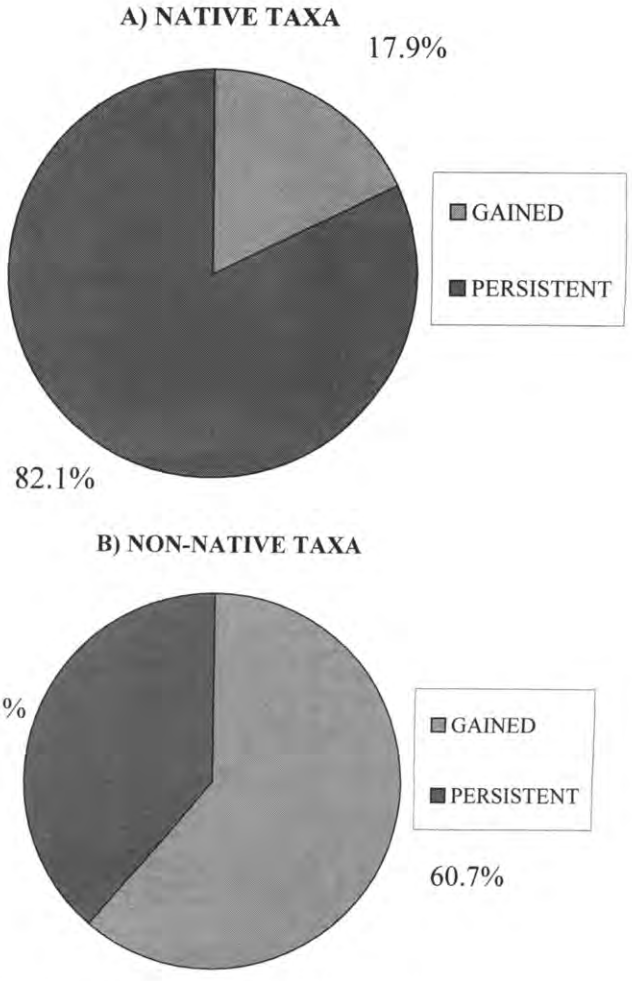

Fig. 4. Proportions of a) native and b) non-native taxa in the current (1990–2000) Ames flora that are "gained" and "persistent." See text for definitions of "gained" and "persistent" taxa.

taxa in these same abundance categories comprise 71.7% (355 of 495) of persistent taxa.

Finally, the tendency to be recently "gained" by the Ames flora is not independent of modern abundance patterns ($\chi^2 = 189.6$, df = 3, $p \leq 0.001$) (Fig. 6). Of the recent additions to the Ames flora, most (87.7%; 243 of 277 taxa) currently have infrequent or rare abundance, even though infrequent and rare taxa comprise only 42.6% (272 of 639) of persistent taxa.

DISCUSSION

The overriding message of this research is that the Ames flora is dynamic, with both the addition and deletion of species having effects on the composition of the current flora. Although the *numbers* of native taxa in the historic (665) and current (652) Ames floras are roughly equal, the *proportion* of native taxa in the Ames flora has declined 12.3% (relative to the historic flora). Similarly, a decline of about 14% in the proportion of native species was reported for the flora of Staten Island (NY) over 112 years (Robinson et al. 1994). This decline in the *proportion* of native taxa in the Ames flora is due primarily to the much higher *number* of non-native taxa in the current flora (264) than are documented from the historic flora (132).

It is clear that the native, historic flora of Ames is gradually being augmented by non-native species. Of the 277 taxa "gained" in the current Ames flora (Table 5), 160 of them (57.8%) are non-native. Although only 20 (12.5%) of these non-native taxa are currently common or frequent in the Ames flora, this subset contains seven taxa which are problematic invasive species in Iowa's natural areas (Lewis 1998, Farrar 2001). These are Japanese barberry (*Berberis thunbergii* DC.), crown vetch (*Coronilla varia* L.), Amur honeysuckle (*Lonicera maackii* (Rupr.) Herder), white mulberry (*Morus alba* L.), European buckthorn (*Rhamnus cathartica* L.), multiflora rose (*Rosa multiflora* Thunb. ex Murray), and Siberian elm (*Ulmus pumila* L.). Among the 140 infrequent and rare non-native taxa newly "gained" to the Ames flora are four additional species that may prove invasive in Ames: garlic mustard (*Alliaria petiolata* (Bieb.) Cav. & Grande), leafy spurge (*Euphorbia esula* L.), purple loosestrife (*Lythrum salicaria* L.) and Osage orange (*Maclura pomifera* (Raf. ex. Sarg.) Schneider). We expect some of these latter species, especially garlic mustard, to become much more conspicuous in Ames in the near future.

It is remarkable that Ames retains so much of its original native flora; 535 of 665 native taxa in the historic flora (80.5%) still occur

Table 5. Plant taxa encountered during the recent (1990–2000) inventory but absent from the historic flora (1859–1899). Abundance codes assigned to these taxa are from Norris et al. (2001) and are defined in the text. OR = origin; N = native species; * = non-native species.

OR	Family	Species	Current Abundance (Norris et al. 2001)
		PTERIDOPHYTES	
N	Aspleniaceae	*Asplenium platyneuron* (L.) Oakes ex D.C. Eaton	rare
N	Aspleniaceae	*Dryopteris carthusiana* (Vill.) H.P. Fuchs	rare
N	Equisetaceae	*Equisetum* × *ferrissii* Clute	frequent
N	Ophioglossaceae	*Botrychium dissectum* Sprengel f. *obliquum* (Muhl.) Clute	rare
N	Ohioglossaceae	*Botrychium dissectum* Sprengel f. *dissectum*	rare
		GYMNOSPERMS	
*	Pinaceae	*Pinus strobus* L.	rare
		DICOTS	
*	Aceraceae	*Acer ginnala* Maxim.	infrequent
*	Amaranthaceae	*Amaranthus hybridus* L.	rare
*	Amaranthaceae	*Amaranthus powellii* S. Watson	rare
*	Anacardiaceae	*Rhus aromatica* Aiton	rare
*	Anacardiaceae	*Rhus typhina* L.	rare
*	Apiaceae	*Conium maculatum* L.	frequent
*	Apocynaceae	*Vinca minor* L.	rare
N	Asclepiadaceae	*Asclepias amplexicaulis* Smith	rare
N	Asclepiadaceae	*Cynanchum laeve* (Michx.) Pers.	frequent
*	Asteraceae	*Artemisia absinthium* L.	rare
*	Asteraceae	*Artemisia annua* L.	infrequent
*	Asteraceae	*Artemisia vulgaris* L.	rare
N	Asteraceae	*Aster cordifolius* L. × *A. drummondii* Lindley	infrequent
N	Asteraceae	*Aster pilosus* Willd.	common
N	Asteraceae	*Aster sagittifolius* Willd.	infrequent
N	Asteraceae	*Bidens polylepis* Blake	infrequent
*	Asteraceae	*Boltonia decurrens* (Torr. & A. Gray) A.W. Wood	rare
*	Asteraceae	*Carduus acanthoides* L.	rare
*	Asteraceae	*Carthamus tinctorius* L.	rare
*	Asteraceae	*Cichorium intybus* L.	infrequent
*	Asteraceae	*Coreopsis tinctoria* Nutt.	rare
*	Asteraceae	*Crepis capillaris* (L.) Wallr.	rare
*	Asteraceae	*Crepis tectorum* L.	rare
*	Asteraceae	*Echinacea purpurea* (L.) Moench	rare
N	Asteraceae	*Eclipta alba* (L.) Hassk.	rare
*	Asteraceae	*Gaillardia pulchella* Foug.	rare
*	Asteraceae	*Galinsoga quadriradiata* Ruiz & Pavon	infrequent
N	Asteraceae	*Gnaphalium obtusum* L.	infrequent
N	Asteraceae	*Grindelia squarrosa* (Pursh) Dunal	rare
N	Asteraceae	*Helianthus maximiliani* Schrader	infrequent
*	Asteraceae	*Hieracium piloselloides* Villars.	rare
N	Asteraceae	*Iva xanthifolia* Nutt.	rare
N	Asteraceae	*Lactuca tatarica* (L.) C.A. Meyer ssp. *pulchella* (Pursh) Stebbins	rare
*	Asteraceae	*Lapsana communis* L.	rare
*	Asteraceae	*Matricaria matricarioides* (Less.) Porter	common
*	Asteraceae	*Ratibida columnifera* (Nutt.) Wooton & Standley	rare
*	Asteraceae	*Senecio vulgaris* L.	infrequent
N	Asteraceae	*Silphium integrifolium* Michx.	rare
*	Asteraceae	*Sonchus arvensis* L.	infrequent
*	Asteraceae	*Taraxacum laevigatum* (Willd.) DC.	infrequent
*	Asteraceae	*Tragopogon dubius* Scop.	frequent
N	Asteraceae	*Vernonia baldwinii* Torrey	rare
*	Berberidaceae	*Berberis thunbergii* DC.	frequent
*	Bignoniaceae	*Campsis radicans* (L.) Seem. ex Bureau	rare
*	Bignoniaceae	*Catalpa speciosa* Warder	infrequent
*	Brassicaceae	*Alliaria petiolata* (Bieb.) Cavara & Grande	infrequent
*	Brassicaceae	*Arabidopsis thaliana* (L.) Heynh.	rare

Table 5. Continued.

OR	Family	Species	Current Abundance (Norris et al. 2001)
N	Brassicaceae	*Arabis glabra* (L.) Bernh.	rare
*	Brassicaceae	*Berteroa incana* (L.) DC.	infrequent
*	Brassicaceae	*Brassica campestris* L.	infrequent
*	Brassicaceae	*Brassica junea* (L.) Czern.	frequent
*	Brassicaceae	*Camelina microcarpa* Andrz. ex DC.	rare
*	Brassicaceae	*Cardamine flexuosa* With.	rare
*	Brassicaceae	*Cardaria draba* (L.) Desv.	rare
*	Brassicaceae	*Chorispora tenella* (Pallas) DC.	rare
*	Brassicaceae	*Descurainia sophia* (L.) Webb ex Prantl	rare
*	Brassicaceae	*Erysimum diffusum* Ehrh.	rare
*	Brassicaceae	*Erysimum hieraciifolium* L.	rare
*	Brassicaceae	*Erysimum repandum* L.	frequent
*	Brassicaceae	*Lepidium campestre* (L.) R. Br.	infrequent
*	Brassicaceae	*Rorippa austriaca* (Crantz) Besser	rare
N	Brassicaceae	*Sibara virginica* (L.) Roll.	rare
*	Brassicaceae	*Sisymbrium loeselii* L.	infrequent
*	Brassicaceae	*Thlaspi arvensis* L.	common
*	Campanulaceae	*Campanula rapunculoides* L.	infrequent
*	Capparidaceae	*Cleome hassleriana* Chodat	rare
*	Caprifoliaceae	*Lonicera maackii* (Rupr.) Herder	common
*	Caprifoliaceae	*Lonicera* × *bella* Zabel	infrequent
*	Caprifoliaceae	*Viburnum lantana* L.	rare
*	Caprifoliaceae	*Viburnum opulus* L.	infrequent
*	Caryophyllaceae	*Arenaria serpyllifolia* L.	rare
*	Caryophyllaceae	*Cerastium vulgatum* L.	common
*	Caryophyllaceae	*Dianthus armeria* L.	infrequent
*	Caryophyllaceae	*Holosteum umbellatum* L.	rare
*	Caryophyllaceae	*Myosoton aquaticum* (L.) Moench	rare
*	Caryophyllaceae	*Sagina procumbens* L.	rare
*	Caryophyllaceae	*Silene cserei* Baumg.	infrequent
*	Caryophyllaceae	*Spergularia marina* (L.) Griseb.	rare
*	Celastraceae	*Euonymus alatus* (Thunb.) Sieb.	rare
N	Chenopodiaceae	*Atriplex patula* L.	infrequent
*	Chenopodiaceae	*Bassia hyssopifolia* (Pallas) Kuntze	rare
*	Chenopodiaceae	*Chenopodium bushianum* Aellen	rare
*	Chenopodiaceae	*Chenopodium glaucum* L.	rare
*	Chenopodiaceae	*Kochia scoparia* (L.) Schrader	infrequent
*	Chenopodiaceae	*Salsola collina* Pallas	frequent
*	Chenopodiaceae	*Salsola iberica* Sennen	rare
N	Convolvulaceae	*Cuscuta pentagona* Engelm.	infrequent
*	Convolvulaceae	*Ipomoea hederacea* (L.) Jacq.	rare
*	Cornaceae	*Cornus stolonifera* Michx.	rare
*	Crassulaceae	*Sedum kamtschaticum* Fisch. & C.A. Meyer	rare
*	Elaeagnaceae	*Elaeagnus angustifolia* L.	rare
N	Euphorbiaceae	*Croton glandulosus* L. var. *septentrionalis* Mueller-Arg.	rare
N	Euphorbiaceae	*Euphorbia dentata* Michx.	frequent
*	Euphorbiaceae	*Euphorbia esula* L.	rare
N	Euphorbiaceae	*Euphorbia serpens* HBK.	frequent
N	Fabaceae	*Cassia marilandica* L.	rare
*	Fabaceae	*Cercis canadensis* L.	infrequent
*	Fabaceae	*Coronilla varia* L.	frequent
N	Fabaceae	*Crotalaria sagittalis* L.	rare
*	Fabaceae	*Lathyrus latifolius* L.	rare
*	Gentianaceae	*Centaurium pulchellum* (Schwartz) Druce	rare
N	Geraniaceae	*Geranium carolinianum* L.	rare
*	Geraniaceae	*Geranium sibiricum* L.	rare
N	Hippocastanaceae	*Aesculus glabra* Willd.	rare
*	Hypericaceae	*Hypericum perforatum* L.	infrequent
N	Hypericaceae	*Hypericum prolificum* (Spach) Steudel	rare

Table 5. Continued.

OR	Family	Species	Current Abundance (Norris et al. 2001)
*	Lamiaceae	*Ajuga reptans* L.	rare
N	Lamiaceae	*Dracocephalum parviflorum* Nutt.	rare
*	Lamiaceae	*Lamium amplexicaule* L.	infrequent
N	Lamiaceae	*Lycopus* × *sherardii* Steele	rare
*	Lamiaceae	*Perilla frutescens* (L.) Britton	rare
N	Lamiaceae	*Physostegia parviflora* Nutt. ex Gray	infrequent
*	Lamiaceae	*Salvia nemorosa* L.	rare
*	Lythraceae	*Lythrum salicaria* L.	rare
*	Malvaceae	*Alcea rosea* L.	rare
N	Malvaceae	*Hibiscus laevis* All.	rare
*	Malvaceae	*Napaea dioica* L.	rare
*	Malvaceae	*Sida spinosa* L.	rare
*	Moraceae	*Humulus japonicus* Sieb.	rare
*	Moraceae	*Maclura pomifera* (Raf. ex Sarg.) Schneider	rare
*	Moraceae	*Morus alba* L.	common
N	Nyctaginaceae	*Mirabilis albida* (Walter) Heimerl	rare
*	Oleaceae	*Ligustrum obtusifolium* Sieb. & Zucc.	rare
*	Oleaceae	*Ligustrum vulgare* L.	rare
N	Onagraceae	*Oenothera parviflora* L.	infrequent
N	Onagraceae	*Gaura biennis* L.	rare
*	Papaveraceae	*Fumaria officinalis* L.	rare
N	Phytolaccaceae	*Phytolacca americana* L.	rare
N	Plantaginaceae	*Plantago patagonica* Jacq.	rare
*	Polemoniaceae	*Phlox paniculata* L.	rare
N	Polygonaceae	*Polygonum achoreum* Blake	frequent
*	Polygonaceae	*Polygonum cuspidatum* Sieb. & Zucc.	rare
N	Polygonaceae	*Rumex mexicanus* Meisner	rare
*	Polygonaceae	*Rumex patientia* L.	rare
*	Polygonaceae	*Rumex stenophyllum* Ledeb.	infrequent
N	Primulaceae	*Androsace occidentalis* L.	rare
*	Ranunculaceae	*Ranunculus testiculatus* Crantz	rare
*	Ranunculus	*Consolida ambigua* (L.) Ball & Heywood	rare
*	Rhamnaceae	*Rhamnus cathartica* L.	common
*	Rhamnaceae	*Rhamnus utilis* Decne.	frequent
*	Rosaceae	*Cotoneaster multiflora* Bunge	rare
N	Rosaceae	*Crataegus succulenta* Schrader ex Link	rare
*	Rosaceae	*Duchesnea indica* (Andrews) Focke	infrequent
N	Rosaceae	*Fragaria vesca* L. var. *americana* Porter	rare
N	Rosaceae	*Geum aleppicum* Jacq. var. *strictum* (Aiton) Fern.	rare
*	Rosaceae	*Physocarpus opulifolius* (L.) Maxim.	rare
*	Rosaceae	*Potentilla argentea* L.	rare
*	Rosaceae	*Potentilla recta* L.	frequent
N	Rosaceae	*Prunus mexicana* S. Watson	frequent
*	Rosaceae	*Prunus tomentosa* Thunb.	infrequent
N	Rosaceae	*Rosa carolina* L.	frequent
*	Rosaceae	*Rosa eglanteria* L.	rare
*	Rosaceae	*Rosa multiflora* Thunb. ex Murray	common
N	Rosaceae	*Rosa setigera* Michx.	rare
N	Rosaceae	*Rubus ablatus* Bailey	infrequent
N	Rosaceae	*Rubus allegheniensis* Porter ex Bailey	infrequent
*	Rosaceae	*Rubus caesius* L.	rare
N	Rosaceae	*Rubus frondosus* Bigel.	rare
*	Rosaceae	*Rubus parvifolius* L.	frequent
N	Rubiaceae	*Galium boreale* L.	rare
N	Rubiaceae	*Galium circaezans* Michx.	infrequent
N	Rutaceae	*Ptelea trifoliata* L.	rare
*	Salicaceae	*Populus alba* L.	infrequent
*	Salicaceae	*Salix fragilis* L.	rare

Table 5. Continued.

OR	Family	Species	Current Abundance (Norris et al. 2001)
*	Scrophulariaceae	*Chaenorrhinum minus* (L.) Lange	infrequent
N	Scrophulariaceae	*Chelone glabra* L.	rare
N	Scrophulariaceae	*Dasistoma macrophylla* (Nutt.) Raf.	rare
N	Scrophulariaceae	*Lindernia anagallidea* (Michx.) Pennell	rare
*	Scrophulariaceae	*Penstemon digitalis* Nutt.	rare
*	Scrophulariaceae	*Veronica polita* Fries	rare
*	Simaroubaceae	*Ailanthus altissima* (P. Miller) Swingle	infrequent
*	Solanaceae	*Datura wrightii* Regel	rare
*	Solanaceae	*Lycium halimifolium* P. Miller	rare
*	Solanaceae	*Petunia axillaris* (Lam.) BSP.	rare
*	Solanaceae	*Solanum dulcamara* L.	infrequent
*	Solanaceae	*Solanum rostratum* Dunal	infrequent
*	Ulmaceae	*Ulmus pumila* L.	common
*	Ulmaceae	*Ulmus pumila* L. × *U. americana* L.	rare
*	Ulmaceae	*Ulmus pumila* L. × *U. rubra* Muhl.	infrequent
N	Urticaceae	*Boehmeria cylindrica* (L.) Sw.	rare
N	Verbenaceae	*Phyla lanceolata* (Michx.) Greene	infrequent
N	Verbenaceae	*Verbena* × *deamii* Moldenke	rare
N	Verbenaceae	*Verbena* × *engelmannii* Moldenke	rare
N	Verbenaceae	*Verbena* × *rydbergii* Moldenke	infrequent
*	Violaceae	*Viola canadensis* (L.) Britton	rare
N	Violaceae	*Viola rafinesquii* Greene	rare
N	Violaceae	*Viola sororia* Willd. × *V. pedatifida* G. Don	rare
*	Violaceae	*Viola tricolor* L.	rare
*	Vitaceae	*Ampelopsis brevipedunculata* (Maxim.) Trautv.	rare
*	Vitaceae	*Parthenocissus tricuspidata* (Sieb. & Zucc.) Planchon	rare
*	Asteraceae	*Boltonia decurrens* (T. & G.) A. Wood.	rare
		MONOCOTS	
N	Alismataceae	*Echinodorus cordifolius* (L.) Griseb.	rare
N	Alismataceae	*Sagittaria australis* (J.G. Smith) J.K. Small	rare
*	Commelinaceae	*Commelina communis* L.	infrequent
N	Cyperaceae	*Carex aggregata* Mack.	rare
N	Cyperaceae	*Carex annectens* (Bickn.) Bickn. var. *xanthocarpa* (Bickn.) Wieg.	infrequent
N	Cyperaceae	*Carex atherodes* Sprengel × *C. trichocarpa* Schkuhr	rare
N	Cyperaceae	*Carex bebbii* (Bailey) Fern.	infrequent
N	Cyperaceae	*Carex crawei* Dewey	rare
N	Cyperaceae	*Carex crawfordii* Fern.	rare
N	Cyperaceae	*Carex frankii* Kunth	rare
N	Cyperaceae	*Carex haydenii* Dewey	infrequent
N	Cyperaceae	*Carex hitchockiana* Dewey	infrequent
N	Cyperaceae	*Carex jamesii* Schwein.	frequent
N	Cyperaceae	*Carex leavenworthii* Dewey	rare
N	Cyperaceae	*Carex mesochorea* Mack.	rare
N	Cyperaceae	*Carex prairea* Dewey	rare
N	Cyperaceae	*Carex stipata* Muhl. ex Willd.	rare
N	Cyperaceae	*Carex tetanica* Schkuhr	rare
N	Cyperaceae	*Carex vesicaria* L.	frequent
N	Cyperaceae	*Cyperus acuminatus* Torrey & Hooker	infrequent
N	Cyperaceae	*Eleocharis engelmannii* Steudel	rare
N	Cyperaceae	*Eleocharis macrostachya* Britton	infrequent
N	Cyperaceae	*Eleocharis obtusa* (Willd.) Schultes	infrequent
N	Cyperaceae	*Scirpus acutus* Muhl. ex Bigelow	rare
N	Juncaceae	*Juncus balticus* Willd. var. *littoralis* Engelm.	rare
N	Juncaceae	*Juncus nodosus* L.	rare
N	Lemnaceae	*Wolffia columbiana* Karsten	rare
*	Liliaceae	*Allium vineale* L.	rare
*	Liliaceae	*Convallaria officinalis* L.	rare
*	Liliaceae	*Erythronium americanum* Ker-Gawl.	rare

Table 5. Continued.

OR	Family	Species	Current Abundance (Norris et al. 2001)
*	Liliaceae	*Hemerocallis fulva* (L.) L.	frequent
*	Liliaceae	*Ornithogalum umbellatum* L.	rare
*	Liliaceae	*Scilla sibirica* Haw.	infrequent
*	Liliaceae	*Trillium nivale* Riddell	rare
N	Najadaceae	*Najas guadalupensis* (Sprengel) Magnus	rare
N	Orchidaceae	*Corallorhiza odontorhiza* (Willd.) Nutt.	rare
*	Orchidaceae	*Epipactis helleborine* (L.) Crantz.	rare
N	Orchidaceae	*Liparis loeselii* (L.) L.C. Rich.	rare
N	Orchidaceae	*Spiranthes magnicamporum* Sheviak	rare
N	Orchidaceae	*Spiranthes ovalis* Lindley	rare
N	Poaceae	*Agrostis stolonifera* L. var. *palustris* (Hudson) Farw.	infrequent
N	Poaceae	*Alopecurus aequalis* Sobol.	rare
N	Poaceae	*Aristida oligantha* Michx.	frequent
*	Poaceae	*Buchloe dactyloides* (Nutt.) Engelm.	infrequent
N	Poaceae	*Calamagrostis inexpansa* Gray	rare
*	Poaceae	*Chloris verticillata* Nutt.	rare
*	Poaceae	*Cynodon dactylon* (L.) Pers.	rare
N	Poaceae	*Dichanthelium acuminatum* (Sw.) Gould	rare
N	Poaceae	*Dichanthelium oligosanthes* (Schultes) Gould	rare
N	Poaceae	*Dichanthelium oligosanthes* (Schultes) Gould var. *wilcoxianum* (Vasey) Gould & Clark	rare
*	Poaceae	*Digitaria bicornis* (Lam.) R. & S.	rare
N	Poaceae	*Elymus riparius* Wieg.	rare
N	Poaceae	*Eragrostis spectabilis* (Pursh) Steudel	rare
N	Poaceae	*Eragrostis trichodes* (Nutt.) Wood	rare
*	Poaceae	*Eriochloa villosa* (Thunb.) Kunth	infrequent
*	Poaceae	*Festuca arundinacea* Schreber	infrequent
*	Poaceae	*Festuca myuros* L.	rare
N	Poaceae	*Festuca ovina* L.	rare
*	Poaceae	*Festuca pratensis* Hudson	rare
*	Poaceae	*Festuca rubra* L.	rare
*	Poaceae	*Festuca trachyphylla* (Hackel) Krajina	rare
N	Poaceae	*Glyceria grandis* S. Watson	infrequent
*	Poaceae	*Hordeum pusillum* Nutt.	infrequent
N	Poaceae	*Leptochloa fascicularis* (Lam.) Gray var. *acuminata* (Nash) Gl.	infrequent
*	Poaceae	*Miscanthus sacchariflorus* (Maxim.) Hackel	infrequent
N	Poaceae	*Muhlenbergia asperifolia* (Nees & Meyer) Parodi	rare
N	Poaceae	*Muhlenbergia bushii* Pohl	infrequent
*	Poaceae	*Panicum miliaceum* L.	rare
N	Poaceae	*Paspalum setaceum* Michx. var. *ciliatifolium* (Michx.) Vasey	rare
*	Poaceae	*Poa annua* L.	common
*	Poaceae	*Poa pratensis* L. ssp. *angustifolia* (L.) Lej.	rare
*	Poaceae	*Poa trivialis* L.	rare
*	Poaceae	*Puccinellia distans* (Jacq.) Parl.	rare
*	Poaceae	*Sclerochloa dura* (L.) Beauv.	rare
*	Poaceae	*Setaria faberi* Herrm.	common
*	Poaceae	*Setaria verticillata* (L.) Beauv.	rare
N	Poaceae	*Tridens flavus* (L.) Hitchc.	rare
N	Potamogetonaceae	*Potamogeton pectinatus* L.	infrequent
N	Potamogetonaceae	*Potamogeton pusillus* L.	rare
N	Typhaceae	*Typha angustifolia* L.	frequent
N	Typhaceae	*Typha* × *glauca* Godron	frequent

in Ames. However, our results suggest that native taxa have a greater tendency to decline and a reduced tendency to increase in abundance than do non-native taxa ($p \leq 0.001$). These results demonstrate the importance of Ames natural areas (Norris et al. 2001) in providing crucial habitat for susceptible native plant species; thus, we recommend the continued long-term preservation and management of natural areas in this city.

Once reduced to low abundance, plant species in Ames (regardless of origin) are more likely to be "lost" from the flora than are more common species ($p < .001$). Uncommon plant species are especially

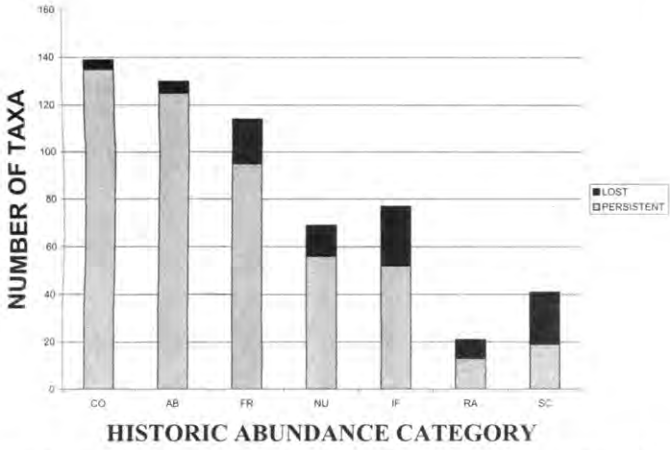

Fig. 5. Numbers of "lost" and "persistent" taxa in the historic (1859–1899) Ames flora assigned to seven abundance categories by Hitchcock (1890). CO = common, AB = abundant, FR = frequent, NU = not uncommon, IF = infrequent, RA = rare, SC = scarce. See text for definitions of "lost" taxa, "persistent" taxa and abundance categories.

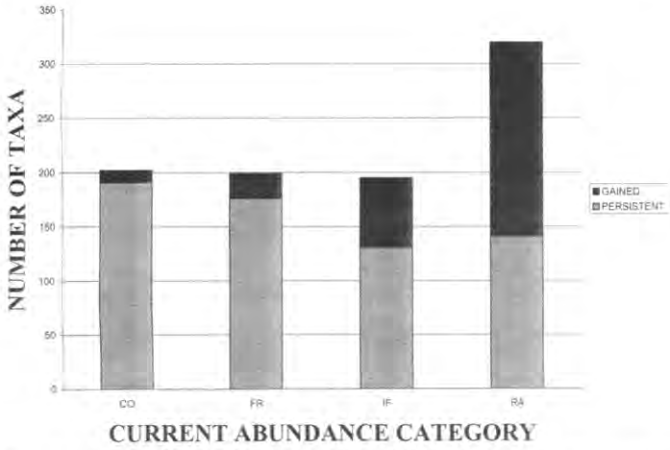

Fig. 6. Numbers of "gained" and "persistent" taxa in the current (1990–2000) Ames flora assigned to four abundance categories by Norris et al. (2001). CO = common, FR = frequent, IF = infrequent, RA = rare. See text for definitions of "gained" taxa, "persistent" taxa and abundance categories.

prone to extirpation because reproductive failure in a given year and/or climatic variation over time (e.g., floods, drought) have potentially high impacts on small populations (Shaffer 1981, Robinson et al. 1994). Furthermore, populations of rare plant species face the threat of encroachment by invasive plant species (Table 5 in Lewis 1998) into their native habitats. We therefore recommend that populations of infrequent and rare native plant species in Ames (Appendix 1 in Norris et al. 2001) be monitored so that potential threats to their habitats (urban development, encroachment by invasive species, etc.) can be minimized or eliminated.

If not for the thorough documentation of the Ames flora historically and recently, the analyses presented in this paper would not have been possible. Obviously, human settlement and land use have had dramatic impacts on natural vegetation throughout Iowa. Mostly, these changes in the Iowa flora proceed with very little documentation. Although floristic work seems to be out of vogue in academia at the present time (Lewis 1998, Norris et al. 2001), we argue that a renewal of long-term (ongoing and/or periodic) floristic work in Iowa and elsewhere is desperately needed. The data collected from such work permit continued analysis of floristic change, more informed decisions by government agencies, developers and conservationists, heightened awareness of native plants among the general public, and more effective stewardship of natural areas (public and private).

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