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Seventy species and hybrids of exotic woody trees, shrubs, and vines have naturalized in Iowa. Nearly half of these species (31) have become invasive pests in parts of the state or have potential do so. Most of the seriously invasive species are spread by bird ingestion of whole fruits. Widespread dispersal by birds hinders eradication efforts and should be considered a trait indicative of potential invasiveness. The economic and ecological values of Iowa forests are seriously compromised by exotic invasive woody species, especially where forests recovering from cropland and pasture are dominated by exotic species. Thus, a simple measure of acres under forest cover is a misleading indicator of the health of Iowa's forest resource.

INDEX DESCRIPTORS: exotic species, forest health, Iowa forests, invasive plants.

Exotic woody plant species are common in Iowa, often dominating disturbed areas. Some, such as multiflora rose (*Rosa multiflora* Thunb. ex Murray), are notorious pests. However, because no formal accounting of exotic and/or invasive woody species in Iowa has heretofore been published, it is difficult to assess whether the problem of woody invasive species is increasing. What I attempt here is to list those woody species considered to be exotic in Iowa at this time and to identify those considered to be most problematic. Quantitative assessments of exotic species abundances are desirable, but are beyond the scope of this paper.

A listing of exotic/invasive species is not as straightforward as it might seem. "Invasive" implies rapid spread and displacement of other species. Not all exotics are invasive, and not all problem invaders are exotic. Eastern red cedar (*Juniperus virginiana* L.), smooth sumac (*Rhus glabra* L.) and trembling aspen (*Populus tremuloides* Michx.) are certainly invasive into Iowa's prairie remnants, but these are native to Iowa and probably native to the fringes of Iowa's original prairie where they were held in check by recurring prairie fires. "Exotic" is a relative term that can be used restrictively to include only non-North American taxa. It can also include North American species such as Osage orange or hedgeapple (*Maclura pomifera* Raf. ex Sarg.) that are widespread and invasive in southern Iowa pastures, but probably not native to Iowa. There are also a large number of exotic species by either definition that are grown in Iowa but not known to reproduce on here their own (i.e., have not become naturalized). If our goal is to identify and rank those species that are problematic or potentially problematic in their displacement of native Iowa species in natural habitats, then it is prudent to construct a list that includes all naturalized species not native to the state.

METHODS

The Vascular Plants of Iowa checklist (Eilers and Roosa 1994) was used to construct an initial list of non-native woody species that have become naturalized in the state. To the list thus generated, were added species known from other sources (e.g., Lewis 1998, Widrlechner 1998, Norris et al. 2001) and from personal observation to have naturalized in Iowa. This list was annotated as to invasiveness and principal means of dispersal on the basis of personal experience and in consultation with Mark Widrlechner and others. A short list of the most problematic species was similarly developed and analyzed. Nomenclature in these lists follows Eilers and Roosa (1994) and, for species not previously included in their list of Iowa vascular plants, Gleason and Cronquist (1991) or Rehder (1940).

RESULTS AND DISCUSSION

Seventy exotic woody species and hybrids are known to be naturalized in Iowa (Table 1). Thirty-one of these form a core list of species known to be invasive in some areas of the state or considered to be potentially invasive. The remaining species have only rare naturalized occurrence, have only vegetative persistence or for other reasons have low potential for invasiveness. It must be noted that the list contains some species that might be native to Iowa (e.g., red maple, *Acer rubrum* L.) and excludes others (e.g., pecan, *Carya illinoensis* (Wang.) K. Koch) that might owe their presence in Iowa to human introduction. Relative to the total number of woody plants listed by Eilers and Roosa (1994) plus the species added from recent studies, these 70 species and hybrids constitute more than 25% of all woody species native or naturalized in the state.

The core list of invasive species was further reduced to a "dirty dozen" of the most problematic species for closer examination (Table 2). Members of this list are approximately equally divided between trees and shrubs and between invaders of open areas and invaders of woodlands. Notably, 75% of the dirty dozen (all but *Ulmus, Salix* and *Maclura*) are dispersed primarily by birds that feed upon their fleshy fruits.

Comparison of the total list of exotic Iowa woody plants with the shorter lists of problem species suggests that seed dispersal mechanisms are important in assessing potential for invasiveness (Table 3). Half of the exotics established in Iowa are dispersed through bird ingestion of the entire fruit. The proportion of such species increases as one considers the relative invasiveness of the taxa, with 55% of the core list and 75% of the most invasive species having this trait. This trend suggests that dispersal by birds as an attribute predisposes species to invasiveness. Certainly, wide dispersal by birds hinders eradication efforts of the most invasive species.

Not surprising, the second most prevalent group of invasive species contains those dispersed by wind (Table 3). These species tend to be prolific seeders, and several spread widely along stream corri-

Table 1. Exotic woody species and hybrids naturalized in Iowa. Species marked as on the list are those considered invasive or potentially invasive. Dispersal indicates the principal means by which these species migrate to new sites or persist after establishment.

Species	Core List	Dispersal
Acer ginnala Maxim.	x	wind
Acer rubrum L.		wind
Aesculus hippocastanum L.		other
Ailanthus altissima (P. Miller) Swingle	x	wind + vegetative
Alnus glutinosa (L.) Gaertn.		wind
Ampelopsis brevipedunculata (Maxim.) Trautv.		bird
Berberis thunbergii DC.	x	bird
Berberis vulgaris L.		bird
Campsis radicans (L.) Seem. ex Bureau	x	wind
Caragana arborescens Lam.		other
Castanea dentata (Marsh.) Borkh.		other
Catalpa bignonioides Walter		wind
Catalpa speciosa Warder	x	wind
Celastrus orbiculatus Thunb.		bird
Cornus alba L.		bird
Cotoneaster multiflora Bge.		bird
Elaeagnus angustifolia L.	x	bird
Elaeagnus umbellata Thunb.	x	bird
Euonymus alatus (Thunb.) Sieb.	x	bird
Euonymus europaeus L.		bird
Ligustrum obtusifolium Sieb. & Zucc.		bird
Ligustrum vulgare L.		bird
Liriodendron tulipifera L.		wind
Lonicera japonica Thunb.		bird
Lonicera maackii Maxim.	x	bird
Lonicera morrowi Gray		bird
Lonicera tatarica L.	x	bird
Lycium halmifolium P. Miller	x	bird
Maclura pomifera (Raf. ex Sarg.) Schneider	x	other
Malus sylvestris (L.) P. Miller	x	other
Morus alba L.	x	bird
Morus alba L. × *M. rubra* L.	x	bird
Parthenocissus tricuspidata (Sieb. & Zucc.) Planch		bird
Philadelphus pubescens Loisel		wind
Picea abies (L.) Karst.		wind
Populus alba L.	x	vegetative
Populus balsamifera L.		wind + vegetative
Populus nigra var. *italica* Moench		vegetative
Populus × *rouleauiana* Boivin	x	vegetative
Prunus persica (L.) Batsch		other
Prunus tomentosa Thunb.	x	bird
Pyrus communis L.		other
Rhamnus cathartica L.	x	bird
Rhamnus davurica Pallas		bird
Rhamnus frangula L.		bird
Rhamnus utilis Dcne.		bird
Ribes sativum (Reichenb.) Syme		bird
Robinia pseudoacacia L.	x	other
Rosa eglanteria L.	x	bird
Rosa multiflora Thunb. ex Murray	x	bird
Rubus caesius L.		bird
Rubus idaeus L.		bird
Rubus odoratus L.		bird
Rubus parvifolius L.	x	bird
Salix alba L.	x	wind + water
Salix babylonica L.		vegetative
Salix fragilis L.	x	wind + water
Salix pentandra L.		vegetative
Salix purpurea L.		wind
Salix × *rubens* Schrank.	x	wind + water
Sorbaria sorbifolia (L.) A. Br.		wind
Sorbus aucuparia L.	x	bird
Syringa vulgaris L.		wind + vegetative
Thuja occidentalis L.		wind
Tilia heterophylla Vent.		other
Ulmus pumila L.	x	wind
Ulmus rubra Muhl. × *U. pumila* L.	x	wind
Viburnum lantana L.	x	bird
Viburnum opulus L.	x	bird
Wisteria frutescens (L.) Poiret		other

Table 2. Iowa's "Dirty Dozen" most problematic invasive woody species.

Japanese barberry	*Berberis thunbergii*
Russian olive	*Elaeagnus angustifolia*
Autumn olive	*Elaeagnus umbellata*
Winged burning bush	*Euonymous alatus*
Amur honeysuckle	*Lonicera maackii*
Tartarian honeysuckle	*Lonicera tatarica*
Osage orange	*Maclura pomifera*
White mulberry	*Morus alba*
Buckthorn	*Rhamnus cathartica*
Multiflora rose	*Rosa multiflora*
White willow	*Salix alba*
Siberian elm	*Ulmus pumila*

Table 3. Dispersal mechanisms of Iowa's exotic woody species. "Bird" refers to dispersal by ingestion and transport of whole fruits.

Disperal agent	All exotics (%)	Core list (%)	Dirty Dozen (%)
Bird	35 (50.0)	17 (54.8)	9 (75.0)
Wind	20 (28.6)	9 (29.0)	2 (16.8)
Vegetative	5 (7.1)	2 (6.5)	0
Other	10 (15.3)	3 (9.7)	1 (8.3)
Total	70	31	12

dors and fence rows. These species can rapidly infest disturbed areas. As a group, however, these are more restricted in their ability to move across inhospitable habitat. Relatively few heavy-fruited species have become persistent exotics. A small group of exotic species such

as white poplar (*Populus alba* L.) persist primarily through vegetative spread via root suckering.

About half of Iowa's most invasive exotic species are primary invaders of pastures, abandoned crop ground and other open areas. The most serious economic pest among these is the multiflora rose (*Rosa multiflora*). Although first introduced in 1886 as rootstock for cultivated roses, it became a serious problem after reintroduction and promotion for wildlife food and habitat and for living fences in the mid-1900s (Hoffman and Kearns 1998). Its resistance to grazing has resulted in significant loss of pasture, and its tough thorny stems restrict movement across the landscape by large animals and people. Similarly resistant to grazing is Osage orange (*Maclura pomifera*). Widely planted for living fences and as a source of decay-resistant fence posts, it has spread into pastures and waste areas across southern Iowa.

Another spiny invader of pastures, old fields and clearings is black locust (*Robinia pseudoacacia* L.) which is native to the eastern United States and Ozark region but not Iowa. The exotics, black locust, Osage orange and multiflora rose, together with the native species, honeylocust (*Gleditsia triacanthos* L.), hawthorns (*Crataegus* L. spp.), prickly ash (*Zanthoxylum americanum* P. Miller), gooseberries (*Ribes* L. spp.) raspberries and blackberries (*Rubus* L. spp.) and eastern red cedar (*Juniperus virginiana* L.), form a suite of species that persist and often increase under cattle grazing due to their armament of thorns, spines, prickles or prickly leaves. When grazing is withheld, their populations quickly expand to produce a thick cover that excludes other vegetation. Cattle grazing in woodlands similarly promotes spread of armed species, the most notable of these being the gooseberries and prickly ash among the natives, along with the exotic multiflora rose and Japanese barberry (*Berberis thunbergii* DC.). It is probably significant that half of our worst exotic invaders bear some kind of armament.

Less problematic in pastures, but aggressive invaders of open disturbed sites, fence rows and stream corridors are Russian and autumn olives (*Elaeagnus angustifolia* L. and *E. umbellata* Thunb., white mulberry (*Morus alba* L.), Siberian elm (*Ulmus pumila* L.) and exotic willows (*Salix alba* L. and others). White mulberry was initially introduced to the east coast of the United States as silkworm food to support a potential silk industry early in the seventeenth century (Feltwell 1990). Siberian elm was introduced to the Midwest in the mid-nineteenth century as an ornamental favored for its tolerance to drought and cold (Hoffman and Kearns 1992). Siberian elm and white mulberry have now become two of Iowa's most common trees, often dominating young forests. While communities of these trees provide some forest amenities, they are often so dense with seedlings and young trees that they retard colonization by more valuable native trees and herbaceous species.

Siberian elm and white mulberry each pose another insidious threat to native species. Each hybridizes readily with a related native species [i.e., red elm (*Ulmus rubra* Muhl.) and red mulberry (*Morus rubra* L)]. Hybrid plants become especially prevalent where the native species are sufficiently outnumbered so that their female flowers receive pollen primarily from the introduced species, thus hindering reproduction of the native species. This is of special concern where rare red elm survivors of Dutch Elm Disease (*Ophiostoma ulmi* (Buisman) Nannf.) are prevented from propagating their resistant genotypes because of pollen competition.

Black willow (*Salix nigra* Marsh.), the largest and longest-lived of Iowa's native willows, is becoming increasingly difficult to find along central Iowa streams. In its habitat instead are a number of introduced species, most notably the white willow (*Salix alba* L.). These faster-growing, more aggressive species are much shorter lived and generally do not persist long in bottomland forests to provide large soft-wooded snags favored by cavity-nesting birds.

Some of the species discussed above can also become forest understory pests, especially multiflora rose and white mulberry. In addition to these are a number of species that thrive as understory shrubs, especially in woodlands that have experienced understory disturbance (e.g., pasturing). Currently the most troublesome of these are the bird-dispersed bush honeysuckles (*Lonicera tatarica* L. and *L. maackii* Maxim.) and European buckthorn (*Rhamnus cathartica* L). Although Tartarian honeysuckle and European buckthorn have a long presence in Iowa, extensive occurrence of Amur honeysuckle (*L. maackii*) seems to be only recently recognized as it is not included in *The Vascular Plants of Iowa* (Eilers and Roosa 1994). All of these species produce dense cover that displaces native vegetation, especially herbaceous perennials.

Less dense in its cover and probably less competitive with native species is Japanese barberry (*Berberis thunbergii* DC.). Nevertheless, this spiny exotic seems ubiquitous in dry woodlands in the eastern half of the state. Another species becoming more prominent in mesic woodlands is the winged burning bush (*Euonymus alata* (Thunb.) Sieb.), one of the most commonly planted ornamental shrubs in Iowa. Also deserving mention as potentially increasing in occurrence are the Guelder-rose (*Viburnum opulus* L.) and round-leaved bittersweet (*Celastrus orbiculatus* Thunb.), both escaping from cultivation.

If there is any good news regarding invasive woody species in Iowa, it is their limited presence in our least disturbed woodlands. A vegetation analysis of woodlands in state parks found that although exotics were frequently present (especially bush honeysuckles and Japanese barberry), they seldom dominated the understory as they often do in younger or recently disturbed woodlands preserves (Raich et al. 1999, Norris and Farrar 2001). It is not clear whether this implies that cover by exotics decreases with time in the absence of disturbance or that woodlands with intact native understories resist invasion by exotics.

Clearly, further study of Iowa's woody exotic species is needed. Permanent plots now in place (Raich et al. 1999, Mabry 2000) will allow monitoring of exotics relative to management practices and to passage of time. Objective analyses of the effects of exotics on native plant and animal species and on ecological processes are critical, as well as research on and implementation of control measures. Iowa also needs a more detailed current accounting of the ecological health of its forests.

Botanists and forest ecologists, as well as the general public, may be guilty of misreading the status of Iowa's forests. Surveys indicate less of a decline in area under forest cover since European settlement than is the case for prairies and wetlands, and an actual increase forest acreage since 1974 (Jungst et al. 1998). But figures of forest acreage are based simply on stems per acre or degree of canopy closure. They do not reflect species dominance in the overstory and ignore understory structure and composition. No one includes bluegrass pastures in tallying the acreage of prairie in the state, yet a woodland dominated by Siberian elm and white mulberry is counted as forest, so long as the trees are sufficiently tall and dense.

A less obvious but also seriously misleading error is omission of the status of the understory of forests that still have an overstory dominated by native trees. Too often these "forests" are mere canopy shells due to pasturing that has eliminated the native understory of woody and herbaceous species. As the current canopy trees of such forests die or are harvested, these forests quickly become dominated by understory exotics and aggressive pioneer species leaving little chance for regeneration of the original canopy.

Norris and Farrar (2001) surveyed 44 forests comprising 5457 hectares in an evaluation of forest quality in northeast Iowa. Ratings of "highly natural," "moderately natural," "moderately altered" or "highly altered" were assigned based on tree size, canopy structure (number of canopy layers and cover by each), and dominance by

expected native species in canopy, subcanopy and shrub layers. Forests rated "highly natural" contained trees with dbh > 40 cm, well differentiated canopy and subcanopy layers and a diffuse shrub layer, with all layers dominated by native species expected for that habitat (i.e., no exotics contributing as much as 25% cover). By these measures, only 20% of the forests surveyed (25% of the total area surveyed) rated "highly natural", whereas 27% of the forests (18% of the total area) rated moderately to highly altered. The latter forests often had poor differentiation of canopy and subcanopy layers with a dense shrub layer and one or more of the layers dominated by species not naturally expected (primarily exotics) for the sites. Most of these forests had experienced moderate to heavy grazing. A statewide natural quality evaluation of woodlands based on the method of Norris and Farrar (2001) would present a much more informative picture of the status of Iowa's forests. Until such is accomplished we must exercise caution in interpreting the health and extent of Iowa's forest resource.

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