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INVASIVE SPECIES IN AN URBAN FLORA: HISTORY AND CURRENT STATUS IN INDIANAPOLIS, INDIANA

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ABSTRACT. Invasive plant species are widely appreciated to cause significant ecologic and economic damage in agricultural fields and in natural areas. The presence and impact of invasives in cities is less well documented. This paper characterizes invasive plants in Indianapolis, Indiana. Based on historical records and contemporary accounts, 69 of the 120 species on the official Indiana state list are reported for the city. Most of these plants are native to Asia or Eurasia, with escape from cultivation as the most common mode of introduction. Most have been in the flora of Indianapolis for some time. Eighty percent of Indianapolis' invasive herbaceous plants were present before 1940, but only 14% of woody invasive plants were known to be present in the city at that time. The largest group of woody invasives is shrubs. Newly present invasive plants continue to be reported for Indianapolis. Expert opinion rates Callery Pear, Japanese knotweed, and Japanese stiltgrass as the greatest emerging threats.

Keywords: Indianapolis, invasive plants, invasive species, urban flora

INTRODUCTION

An invasive species is defined in the United States by Executive Order as "a species that is: 1) non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health" (USDA, NISIC 2016). Invasive species (exotic insects, plants, fish, birds, mammals, and many other organisms) are a serious threat, resulting in estimated costs and damages of more than $120 billion annually in the United States (Pimental et al. 2005) and more than €12 billion annually in Europe (van Ham et al. 2013). Human actions are the primary means of introduction.

Urban areas are often points of introduction for invasives (Pyšek 1998). In cities, invasive plants have been shown to alter species composition, resulting in loss of biodiversity and declines in primary productivity, to diminish ecosystem services (e.g., erosion control), to cause infrastructure deterioration, to alter nutrient cycling, and to contribute to declines in property value (van Ham et al. 2013). Additional social impacts include the perception of spaces overgrown with invasives as signs of urban decay, and loss of visual connection with natural features such as riparian corridors (van Ham et al. 2013).

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This paper reports on invasive plants known to be present in Indianapolis/Marion County, Indiana, USA. The city and the county are the same governmental unit and so occupy the same geographic space, referred to as Indianapolis in this paper. Indianapolis is a model urban area to study invasive plants for several reasons. Much is known about its floristic composition, from the late 1800s through current times. Indianapolis was almost entirely forested in pre-European presettlement times, but forests were reduced to 13% cover by the late 1900s (Barr et al. 2002). Most of the original forest was converted into row-crop agriculture. Agriculture has declined from 80% of land use in 1922 to 72% in 1953, to 18% by 1990 (http:www.savi.org). The time period from 1953–1990 corresponds with rapid urbanization in the city. This pattern of land use change is likely a model for other cities in the American Midwest. Indianapolis is the twelfth largest city in the United States, with an estimated population of over 900,000 people and total area of 650 km^2 (105,200 ha). The city is in the Central Till Plain Natural Region of Indiana (Homoya et al. 1985), an area characterized by a terrain of gently rolling hills of glacial till.

Species richness of the Indianapolis flora has been documented by Dolan et al. (2011) at about 700 plants. This number was consistent over a 70 year period, but there has been considerable species turn-over, with a loss of rare native plants and an increase in non-native plants from 20.3% to 27.1% of the flora over the years covered by the

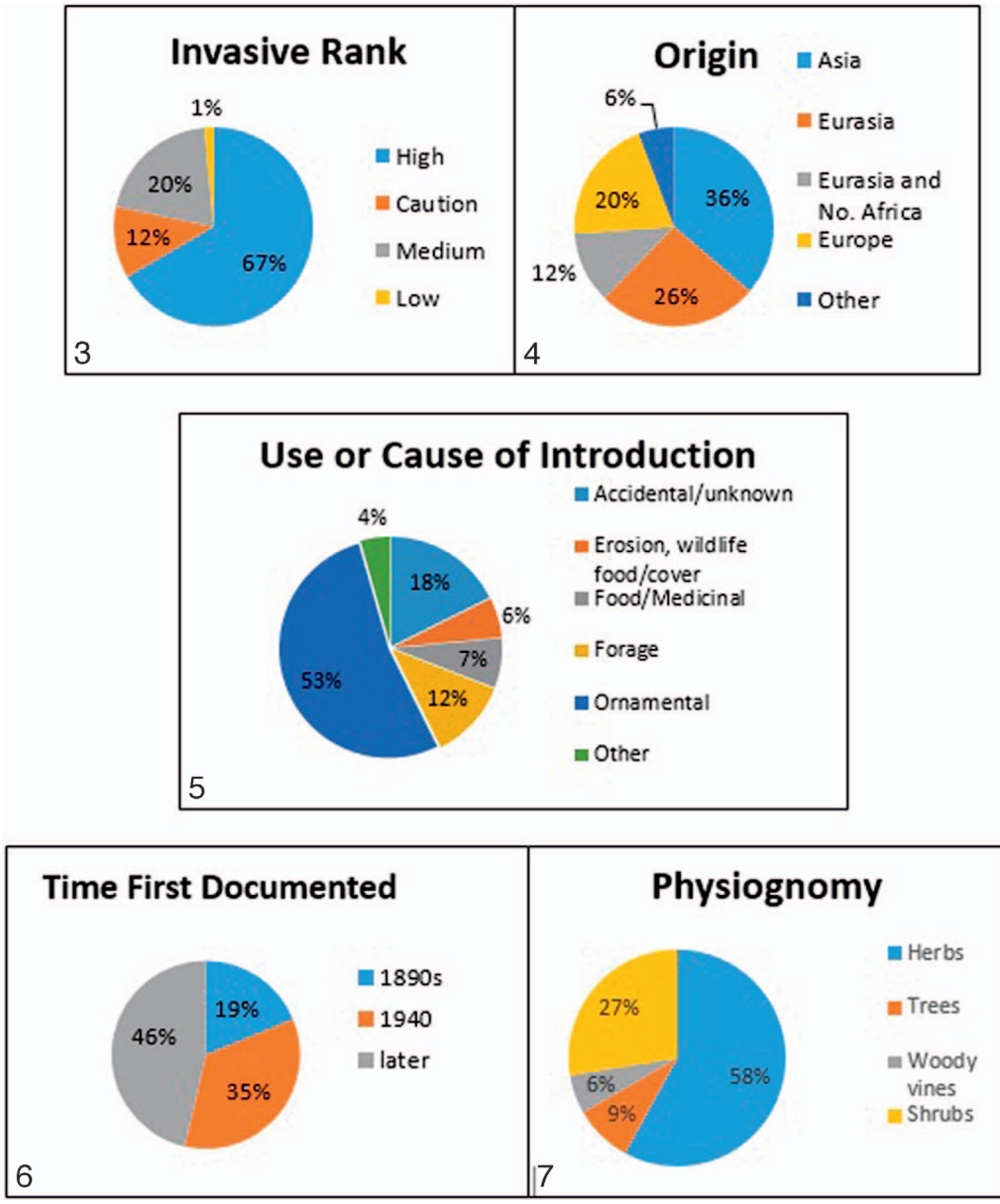
Figures 1–2.—Images of herbarium specimens. 1. Specimen of invasive plant *Lythrum salicaria* collected by Ray Friesner in Indianapolis in 1925, documenting presence of the species in the city as of that date (left). 2. Specimen of *Berberis thunbergii* collected by Charles Deam, with the comment on the label that this ornamental plant was collected far from any dwelling. Comments like these are helpful in establishing records for species that might become invasive (right).

study. These percentages are on par with urban areas across the globe (La Sorte et al. 2014). Not all non-natives in the Indianapolis flora, historically or currently, are considered invasive plants in Indiana (Indiana Invasive Species Council 2016). This report focuses upon invasive species in the Indianapolis flora, including how long they have been known to be present, their origins, and uses or causes of introduction. Finally, the invasive species that are likely to be the biggest problems in the near future for the city are discussed.

METHODS

For this study, plants were identified as invasive if they were present on the Official Indiana Invasive Plant list, established by the Indiana Invasive Species Council (2016). Nomenclature is based on scientific names used in that list. Sources of information on invasives present in the flora of Indianapolis and dates of first record range from historical journal articles to contemporary web-based records. The oldest record is a county list for Marion and adjacent Hamilton County (Wilson 1895). While not comprehensive, this paper does document species presence, often annotated with comments on abundance. Coulter (1899) produced a state-wide flora that sometimes mentions counties and ranges for plants now recognized as invasives in the state.

Deam's 1940 Flora of Indiana is the last comprehensive manual of the state's plants. Deam's flora presents county-level distribution maps based on herbarium specimen vouchers. Overlease & Overlease (2007) reported weed species distributions for Indiana at the county level, based on their own observations and compared these distributions with records from Deam (1940) and Coulter (1899). Dolan et al. (2011) compiled these and other records, including herbarium specimens (Figs. 1 & 2) from the Friesner Herbarium (BUT) of Butler University,



Figures 3–7.—Characteristics of invasive species in the Indianapolis, Indiana flora. 3. Invasive rank based on the Official Indiana Invasive Plant List (top left). 4. Continent of origin (top right). 5. Mode of introduction (middle). 6. Time of first record in the flora (bottom left). 7. Physiognomy (bottom right).

into a historical list for the city (pre-1940) and a more recent list based on species reported by botanists working in the city since that time.

Additional records for invasives in Indianapolis came from the Indiana Plant Atlas (Dolan & Moore 2016), sorted by location (Marion County) and invasiveness, and from Early Detection & Distribution Mapping System (EDDMapS 2016). Origin and mode of introduction of invasives are from Weber (2003) and Czarapata (2005).

Invasive plants that represent the largest current and emerging threats in the city were identified by polling local experts. Eight environ-

Table 1.—Herbaceous species of invasive plants in the Indianapolis, Indiana flora and time of first record. D = listed as present elsewhere in Indiana by Deam (1940); P = planting actively promoted by government agencies at some time.

Scientific name	Common name	Pre-1940	More recent	Invasive rank	Origin	Use/mode of introduction
Alliaria petiolata	garlic mustard		x	high	Europe	food, medicinal
Artemesia vulgaris	mugwort		x	high	Eurasia/N. Africa	medicinal?
Carduus nutans[D]	musk thistle		x	high	Europe/N. Africa	none/unknown
Centaurea stoebe	spotted knapweed		x	high	Europe	none/unknown
Cirsium arvense	Canada thistle	x	x	high	Eurasia	contaminated seed crop?
Cirsium vulgare	bull thistle	x	x	high	Europe	none/unknown
Clematis terniflora	sweet autumn clematis		x	caution	Asia	ornamental
Conium maculatum[D]	poison hemlock		x	high	Eurasia/N. Africa	none/unknown
Convolvulus arvense	field bindweed	x	x	high	Asia	ornamental
Coronilla varia[P]	crown vetch	x	x	high	Eurasia/N. Africa	erosion control
Cynanchum louiseae	black swallow-wort	x	x	high	Europe	ornamental
Daucus carota	Queen Anne's lace	x	x	medium	Eurasia	medicinal?
Dioscorea polystachya[D]	Chinese yam		x	high	Asia	ornamental, food
Dipsacus fullonum	common teasel	x	x	high	Eurasia/N. Africa	wool combing
Dipsacus laciniatus	cut-leaved teasel	x	x	high	Eurasia/N. Africa	wool combing
Euphorbia esula	leafy spurge	x	x	high	Eurasia	accidental contaminant, ornamental
Glechoma hederacea	creeping Charlie	x	x	medium	Europe	medicinal, food
Hesperis matronalis	dame's rocket	x	x	high	Eurasia	ornamental
Humulus japonicus[D]	Japanese hops		x	high	Asia	ornamental
Hypericum perforatum	St. John's wort	x	x	Low	Europe	medicinal
Iris pseudoacorus[D]	yellow iris		x	high	Europe/Africa	ornamental
Kummerowia stipulacea[D,P]	Korean lespedeza		x	high	Asia	forage
Kummerowia striata[P]	striate lespedeza	x	x	medium	Asia	forage
Lespedeza cuneata[P]	sericea lespedeza		x	high	Asia	erosion control, forage
Lythrum salicaria	purple loosestrife	x	x	high	Europe	ornamental, medicinal, honey
Melilotus officinale	sweet clover	x	x	medium	Eurasia	forage, honey
Microstegium vimineum	Japanese stiltgrass		x	high	Asia	accidental, in packing material
Myriophyllum spicatum[D]	Eurasian watermilfoil		x	high	Europe/N. Africa	aquarium trade, boats
Najas minor	braided naiad		x	high	Eurasia/N. Africa	ships' ballast, ornamental
Pastinaca sativa	wild parsnip	x	x	medium	Eurasia	ornamental
Phalaris arundinacea[P]	reed canarygrass	x	x	high	Europe	hay, forage
Phragmites australis	common reed	x	x	high	Global	ships' ballast?
Potamogeton crispus	curly-leaved pondweed	x	x	high	Europe	none/unknown
Ranunculus ficaria	lesser celandine		x	caution	Europe	ornamental

Table 1.—Continued.

Scientific name	Common name	Pre-1940	More recent	Invasive rank	Origin	Use/mode of introduction
Saponaria officinalis	bouncing bet	x	x	medium	Europe	ornamental, soap
Schedonorus arundinaceus[P]	tall fescue	x	x	medium	Europe	forage, erosion control
Sorghum halepense	Johnson grass	x	x	high	Europe	forage
Torilis japonica[D]	Japanese hedge parsley		x	caution	Eurasia	none/unknown
Typha angustifolia	narrow-leaved cattail	x	x	high	Eurasia	ornamental
Vicia cracca[P]	cow vetch	x	x	medium	Eurasia	forage

mental professionals and knowledgeable amateurs from government agencies, non-profit organizations, private consulting firms, and academia were asked to list the invasive plants they perceive as being the greatest current and emerging concerns in Indianapolis.

RESULTS AND DISCUSSION

Sixty-nine of the 120 species listed on the Official Invasive Plant List for Indiana are known to occur in Indianapolis. These invasives comprise approximately 10% of the flora, somewhat less than the 16% average reported for 110 cites by La Sorte et al. (2014). The majority of invasive plants reported for Indianapolis are ranked as highly invasive (Fig. 3). Most plants (62%) originated in Asia or Eurasia (Fig. 4). Escape from cultivation is, by a wide margin, the most common mode of introduction of invasives in Indianapolis (Fig. 5). Accidental or unknown modes of introduction account for 18% of species, with forage accounting for 12%. The first two introduction pathways are most common for urban floras globally as well (La Sorte et. al 2014). Forage plants may be the remnant of former wide-spread agriculture in the area, or may be the result of contemporary seed mixes used to cover bare ground during construction.

Over half of the invasive plants in Indianapolis were known in the flora prior to 1940 (Fig. 6). Nineteen percent were documented by as early as the 1890s. Most invasives are herbaceous ($n = 40$) (Table 1). Shrubs are the most commonly represented woody class ($n = 19$), followed by trees ($n = 6$) and vines ($n = 4$) (Table 2, Fig. 7).

Herbaceous invasives have long been in the flora. As early as the late 1800s, Wilson (1895) noted *Daucus carota* and *Glechoma hederacea* were very common, *Meliolotus officinale* and *Saponaria officinale* were common, and *Vinca minor* was becoming common. Most herbaceous invasives (60%) were known for Indianapolis by Deam in 1940 (Table 1). Another 20% were noted by Deam (1940) for elsewhere in Indiana, so it would not be surprising if they were present in the city (or soon would be) but had not yet been recorded. Arriving since Deam's publication are *Alliaria petiolata, Artemesia vulgaris, Centaurea stoebe, Clematis terniflora, Lespedeza cuneata, Microstegium vimineum*, and *Najas minor*.

Analysis of the dates of record for woody plants reveals a different pattern. Only 14% (4 of 29) were known historically for Indianapolis (Table 2), with another eight present elsewhere in the

Table 2.—Woody species of invasive plants in the Indianapolis, Indiana flora and time of first record. Caution means there is reason to believe the species may become a problem, but not enough data yet to support its listing. D = reported by Deam (1940) for elsewhere in Indiana; K = planted by the city in the 1920s as part of the Kessler Plan; P = planting actively promoted by government agencies at some time.

Scientific name	Common name	Pre-1940	More recent	Invasive rank	Origin	Use/mode of introduction
Trees						
Acer platanoides	Norway maple		x	high	Eurasia	ornamental
Ailanthus altissima	tree-of-heaven	x	x	high	Asia	ornamental
Alnus glutinosa[D,K,P]	black alder		x	high	Eurasia/N. Africa	ornamental
Morus alba[K]	white mulberry	x	x	high	Asia	ornamental, food, silk worms
Pyrus calleryana	Callery pear		x	high	Asia	ornamental
Ulmus pumila	Siberian elm		x	medium	Asia	ornamental
Woody vines						
Ampelopsis brevipedunculata	porcelain berry		x	caution	Asia	ornamental
Celastrus orbiculatus	oriental bittersweet		x	high	Asia	ornamental
Hedera helix	English ivy		x	medium	Asia/N. Africa	ornamental
Lonicera japonica[D]	Japanese honeysuckle		x	high	Asia	ornamental
Shrubs						
Berberis thunbergii[K]	Japanese barberry	x	x	high	Asia	ornamental
Elaeagnus angustifolia[P]	Russian olive		x	medium	Asia	erosion control, ornamental
Elaeagnus umbellata[P]	autumn olive		x	high	Asia	ornamental, wildlife food & cover
Euonymus alatus	burning bush		x	medium	Asia	ornamental
Euonymus fortunei	winter-creeper		x	high	Asia	ornamental
Fallopia japonica	Japanese knotweed		x	high	Asia	ornamental, erosion control
Frangula alnus[P?]	glossy buckthorn		x	high	Eurasia	ornamental
Ligustrum obtusifolium[D]	blunt leaved privet		x	high	Eurasia	ornamental
Ligustrum vulgare[D]	common privet		x	medium	Eurasia	ornamental
Lonicera maackii	Amur honeysuckle		x	high	Eurasia	ornamental, wildlife food & cover, erosion control
Lonicera morrowii[K]	Morrow's honeysuckle		x	high	Eurasia	ornamental
Lonicera tatarica[D,K]	Tatarian honeysuckle		x	high	Eurasia	ornamental
Lonicera × *bella*[K]	Bell's honeysuckle		x	high	Eurasia	ornamental
Rhamnus cathartica[D,K,P?]	common buckthorn		x	high	Eurasia	ornamental
Rhodotypos scandens	jetbead		x	caution	Asia	ornamental
Rosa multiflora[D,K,P]	multiflora rose		x	high	Asia	ornamental, living fence, wildlife cover & food
Rubus phoenicolasius[D]	wine raspberry		x	caution	Asia	ornamental
Viburnum opulus var. *opulus*	highbush cranberry		x	caution	Europe	ornamental
Vinca minor	periwinkle	x	x	medium	Europe	ornamental

Table 3.—The top five ranked invasive plant species, including ties, that pose the biggest current and emerging threats in Indianapolis, Indiana, based on expert opinion. Rankings represent the frequency of citation, with one (1) being the most frequently cited.

Current			Emerging		
Rank	Scientific name	Common name	Rank	Scientific name	Common name
1	*Euonymus fortunei*	purple winter-creeper	1	*Fallopia japonica*	Japanese knotweed
1	*Lonicera maackii*	Amur honeysuckle	1	*Microstegium vimineum*	Japanese stiltgrass
3	*Alliaria petiolata*	garlic mustard	1	*Pyrus calleryana*	Callery pear
4	*Celastrus obiculatus*	oriental bittersweet	4	*Berberis thunbergii*	Japanese barberry
5	*Euonymus alatus*	burning-bush	5	*Clematis terniflora*	sweet autumn clematis
5	*Lonicera japonica*	Japanese honeysuckle	5	*Euonymus alatus*	burning bush
5	*Pyrus calleryana*	Callery pear			

state based on Deam (1940). As noted by Dolan et al. (2011), non-native shrubs escaped from landscaping are the physiognomic group with the largest increase in numbers of species in the Indianapolis flora over the last 70 years. Many of these plants were planted by the city as part of the Kessler Plan, a parkway and boulevard beautification plan during the 1920s (Table 2). Others were actively promoted by the USDA and other government agencies in the past for wildlife food and cover, erosion control, and other purported benefits (Tables 1 & 2).

Five of the seven species that were most frequently cited by restoration experts surveyed for this study as the biggest current invasive plant problems in Indianapolis are woody (Table 3). *Euonymous fortunei* and *Lonicera maackii* tied for first as the biggest current problem. Among plants that were perceived as emerging problems, three (one shrub, one grass and one tree) tied for first: *Fallopia japonica*, *Microstegium vimineum*, and *Pyrus calleryana*.

Early detection and rapid response protocols are the most effective means of preventing the spread of invasive species into new territories. It is widely recognized to be easier to eradicate and control invasive species before they become widely established (e.g., Allendorf & Lundquist 2003). Reports of new sightings posted to EDDMapS and other online sites by consultants, naturalists, academics, and the general public provide the opportunity to track new records and to eradicate plants before they can spread. Greater awareness of invasive plants and their modes or pathways of introduction will hopefully lead to more careful vetting and selection of plants for large-scale landscaping projects in the city and elsewhere.

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