

Review

## Relationship between Invasive Plant Species and Forest Fauna in Eastern North America

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Received: 29 June 2012; in revised form: 24 August 2012 / Accepted: 24 August 2012 /

Published: 12 September 2012

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**Abstract:** Invasive plant species have long been known to cause extensive damage, both economically and ecologically, to native ecosystems. They have historically been introduced by the public, both intentional and not, for a variety of reasons. Many of the woody shrubs, such as *Lonicera maackii* and *Rosa multiflora* were introduced for wildlife cover, forage, and ornamental value. These invasives have quickly out-competed native flora, in many cases drastically impacting and changing the environment they inhabit. In this review, chosen species characteristics have been described, their pathway to invasion explained, and their impacts to native wildlife highlighted. Based on a review of the scientific literature, we determined that not all effects by invasive plants are negative. Many positive impacts can be seen throughout the literature, such as native frogs utilizing *Microstegium vimineum* for cover and nesting habitat. However, some important invasive plant species were not included in this review due to a lack of literature on the subject of the effects on fauna. While much is known about their economic impact and the impact on native plant species, additional work needs to be done in the field of wildlife research to determine current impacts and future implications of non-native, invasive plants on native fauna.

**Keywords:** biological invasion; non-native; wildlife; invasive shrubs; weeds

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## 1. Introduction

The abundance of exotic, invasive plant species, hereafter invasive species, has increased dramatically in forested and other natural areas over the past few decades leading natural resource managers to become concerned about the future management in these areas. Invasive species can cause extensive environmental damage once they are established by altering ecosystem structure and function, which may lead to changes in nutrient cycling and decreased forest productivity in the invaded area [1,2]. In addition, invasive species often outcompete and replace native species decreasing native species biodiversity and, in some cases, lead to the extinction of endangered native plant species [3–5]. In the United States alone there are nearly 1000 plant species listed as either threatened or endangered, and of these, roughly 40% are considered at risk from invasive species due to direct contact, such as predation or indirect influences like competition [6]. Control of invasive species can be costly, difficult, and time consuming. Billions of dollars have been spent in the United States over the past decade to prevent damage from invasive plants [7]. Typically control of invasive species requires repeated treatments and long-term monitoring to ensure that the invasive species does not reestablish after treatment [1,8]. While research on the negative impacts of invasive plants on native flora diversity and production has been extensively documented [4,9–11], the effects of these invasive species on the native fauna are not as clear. Many invasive species are assumed to have negative consequences without sufficient research to back up these claims, simply for being out of their natural environment. For example, *Lythrum salicaria* (Purple loosestrife) was long considered to have large negative impacts to native bird populations [12,13], but once these reviews were looked at closely, it was revealed that this species had little to no negative impact on many of the native bird populations previously studied [14]. We hypothesize that invasive species may have positive, as well as negative, impacts and that classifying invasive plants as either “good” or “bad” for a native ecosystem is missing the big picture. In this review, we will examine the current literature to determine the response of native fauna, both negative and positive, to some of the more common invasive plant species. The invasive species chosen, both woody and herbaceous, are highlighted in this review based on the current literature available on this subject and their spread throughout eastern North America. The sources used throughout this review were found through a systematic search of journals using keywords such as fauna, wildlife, effects, invasive species, *etc.* Though our expertise lies within eastern forests, the main points of this review are readily applicable to other woodland areas.

## 2. Woody Species

Many invasive shrubs were first introduced into North America for their aesthetic value, typically having bright berries or colorful flowers, or for providing wildlife habitat and forage [15,16]. For example, *Rosa multiflora* (multiflora rose), an invasive perennial shrub first introduced in the early 1900s, was used as “living fences” in landscaping, as it was less expensive than wire fences and to provide cover for wildlife [17]. The species has spread throughout wooded areas and grasslands of eastern North America by seed that is dispersed by birds. Invasive woody species have many traits that have allowed them to be extremely successful in disturbed areas. Their growth is rapid, they are typically shade and drought tolerant, and are widely dispersed by seed-eating birds. These qualities

have allowed these exotic species to out-compete native plant species and expand their ranges throughout the United States [1].

***Lonicera maackii* (Amur honeysuckle)**, a deciduous shrub from China that grows near riparian and forest edges, can reach heights of up to 6 m, leafs out before native species, and retains its leaves long after native species leaves have senesced. This species was originally brought to the United States in 1898 in hope to improve wildlife habitat with its high berry production [15]. The species became established throughout the eastern North America where it thrives in urban or urban-fringe landscapes, particularly open sites and forest edges [15].

Research indicates twigs and foliage of *L. maackii* are consumed by small mammals and *Odocoileus virginianus* (white tailed deer) in eastern North America hardwood forests [18,19], while native songbirds readily consume the fleshy fruit produced [20]. Meiners [21] reported that *L. maackii* also provides added cover for small mammals, but this can lead to increased seed predation and is a possible contributing factor to the decline in native tree seedlings. The presence of *L. maackii* has also been linked to an increase in mortality rates of songbird nests near watersheds, particularly in more urban landscapes [22,23]. Multiple theories have been proposed to explain this, one being that invasive shrubs tend to thrive on edges of forests and this leaves songbird nests within them more susceptible to predation [24–26]. Another hypothesis is that shrub height plays a factor and songbirds nests in invasive shrubs tend to be lower to the ground [27–30]. Some research has shown that nonindigenous shrubs may lack native plant defenses, such as thorns, which leave nests at a higher risk of predation [23]. Amphibian populations may also be affected by the presence of *L. maackii*. In a laboratory study of amphibian populations native to oak dominated forest communities in the central United States, the Watling *et al.* [31] reported *Anaxyrus americanus* (American toad) mortality increased when tadpoles were raised in *L. maackii* extract compared to extract from native leaf litter. This increase was attributed to increased phenolic compounds that inhibited respiration. The other species studied *Ambystoma maculatum* (spotted salamander), *Hyla* sp. (tree frog), and *Lithobates blairi* (leopard frog) did not decrease in mortality when raised in *L. maackii* extract, but *L. blairi* behavior was altered in the extract which may make it more vulnerable to predators [31]. Finally, research conducted by Allan *et al.* [29] has shown that with an increase in *L. maackii*, comes an increase in ticks and tick-borne diseases. In this study, *O. virginianus* preferred habitat with a higher density of invasive shrub and being a common host for ticks, where more *O. virginianus* were found so were more ticks and tick-borne diseases. Obvious implications for this can be an increase in human exposures to the diseases and an expansion of the infected tick population [32].

***Berberis thunbergii* (Japanese Barberry)** is an invasive, compact, thorny perennial shrub that is native to southern and central Japan [33]. *Berberis thunbergii* was originally introduced to the New England area around 1875 for ornamental value, wildlife, and erosion control [34]. It now has established populations throughout the northeastern United States, as well as five provinces in Canada. *Berberis thunbergii* grows best in well-drained soils and prefers areas with partial sunlight, making edges, roadsides, fences, and old fields ideal environments, but the species can flower and produce seed under full shade [34].

Work conducted in southeastern New York has shown that this invasive shrub may have some positive effects on avian abundance in woodland communities. Schmidt *et al.* [35] reported that nesting success of *Catharus fuscescens* (veeries) built in *B. thunbergii* were less likely to be predated

upon than those nests located on the ground, had twice the fledgling success as ground nests, and were overall chosen at a higher rate than other substrates. This was attributed to less rodent predation, due to rodents seeming to avoid foraging near *B. thunbergii* [35]. Work done in Connecticut suggests areas infested with *B. thunbergii* provide ideal habitat for small mammals and *O. virginianus*, however this may also increase tick populations [36]. *Peromyscus leucopus* (white-footed mouse) is a common host for ticks. With an increase in *P. leucopus* populations, came an increase in *Ixodes scapularis* (blacklegged ticks). Finally, although *B. thunbergii* is generally considered browse resistant, *O. virginianus* has been observed consuming *B. thunbergii* berries when other forage was scarce [34,36].

***Elaeagnus umbellata* (Autumn Olive)**, an invasive shrub native to Asia, was brought to the United States for wildlife usage [37]. Until recently it was recommended as a cover crop to improve wildlife habitat [38]. However, it was recognized as a problematic species that reduces native plant species diversity and productivity and is now considered invasive [39]. *Elaeagnus umbellata* can be found throughout the eastern United States in woodlands, grasslands, abandoned fields, and other disturbed areas. It is drought and moderately shade tolerant, enabling it to survive on a variety of sites.

As mentioned, *E. umbellata* was introduced for wildlife purposes therefore it is no surprise that multiple bird species utilize this invasive shrub for both cover and nesting sites [40]. Native bird species also readily consume the fruit produced including *Bonasa umbellus* (ruffed grouse), *Colinus virginianus* (northern bobwhite), *Zenaida macroura* (mourning dove), *Cardinalis cardinalis* (northern cardinal), *Passerella iliaca* (fox sparrow), and *Melospiza melodia* (song sparrow) [40]. In a study of feeding choices between fruit from native species and *E. umbellata* fruit, *Turdus migratorius* (American robin) preferred the invasive species fruit [41]. However, widespread consumption of *E. umbellata* fruit, as well as other invasive plant fruit, has facilitated the spread of invasive species in hardwood forests in the eastern United States [42,43]. Although it can be browsed by *O. virginianus*, Knapp *et al.* [44] reported that preference for native species by the large herbivore can also facilitate invasion of *E. umbellata*. This is an example of the enemy release hypothesis that has become such a staple among researchers in the field of invasive species. When these species move from their native habitat to a foreign area, they are generally faced with little or no natural predators, allowing for an unchecked growth. The ecological implications of this can be great. While invasive species go without predation, native species are preferentially consumed and allow for an even greater expansion of the non-native species. These implications should be considered when developing management plans.

### 3. Herbaceous Species

Although not as common as invasive woody species in forested areas [45], invasive herbaceous species can be problematic in areas they invade. While invasive herbaceous species typically require some disturbance before the population invades into forested areas, some species such as *Alliaria petiolata* (garlic mustard) can invade mature forests and outcompete native plants [46]. As observed with some invasive woody plant species, some invasive herbaceous plant species have been able to out-compete native species in eastern hardwood forests due to the selective foraging of the large populations of *O. virginianus* [47]. As *O. virginianus* preferentially browse native plants, while avoiding non-native plant species, the invasive plants are given the opportunity to reproduce and spread without barriers.

***Alliara petiolata* (Garlic mustard)** is a cool season, biennial herb native to western Eurasia. It is believed to first be introduced into America by early settlers using it as a culinary herb as well as for medicinal properties [48,49]. In its native range, it is generally found in humid maritime climates with high shade. Its current range in North America is from southern Ontario down through Tennessee and throughout New England and the Midwest. The species ranges in height from 30 to 100 cm and invades the ground cover of disturbed and undisturbed forested areas, preferring moist and shaded areas near rivers, floodplains and edges [48].

There have been no published reports highlighting the positive impacts of *A. petiolata* on forest fauna; however several examples of negative impacts exist in the literature. Presence of *A. petiolata* was attributed to decreased population decline of *Pieris napioleracea* (mustard white butterfly) a rare, native butterfly found in the northeastern United States [50]. The authors reported that although females would oviposit on *A. petiolata* plants, the plant did not support larval growth, thus decreasing population persistence. Other research suggests that *A. petiolata* is unpalatable to *O. virginianus*, which facilitates the invasive success of the plant in eastern North American forests [51]. Knight *et al.* [47] observed *O. virginianus* preferential browsing on native forest plants such as *Trillium grandiflorum* (white trillium), *Asarum canadense* (wild ginger), *Polygonatum biflorum* (Solomon's seal), *Arisaema truphyllum* (Jack-in-the-pulpit), *Sanguinaria canadensis* (bloodroot) and *Hydrophyllum virginianum* (Virginia waterleaf) in a Pennsylvania hardwood forests. The authors concluded that as *O. virginianus* preferentially chose native herbaceous species over non-native. With no natural predators to consume the non-native species the understory of this forest quickly turned to a highly invasive composition, completely changing the habitat for other native fauna [47].

***Lythrum salicaria* (Purple loosestrife)** is a fast growing Eurasian perennial herb associated with wetland, marshy, or riparian sites [52]. Height ranges from 0.5 to 3.5 m [53]. It was first introduced to the United States in the 1800s as an ornamental [54] and quickly spread through marshes and wetlands dispersed primarily by water, but also assisted by waterfowl and other birds [55]. This invasive species is extremely hard to eradicate due to its massive seed bank, up to ten times larger than any other wetland species, and the fact that seeds can remain dormant in the soil for years [56].

Although initial reviews (e.g., [12,13]) indicated dense stands of *L. salicaria* create conditions which negatively impact wildlife, much of the evidence used to support this argument was anecdotal and unsubstantiated by peer reviewed studies and the impact of *L. salicaria* on wildlife populations is not as negative as once believed [14]. In a study of avian responses to areas invaded by *L. salicaria* Whitt *et al.* [57] reported a negative impact on *Cistothorus palustris* (marsh wren), but five other bird species observed were not affected by *L. salicaria*. There is evidence that compounds leached from *L. salicaria* significantly reduce survival rates and overall performance of *Bufo americanus* (American toad tadpoles) [58], but rates used in the experiment were greater than what is naturally found in the environment [14]. In an extensive review on the impacts of *L. salicaria*, Lovoie [14] reported that there have been no studies published on small mammals or waterfowl making it difficult for critical analysis on the impact of this species on wildlife populations in the eastern North America.

***Microstegium vimineum* (Japanese stiltgrass)**, an annual, C<sub>4</sub> grass species native to southeastern Asia, first appeared in the United states in Tennessee in 1919, but has spread throughout most of the United States east of the Mississippi [10,59–61]. It can grow in a wide variety of soil and light conditions forming dense monocultures on the forest floors [62]. *Microstegium vimineum* produces an

abundant amount of seed that remains viable in the seed bank for a number of years after production making it a difficult species to control. It typically invades streamside forest habitat and is spread through animal or water dispersal, preferably in disturbed areas [63].

Originally introduced to the North America as packing material, *M. vimineum* is unpalatable to most forest herbivores, including generalist species such as *O. virginianus* showing again how an invasive species may overtake a habitat due to exclusion from browsing. In areas where large populations of *O. virginianus* and *M. vimineum* exist, the herbivore prefers to browse other native grasses [64], reducing native plant species and in turn increasing *M. vimineum* populations [51,65]. In a study of invasive plant ecology in southern Appalachia, Webster *et al.* [1] reported heavy foraging by *O. virginianus* reduced the ability of native plant species to recover during times of drought, when *M. vimineum* is susceptible of being overtopped, resulting in continued dominance of *M. vimineum*. However, in areas where high *O. virginianus* populations have decreased native understory plant species abundance, such as urbanized forest, *M. vimineum* may have some positive impacts on forest fauna. Nagy *et al.* [66] reported areas invaded with *M. vimineum* provided cover for native frogs in old growth *Tsuga canadensis* (eastern hemlock) and secondary hardwood dominated forests in New York. Amphibians utilized stands of *M. vimineum* when *O. virginianus* browsing has reduced native cover [66]. Increased frog abundance was attributed increased moisture retention in of areas invaded with *M. vimineum* as well as extra food due to the increase abundance of earthworms in highly invaded areas [66].

***Phalaris arundinacea* (Reed Canary Grass)** is a cool season, large coarse perennial grass that can reach heights of up to 2 m and reproduces through seeds or rhizomes [67]. This grass is native to North American and Eurasian. The Eurasian varieties were introduced as early as the 1800s for soil control, and though they are very difficult to tell apart it, is generally thought that the Eurasian type is the invasive species due to its increased aggressiveness compared to its native counterpart [68]. *Phalaris arundinacea* grows best on wet, fertile soils in full sun. It is very aggressive in riparian forest areas, and can particularly be a problem in young forest stands. The species forms dense monotypic stands that decrease native plant species diversity and productivity [68].

Reviews of *P. arundinacea* suggest that although the species is palatable to livestock and wildlife, it is not superior to other forage grasses [69,70]. However, multiple studies indicate that the species provides cover for a number of small mammal, large ungulate species and upland game birds [69], and nesting habitat for *Rana pipiens* (northern leopard frog) [71]. In a statewide study of bottomland areas invaded by *P. arundinacea* in Illinois, Spryreas *et al.* [72] reported that although increased abundance of *P. arundinacea* corresponded with a decrease in native plant cover and diversity, changes in faunal abundance were not as clear. Some groups of fauna, such as homopterans and *Peromyscus leucopus* (white-footed mouse), showed a negative correlation in regards to diversity and abundance. However, species abundance for *Microtus* spp. (voles) increased with *P. arundinacea* cover. Finally, many more groups of fauna including avian, other small mammals, and arthropod communities showed no correlation either way.

#### 4. Conclusions

This review highlights the impact of invasive plants on fauna in eastern North American ecosystems. While invasive plants are generally reported to have negative impacts on ecosystem function and diversity [1,2], our review indicates that they can also have many positive impacts on fauna in eastern ecosystems, particularly in ecosystems near developed areas that are otherwise devoid of plant cover (Table 1). The positive impact of invasive plants on forest fauna should not come as a surprise, as many of these species were introduced to benefit wildlife as a food source or for cover [15,34,37]. However, in comparison to studies of invasive plants on productivity and diversity, we observed that studies examining of the impact on forest fauna were somewhat limited in the scientific literature. For example, several problematic invasive plants in the southeastern United States such as *Imperata cylindrica* (cogongrass) and *Pueraria montana* var. *lobata* (kudzu) were not discussed in this paper because of the paucity of information available on the impact of these species on forest fauna. In addition, this review primarily focused on the direct impacts of invasive plant species on forest fauna, we did not examine the indirect impacts, such as, the consequences of an invasive plant species reducing native tree regeneration and potentially changing future forest cover. Therefore we feel that the impact of invasive plant species is variable and think that it is not prudent to group all invasive plants together as “good” or “bad” for forest fauna in eastern North America. This idea has become a large area for debate in the ecological community. In 2011, Davis *et al.* [73] published a paper claiming that the main reason for our attempts at controlling invasive species is due to tradition and a bias within ecological and conservation societies. They bring to light the ideas that many of the species considered today to be native were once non-native and that many native species cause much more damage than their non-native counterparts. One example being *Dendroctonus ponderosae*, the mountain pine beetle, which has had negative effects to the ecosystems it has been expanding to but has not been dealt with like other invasive beetle species. Finally, they discuss the idea that the manpower and cost for attempting to control invasive species is too high for the benefits to outweigh them [73]. Another thought to consider is that many invasive plant species are found in areas where native species have been removed because of development. For instance, *L. maackii* prefers disturbed urban areas where other shrubs may not be found. Many of the species mentioned in this review thrive in disturbed areas with less light, water, and nutrient availability, which raises the question: is some ground cover, even invasive, better for native wildlife than none? Judgment should be made for individual species (plant and fauna) for a given ecosystem before determining what management action should be made for (or against) that species.

**Table 1.** Summary of negative and positive effects of invasive plant species on native fauna in eastern North America.

Invasive Plant Species	Negative Effects	Positive Effects	References
<i>Rosa multiflora</i>		Provide cover for wildlife	[14]
<i>Lonicera maackii</i>	Increase mortality of songbird nests Increase in tadpole mortality rate	Provides cover for small seed-eating mammals Provides forage in form of berries, twigs, and foliage	[12,15–20,28]
<i>Berberis thunbergii</i>	Certain rodents avoid Increase in black-legged tick population	Decrease songbird nest predation Increase white-footed mice populations Provide forage for <i>O. virginianus</i> when other sources are scarce	[30–32,36,37]
<i>Elaeagnus umbellata</i>		Preferred nesting areas for certain songbirds Provides cover and food for songbirds	
<i>Alliaria petiolata</i>	<i>O. virginianus</i> do not use as forage Decline in population of <i>P. napi oleracea</i>		[43,46,47]
<i>Lythrum salicaria</i>	Possible negative effects to <i>C. palustris</i> Reduce survival rates of American Toad tadpoles		[56,57]
<i>Microstegium vimineum</i>	Unpalatable to most forest herbivores	Provides cover for native frog populations Retains moisture, utilized by amphibians	[63,65]
<i>Phalaris arundinacea</i>	Decrease in homopteran diversity and abundance Decrease <i>P. leucopus</i> populations	Cover for a variety of wildlife Nesting habitat for <i>R. pipiens</i> Increase populations of <i>Microtus</i> spp.	[69–71]

## Conflict of Interest

The authors declare no conflict of interest.

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