Growing and Marketing Woody Species To Support Pollinators: An Emerging Opportunity for Forest, Conservation, and Native Plant Nurseries in the Northeastern United States

R. Kasten Dumroese and Tara Luna

Research Plant Physiologist, U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Moscow, ID; Consulting Botanist and Plant Ecologist, East Glacier Park, MT

Abstract

The decline of insects that pollinate flowers is garnering more attention by land managers, policymakers, and the general public. Nursery managers who grow native trees, shrubs, and woody vines have a promising opportunity to showcase these species, marketing their contributions to pollinator health and other ecosystem services in urban and wild landscapes. Species either not currently in production or in demand may benefit from niche markets that can be created around specific pollinators, especially butterflies and moths with their showy coloration. This is particularly true in the Northeastern United States because of the high diversity of woody species. Nursery catalogs can take advantage of free, online sources of images to highlight woody species and their pollinators. Marketing "pollinator packages," suites of plants that combine different flowering times, forest canopy types, and plant forms (trees, shrubs, and vines), has potential to increase sales and improve habitat for native pollinators. This paper was presented at a joint meeting of the Northeast Forest and Conservation Nursery Association and Southern Forest Nursery Association (Kent Island, MD, July 20–23, 2015).

Introduction

The general public is well aware of the pollinator crisis in North America. Honey bee colony collapse disorder, suspected to be caused by a complicated interaction of parasites and pathogens and other factors, exacerbated by pesticide use, including neonicotinoids, has resulted in steep and often sudden population declines (Alaux et al. 2010; Cox-Foster et al. 2007; Dainat et al. 2012; Johnson et al. 2009, 2010). Reduction and fragmentation of habitat and pesticides have negatively affected abundance and species richness of wild, unmanaged bees (Gill et al. 2012, Whitehorn et al. 2012, Winfree et al. 2009) and the iconic monarch butterfly (*Danaus plexippus* L.; Lepidoptera: Nymphalidae; see table 1 for more details on insect nomenclature). These declines have triggered discussion about the immediate need to reverse these population trends to protect food production, native flora and fauna, and other ecological services necessary for environmental health and economic stability. As a result, the White House (2015) released an initiative to support pollinators, and it includes language that supports using native plants as a key strategy to assist in pollinator recovery.

Thus, an opportunity and a crucial national need exist for managers of forest and conservation nurseries to highlight, produce, and promote native woody species that support pollinators. This article focuses on the Northeastern United States, which we define as Minnesota south to Missouri and east to the Atlantic, although the general concepts are applicable anywhere.

Insects that pollinate plants come in myriad shapes and sizes and are represented by four taxonomic orders: (1) Coleoptera (beetles), (2) Diptera (flies), (3) Hymenoptera (bees and wasps), and (4) Lepidoptera (butterflies and moths) (table 1). On one hand, native bees and bumble bees, with their hairy legs and bodies that come in close contact with floral stamens and with their purposeful collection, transport, and consumption of pollen, are very efficient pollinators (figure 1). On the other hand, most butterflies have smooth bodies and long legs that elevate them above the stamens, and they

Table 1. Common insect pollinators mentioned in this publication: a who's who in the language[a] of entomologists.

Order *Family* *Genus*	Common names
Coleoptera	beetles
Diptera	true flies
Syrphidae	syrphid flies, flower flies, hover flies
Hymenoptera	ants, bees, wasps
Andrenidae	
Andrena	mining bees
Apidae	
Apis	honey bees
Bombus	bumble bees
Xylocopa	carpenter bees
Lepidoptera	butterflies, skippers, and moths
Geometridae	ankerworms, geometers, measuringworms
Hesperiidae	skippers
Limacodidae	saddleback caterpillars
Lycaenidae	gossamer-winged butterflies, blues, coppers, hairstreaks, harvesters
Noctuidae	cutworms, dagger moths, noctuid moths, owlet moths, underwings
Nymphalidae	admirals, anglewings, brush-footed butterflies, checkerspots, crescents, fritillaries, mourningcloaks
Papilionidae	swallowtail butterflies
Saturniidae [b]	giant silkworm moths, royal moths
Sphingidae	hawk moths, sphinx moths

[a] From Integrated Taxonomic Information System (June 2015).

[b] Members of the Saturniidae are not pollinators, because adults do not feed (they generally live less than 7 days), but many woody species host their larvae.

primarily consume nectar as their energy source; thus, contact with pollen is more accidental, which makes them less efficient pollinators. Some moths and flowers have an obligate pollination strategy. For butterflies and moths, their lack of pollination prowess is often compensated, from a home gardener's perspective, by beautiful colors in striking patterns (figure 2). Other animals, such as bats and hummingbirds, are important pollinators, too. While many native woody plants provide pollen and nectar sources for all pollinators, they are particularly important host plants for the larvae of many species of butterflies and moths. Thus, much of the focus of this article is on the role of woody native plants whose flowers support a broad palette of pollinators in general and, specifically, support butterfly and moth larvae.

Figure 1. Native bumble bees (*Bombus* species; Hymenoptera: Apidae) with their hairy bodies and legs that drag across floral stamen are efficient pollinators (top). Brightly colored butterflies, such as this painted lady (*Vanessa cardui* L.; Lepidoptera: Nymphalidae) (bottom), are generally less efficient pollinators but may provide nursery managers with better marketing options when describing woody plants important to "pollinators" in general. (Photos by R. Kasten Dumroese, 2014)

The Potential To Grow Northeastern Native Woody Species for Pollinators

The Northeastern United States is a region of exceptional native woody plant diversity. Many of these woody plant genera are currently in the nursery trade; however, additional native species could be introduced and promoted. Some of these, for example, *Cladrastis* Raf. (yellowwood), *Cephalanthus* L. (buttonbush), *Oxydendrum* DC. (sourwood), Sassafras Nees & Eberm. (sassafras), and *Viburnum* L. (viburnum) have unusual foliage or flowers that make them worthy of greater use in natural and more formal landscapes (Harrison 2006). Although a number of eastern native forbs have been identified as important for supporting pollinator populations, native woody species have been largely left out of the discussion. That oversight is most unfortunate because nearly all native tree, shrub, and

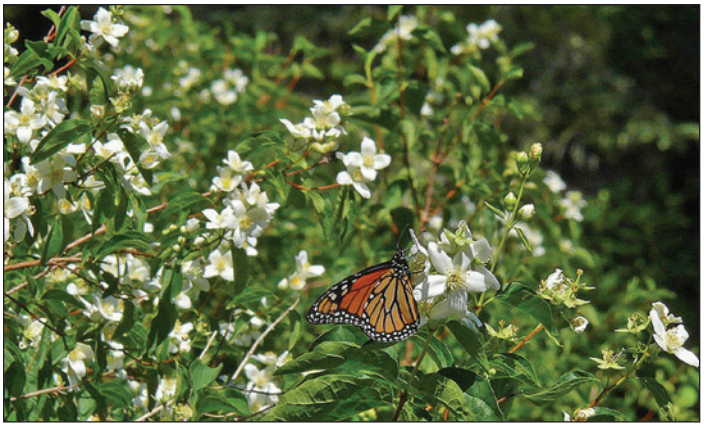

Figure 2. A monarch butterfly (*Danaus plexippus*) feeding on *Philadelphus* L. (mock orange). (Photo by Tanya Harvey, Native Plant Society of Oregon, 2012)

woody vine genera of the Eastern United States are known larval hosts and important nectar sources for native lepidopteran (butterfly and moth) species (Tallamy and Shropshire 2009) and support native and domesticated bees. Fragmentation and reduction of eastern forests and shrub-dominated communities, along with the prevalence of exotic ornamental plants for use in urban and rural communities, are important contributing factors to pollinator declines.

Supplying native eastern woody species important to pollinators is an important way to conserve and enhance pollinator populations, especially in urban areas where exotic ornamental genera are widely planted. Most popular ornamental woody genera have native North American counterparts that can be planted and promoted in nursery markets and through public awareness campaigns. Exotic ornamentals may be visited by bees, but most ornamentals do not serve as larval hosts for native Lepidoptera (Tallamy 2007). Similarly, natural communities invaded by invasive woody exotics host fewer native woody plants (in terms of species and abundance), resulting in concomitant declines in the species richness, composition, and abundance of butterflies and moths (Burghardt et al. 2010). Informing and educating the public, restoration biologists, and other land managers about the benefits of native woody species to pollinators will be an important component in supporting pollinator populations that may also yield economic benefits to forest and conservation nurseries. Nurseries should consider working together to inform citizens about the benefits of these plants, because wide-scale public perception and knowledge are important to reversing declining population trends and generating new nursery markets (Meyer 2005).

Woody Species and Pollinators

The work by Tallamy and Shropshire (2009) shows that 15 times more native lepidopteran species use native woody plant species as larval hosts than those that use nonnative ornamental woody species, and, when herbaceous plants and woody plants were compared, woody species supported 10 times more lepidopteran species. Because all flowering native woody species produce nectar, pollen, or both, these species are critical to bee populations as well.

Native woody species are used as larval food sources, for shelter during larval development, and for pupation, and adults use trees, shrubs, and forbs as nectar sources. Native shrub communities in the Northeastern United States are important for Lepidoptera of conservation concern (Wagner et al. 2003). Varying stratum or canopy layers of nectar sources in shrub and forested communities coincide with lepidopteran flight patterns and feeding habits, and the lack or absence of taller feeding layers can lead to decreased habitat use and reduced species richness of butterflies and moths. Native woody plant diversity ensures that a range of nectar availability is present throughout the multigenerational life cycles for this group of pollinators. At the same time, a range of alternate and highly important nectar and pollen sources need to be available for native honey bee and bumble bee populations throughout the growing season. As a consequence, restoration and urban pollinator-supportive landscapes will require multiple native woody species that exhibit a range of flowering phenology.

On one hand, native lepidopteran species that are specialist feeders have coevolved with certain plant lineages or species; are adapted to the flowering phenology, tissue chemistry, and physical structure of the host; and, thus, require the presence of this specific native plant species or a very close relative for reproductive success (Wardhaugh 2014). Native generalists, on the other hand, are able to use a range of woody plants as larval hosts, and, as a consequence, are often more common or have broader geographic distributions. Reduction of natural habitat, use of pesticides, and the effects of climate change, however, have resulted in pollinator population reduction, range shifts, and changes in the flowering phenology of larval host plants. As a result, many of the more common native butterflies and moths require consideration in wildland and urban landscape restoration plans. Recent and rapid decline of monarch butterfly populations (figure 2) exemplify the need to

restore native nectar sources, larval host plants, and shelter sites for more common species, including those that exhibit wide migratory patterns or geographic ranges.

Combinations of woody plant species, with a range of early spring to fall flowering phenology, can assist in the recovery of declining bee and butterfly populations. Native shrub combinations can be used for urban landscapes; these landscapes can provide other wildlife benefits such as food, shelter, and nesting sites while reducing maintenance costs. Examples of native eastern trees, shrubs, and woody vines that support bees, butterflies, and moths and that also exhibit a range of desirable ornamental characteristics are shown in table 2. The Pollinator Partnership has a handy online tool that provides ecoregional planting guides (http://www.pollinator.org/guides.htm); entering a ZIP Code provides a link to a summary of plants for pollinators, including woody species, for that area.

Riparian Species

This section about riparian species discusses some of these native woody plants and their benefits to native pollinators in more detail.

It is surprising that native wetland- and riparian-dependent Salicaceae species, such as *Salix* L. (willow) and *Populus* L. (cottonwood), serve as larval hosts for more than 700 butterfly and moth species, including those that are largely found only in wetland habitats. These habitats are also preferential nesting and brooding habitat to numerous migratory songbirds, in part, due to the abundance of insect larvae necessary for raising successful broods. Many willows flower during early spring. Male and female flowers have nectar glands, and pollen from male flowers is often the only available pollen source when native bees (Hymenoptera: Apidae) and flower flies (Diptera: Syrphidae) first emerge after winter (Ostaff et al. 2015).

Table 2. Woody plants, their form (shrub, tree, vine), their floral phenology and pollinators, and the lepidopteran larvae they host.

Genus/ species[a]	Family	Plant form[b]	Flowering	Pollinators (HB = hummingbirds)	Host native Lepidoptera family (species)	Sources[c]
Acer L.	Aceraceae	T	Mid-spring	*Apis*	*Limacodidae* (287)	1,4,9
Aesculus L.	Hippocastanaceae	T	Summer	*Bombus*, Nymphalidae, HB	*Nymphalidae* (33)	1,2,4
Alnus Mill.	Betulaceae	T	Spring	Wind	(248)	1
Amelanchier Medik.	Rosaceae	S/T	Mid-spring	*Apis*, *Bombus*	6+ families (119)	1,3,4,7
Amorpha L.	Fabaceae	S	Summer	*Bombus*, HB	*Hesperiidae* (23)	1,3,4,
Arctostaphylos uva-ursi (L.) Spreng.	Ericaceae	S	Spring	*Apis*, *Bombus*	*Lycaenidae* (15)	1–4
Aristolochia L.	Aristolochiaceae	S	Summer	*Papilionidae*	*Papilionidae* (1)	1,3,4
Aronia Medik.	Rosaceae	S	Spring	*Apis, Bombus*	(5)	1,4
Asimina Adans.	Annonaceae	S/T	Spring	*Coleoptera*	*Papilionidae* (12), *Limacodidae*	1–4, 9
Baccharis L.	Asteraceae	S	Summer/fall	*Nymphalidae*	*Lycaenidae* (20)	1–4
Betula L.	Betulaceae	T	Spring	Wind	(400)	1,2,4
Bignonia capreolata L.	Bignoniaceae	V	Spring	*Bombus*, HB	*Sphingidae*	3
Callicarpa americana L.	Verbenaceae	S	Summer	*Apis, Bombus, Nymphalidae*	(1)	1,2,4
Campsis radicans (L.) Seem. Ex Bureau	Bignoniaceae	V	Summer	*Bombus*, HB	*Sphingidae* (7)	1–4
Carpinus L.	Betulaceae	T	Spring	Wind	*Lycaenidae* (66)	1,2,4
Carya Nutt.	Juglandaceae	T	Early summer	Wind	*Lycaenidae, Limacodidae* (233)	1,2,4,9
Castanea Mill.	Fagaceae	T	Early summer	Wind	(125)	1,2,4
Catalpa Scop.	Bignoniaceae	T	Late spring	*Bombus, Sphingidae*, HB	*Sphingidae* (7)	1,2,4
Ceanothus americanus L.	Rhamnaceae	S	Summer	*Apis, Bombus*	*Lycaenidae* (43)	1,4
Celastrus scandens L.	Celastraceae	S	Summer	*Apis, Bombus*	*Geometridae* (5)	1,4
Celtis L.	Ulmaceae	T	Spring/summer	Wind	(41)	1,4

Genus/ species[a]	Family	Plant form[b]	Flowering	Pollinators (HB = hummingbirds)	Host native Lepidoptera family (species)	Sources[c]
Cephalanthus occidentalis L.	Rubiaceae	S/T	Early summer	*Bombus, Nymphalidae, Sphingidae*	*Sphingidae* (19)	1,3
Cercis canadensis L.	Fabaceae	T	Early spring	*Apis, Bombus*, HB	*Lycaenidae* (19)	1,2,4
Chamaedaphne calyculata (L.) Moench	Ericaceae	S	Early spring	*Bombus*	*Lycaenidae* (15)	1,4
Chionanthus virginicus L.	Oleaceae	S	Late spring	*Apis, Bombus*	*Sphingidae* (8)	1,3,4
Cladrastis kentukea (Dum. Cours.) Rudd	Fabaceae	T	Late spring	*Apis, Bombus*	–	1–5
Clethra L.	Clethraceae	S	Mid-summer	*Apis, Bombus*, HB	*Geometridae* (9)	1,2
Cornus L.	Cornaceae	S/T	Summer	*Apis, Bombus*	*Lycaenidae* (115)	1,2,4
Corylus L.	Betulaceae	T	Early spring	Wind	(124)	1,4
Cotinus obovatus Raf.	Anacardiaceae	T	Summer	Wind	(4)	1,4
Crataegus L.	Rosaceae	T	Early summer	*Apis, Bombus*	10 families (158)	1–5
Diervilla Mill.	Caprifoliaceae	S	Late spring	*Bombus*	*Sphingidae* (4)	1,3
Diospyros L.	Ebenaceae	T	Early summer	*Apis*	*Saturniidae* (44), *Limacodidae*	1–4,9
Elaeagnus commutata Bernh. ex Rydb.	Elaeagnaceae	S	Summer	*Apis, Syrphidae*	*Saturniidae* (22)	1,3
Eubotrys racemosa (L.) Nutt.	Ericaceae	S	Early spring	*Apis, Bombus*	–	1,4
Fagus L.	Fagaceae	T	Spring	Wind	9 families (124)	1,2,4
Fothergilla gardenii L.	Hamamelidaceae	S	Spring	*Apis, Bombus*	–	2,4
Fraxinus L. (black, blue, green)	Oleaceae	T	Late spring	*Apis*	29 families (141)	1,2,4
Gaylussacia Kunth	Ericaceae	S	Early summer	*Apis, Bombus*	*Lycaenidae* (42)	1,3,4
Gleditsia triacanthos L.	Fabaceae	T	Summer	*Apis, Bombus*	*Hesperiidae* (42)	1,2
Gymnocladus dioicus (L.) K. Koch	Fabaceae	T	Late spring	*Apis, Bombus, Papilionidae*, HB	*Sphingidae* (4)	1,4
Halesia Ellis ex L.	Styracaceae	S	Spring	*Apis, Bombus*	(7)	1,4
Hamamelis L.	Hamamelidaceae	S	Spring, fall	*Apis, Syrphidae*	*Lycaenidae* (62)	1,3,4
Hydrangea L. (fertile)	Hydrangeaceae	S	Early spring	*Apis, Bombus*	*Sphingidae* (5)	1,4
Ilex L.	Aquifoliaceae	S	Mid-spring	*Apis*	*Lycaenidae* (34)	1,2,3,4
Itea virginica L.	Grossulariaceae	S	Early summer	*Apis, Bombus, Nymphalidae*	*Lycaenidae* (1)	8
Juglans L.	Juglandaceae	T	Spring	Wind	(123)	4
Kalmia L.	Ericaceae	S	Mid-spring	*Apis, Bombus*	*Noctuidae* (31)	1,2,4
Leucothoe D. Don	Ericaceae	S	Early spring	*Apis, Bombus*	(3)	1,4,6
Lindera benzoin (L.) Blume	Lauraceae	V	Mid-spring	*Nymphalidae*	*Papilionidae, Lycaenidae* (9), *Saturniidae, Geometridae*	1,2,3,4,9
Liquidambar styraciflua L.	Hamamelidaceae	T	Spring	*Apis, Syrphidae*	*Papilionidae* (33)	1
Liriodendron tulipifera L.	Magnoliaceae	T	Spring	*Apis, Bombus, Coleoptera, Syrphidae*	*Papilionidae* (19)	1
Lonicera L.	Caprifoliaceae	S/V	Early summer	*Bombus, Nymphalidae*, HB	*Geometridae, Noctuidae, Nymphalidae* (33)	1–4
Lyonia L.	Ericaceae	S	Early summer	*Apis, Bombus*	*Lycaenidae*	8
Magnolia L.	Magnoliaceae	T	Summer	*Coleoptera*	*Saturniidae* (21)	1,2
Mahonia Nutt.	Berberidaceae	S	Early spring	*Apis, Bombus*	–	1
Malus Mill.	Rosaceae	T	Spring	*Apis, Bombus*	(308)	1

Genus/ species[a]	Family	Plant form[b]	Flowering	Pollinators (HB = hummingbirds)	Host native Lepidoptera family (species)	Sources[c]
Myrica L.	Myricaceae	S	Mid-spring	*Apis, Bombus*	(106)	1,3,4
Nyssa L.	Cornaceae	T	Mid-spring	*Apis, Bombus*	(25)	1,2
Ostrya virginiana (Mill.) K. Koch	Betulaceae	T	Early spring	Wind	(91)	1
Oxydendrum DC.	Ericaceae	S/T	Mid-summer	*Apis, Bombus*	*Saturniidae* (14)	1,4
Parthenocissus Planch.	Vitaceae	V	Mid-summer	*Apis,* native solitary bees	*Geometridae, Sphingidae* (32)	1,7
Physocarpus opulifolius (L.) Maxim., orth. cons.	Rosaceae	S	Mid-summer	*Apis, Bombus, Nymphalidae*	*Geometridae* (146)	1,3,4
Populus L.	Salicaceae	T	Spring	Wind	9 families (358) (*Papilionidae, Nymphalidae*)	1
Prunus L.	Rosaceae	S/T	Spring/summer	*Apis, Bombus*	13 families (>450) (*Papilionidae, Lycaenidae, Limacodidae*)	1–5,7,9
Quercus L.	Fagaceae	T	Spring/summer	Wind	13 families (518)	1–4
Rhododendron L.	Ericaceae	S	Spring/summer	*Apis, Andrena,* HB	*Lycaenidae* (50)	1,2,3,4
Rhus L.	Anacardiaceae	T	Early summer	*Apis*	*Lycaenidae* (54)	1,4
Ribes L.	Grossulariaceae	S	Early summer	*Bombus,* HB	*Lycaenidae* (92)	1–5
Robinia L.	Fabaceae	T	Spring	*Apis, Bombus*	*Hesperiidae* (67)	4
Rosa L.	Rosaceae	S	Early summer	*Apis, Bombus*	7 families (122)	1–4
Rubus L.	Rosaceae	S	Mid-summer	*Apis, Bombus*	9 families (151)	1–4
Salix L.	Salicaceae	S/T	Spring	*Apis, Syrphidae*	11 families (440) (*Papilionidae, Nymphalidae*)	1
Sambucus L.	Caprifoliaceae	S	Early summer	*Apis, Diptera*	(40)	1,2
Sassafras albidum (Nutt.) Nees	Lauraceae	S/T	Spring/summer	*Apis, Bombus*	*Papilionidae, Saturniidae* (36)	1,2,4
Smilax L.	Smilacaceae	V	Spring	*Apis, Coleoptera, Diptera*	(17)	1
Sorbus L.	Rosaceae	S/T	Early summer	*Apis, Bombus*	*Papilionidae* (62)	1,4
Spiraea alba Du Roi	Rosaceae	S	Spring/summer	*Apis*	*Lycaenidae, Saturniidae* (86)	1,2,4,7
Stewartia ovata (Cav.) Weath.	Theaceae	S	Summer	*Apis, Bombus, Nymphalidae*	(1)	1,4
Styrax L.	Styracaceae	S	Spring	*Apis, Bombus*	–	1,4
Symphoricarpos Duham.	Caprifoliaceae	S	Summer	*Apis*	*Nymphalidae* (24)	1,3,4
Tilia L.	Tiliaceae	T	Spring/summer	*Apis*	*Nymphalidae, Sphingidae* (142)	1,4
Ulmus L.	Ulmaceae	T	Early spring	Wind	*Nymphalidae* (206)	1,2,4
Vaccinium L.	Ericaceae	S	Late spring	*Apis, Bombus*	*Lycaenidae* (286)	1–4
Viburnum L.	Caprifoliaceae	S/T	Early summer	*Apis, Nymphalidae*	*Lycaenidae, Nymphalidae, Noctuidae (97)*	1–4,7
Vitis L.	Vitaceae	V	Summer	*Apis,* native solitary bees	*Geometridae, Sphingidae* (72)	1,7
Wisteria L.	Fabaceae	V	Spring/summer	*Apis, Xylocopa*	*Hesperiidae* (18)	1,4,5
Zanthoxylum americanum Mill.	Rutaceae	S/T	Early summer	Native solitary bees	*Papilionidae* (6)	1,3,5

[a] Nomenclature follows USDA NRCS (2016).

[b] S = shrub. T = tree. V = vine.

[c] Sources: 1: Tallamy and Shropshire (2009). 2: Webb (2008). 3: LJWC (2015). 4: Cullina (2002). 5: BAMONA (2015). 6: Schweitzer (1980). 7: Fergusen (1975). 8: Wright and Pavulaan (1999). 9: Lill (2008).

Given the estimates that up to 90 percent of wetland and riparian habitat has been lost in the Midwestern United States alone (EPA 2015), marketing the importance of native Salicaceae for riparian restoration and its associated benefits to water quality, native pollinators, migratory songbirds, and butterflies could stimulate interest in these easy-to-grow species that can be grown from both seeds and cuttings. Willows and cottonwoods are dioecious, so growers will need to produce male and female nursery stock. Seedlings will result in a mixture of sexes; cutting propagation, however, will require that donor trees are identified to gender before cutting collection (Landis et al. 2003).

Rosaceae Species

Many common, native woody Rosaceae shrub genera commercially available in the native nursery trade are crucial for native bees, European honey bees, and bumble bees (Apidae) and host an overwhelming number of rare and common butterfly and moth species (Wagner et al. 2003). Native cherries, such as *Prunus americana* Marshall (American plum), *P. pensylvanica* L. f. (pin cherry), *P. serotina* Ehrh. (black cherry), and *P. virginiana* L. (chokecherry), support exceptionally high lepidopteran richness, serving as hosts for 429 species in the gossamer-winged butterfly family (Lepidoptera: Lycaenidae) (Tallamy and Shropshire 2009) and for swallowtail butterflies (Papilionidae).

Other Rosaceae woody genera, such as *Rubus* L. (wild raspberry), are preferential nectar sources for butterflies and moths (Grundel et al. 2000). *Rubus* and *Rosa* L. (wild rose) host up to 9 lepidopteran families and more than 100 species each (Tallamy and Shropshire 2009), and *Spiraea alba* Du Roi (white spiraea) hosts 86 gossamer-winged butterfly and sphinx moth (Sphingidae) species. *Amelanchier alnifolia* (Nutt.) Nutt. ex. M. Roem (serviceberry) occurs across the Northern and Central United States and hosts at least 6 butterfly and moth families and up to 125 species.

Ericaceae Species

Native Ericaceae shrubs generally flower during spring and provide early important nectar and pollen sources for pollinators. Examples include *Arctostaphylos uva-ursi* (L.) Spreng. (bearberry), *Gaylussacia* Kunth (huckleberry), *Rhododendron* L. (native azalea), *Vaccinium* L. (blueberry and cranberry), including native *Vaccinium* species that are important commercial food crops. These genera are also important larval hosts for butterflies and moths: more than 340 gossamer-winged butterfly species, including copperwings (Lycaeninae), blues (Polyommatinae), and hairstreaks (Theclinae). Eight *Gaylussacia* species and at least 20 native *Rhododendron* and 20 *Vaccinium* species occur in the Eastern United States (Gleason and Cronquist 1991), yet many are not widely available in nurseries, including some that have broad geographic ranges in the Eastern United States. *Gaylussacia baccata* (Wangenh.) K. Koch, *G. frondosa* (L.) Torr. & A. Gray ex Torr., and *G. dumosa* (Andrews) Torr. & A. Gray (black, blue, and dwarf huckleberry, respectively) occur throughout most of the Eastern and Southeastern United States and consequently have larger restoration and homeowner markets, while other species are found in smaller ranges in the Southeastern States and may be available from only a few specialist nurseries.

Rhododendrons are some of the most popular ornamental woody plants in the Eastern United States. Native *Rhododendron* species, in general, are available in a few specialist nurseries. Five species are found throughout the Northeastern and Southeastern United States: *Rhododendron arborescens* (Pursh) Torr. (smooth azalea), *R. calendulaceum* (Michx.) Torr. (flame azalea; figure 3), *R. maximum* L. (great laurel), *R. periclymenoides* (Michx.) Shinners (pink azalea), and *R. prinophyllum* (Small) Millais (early azalea).

These species exhibit a range of flower color, habit, and height and can easily be used for mass flowering shrub plantings in urban landscapes. Other native *Rhododendron* species have more restricted southeastern ranges but are important components of forests, larval hosts, or of conservation concern.

Among the Ericaceae, the Eastern United States is the center of *Vaccinium* diversity and origin of important food crops: *V. angustifolium* Aiton (lowbush blueberry), *V. corymbosum* L. (highbush blueberry), and *V. macrocarpon* Aiton (cranberry). *Viburnum arboreum* Marshall (farkleberry) and *V. stamineum* L. (deerberry) occur across the Eastern United States

Figure 3. Flowers of native rhododendrons, such as *Rhododendron calendulaceum* (flame azalea), provide pollen and nectar to a variety of insects that pollinate plants, including honey and mining bees; serve as host to the larvae of more than 50 species of gossamer-winged butterflies; and offer a stunning visual display in the home garden or natural landscape. (Photo by Joseph G. Strauch, Jr., Strauch Photography, 1995)

but are not widely promoted. Blueberries are very popular as home landscape food crops, and other *Vaccinium* species, with more restricted ranges, can be promoted for similar purposes.

Spring-Flowering Plants

Many spring-flowering native shrubs are critical early nectar and pollen sources for bees and also host numerous butterfly and moth species. For example, *Myrica gale* L. (sweetgale) supports native bees and bumble bees and hosts at least 106 species of butterflies and moths (table 2). Spring-flowering *Viburnum prunifolium* L. (black haw) and summer flowering *Itea virginica* (Virginia sweetspire) are pollinated by bees and brush-footed butterflies (Tallamy and Shropshire 2009). *Itea virginica* also serves as an alternate, later season host to a recently described butterfly (*Celastrina idella* D. Wright and Pavulaan [Lycaenidae]) when flowers of its preferred host, *Ilex* L. (holly), are unavailable (Wright and Pavulaan 1999).

It is interesting that mid-spring flowering *Lindera benzoin* (L.) Blume (spicebush), which can be grown as a 1+0 bareroot crop (Hoss 2006), is pollinated by brush-footed butterflies and hosts nine swallowtail and gossamer-winged butterfly species. Spicebush could be marketed as an alternative to the ornamental *Buddleja davidii* L. (Buddlejaceae) (butterfly bush), which does not host native lepidopteran species.

Spring-flowering *Hydrangea* L. (hydrangea), *Sassafras albidum* (Nutt.) Nees (sassafras), *Styrax* L. (snowbell), *Oxydendrum*, and summer-flowering native plants, including *Campsis radicans* (L.) Seem. Ex Bureau (trumpet creeper; figure 4), *Lonicera* L. (honeysuckle), and *Physocarpus opulifolius* (L.) Maxim. (common ninebark) are important nectar sources. These species also host larvae of multiple moth species, including exceptionally beautiful genera, such as sphinx moths and the luna moth (*Actias luna* L. Saturniidae) and also the smaller moths of the Geometridae. Native plants that produce tubular flowers, such as *Campsis, Diervilla* Mill. (bush honeysuckle), and *Lonicera*, are also nectar sources and are pollinated by migratory ruby-throated hummingbirds (*Archilochus colubris* L. [Trochilidae]). It is important to note that native trees and shrubs that flower or continue flowering during late summer and early fall in the upper Midwest and Northeast, such as *Diervilla lonicera* Mill. (northern bush honeysuckle), *Sambucus* L. (elderberry), *Symphoricarpos* Duham. (snowberry), and *Viburnum* provide

Figure 4. The large, tubular flowers of *Campsis radicans* (trumpet creeper), a native vine, are visited by bumble bees and hummingbirds. Foliage is consumed by the larvae of at least seven species of sphinx moths, sometimes referred to as "hummingbird moths." (Photo by Joseph G. Strauch, Jr., Strauch Photography, 1995)

late-season nectar sources at a different stratum, or canopy level, than do late-flowering native forbs, and they also provide necessary shelter during the fall migration of monarch butterflies.

Other Species

Native woody vines provide wildlife cover in restoration plantings and provide screening in home landscapes. Woody vines in the Fabaceae family, including *Wisteria frutescens* L. Poir. (American wisteria), exhibit similar desirable characteristics found in widely marketed introduced Asian species, but they are pollinated by native carpenter bees (*Xylocopa* L.) and honey bees (*Apis* L.) and host the larvae of skipper butterflies (Hesperiidae). *Aristolochia macrophylla* Lam. (pipevine) is the larval host for the pipevine swallowtail butterfly (*Battus philenor* L.), a butterfly of unknown conservation status. Formerly popular native vines in the Vitaceae family, such as *Campsis radicans* and *Parthenocissus quinquefolia* (L.) Planch. (Virginia creeper), can, in the current market, be repromoted to support pollinators.

Other lesser known woody taxa, such as *Zanthoxylum americanum* Mill. (common pricklyash), host swallowtail butterflies, such as the eastern tiger swallowtail (*Papilio glaucus* L.) and the largest North American butterfly, the giant swallowtail (*P. cresphontes* Cramer) (figure 5). Larval host specificity to these showy butterflies could also be used as a marketing strategy.

Shrub layers in natural communities contain numerous caterpillars necessary for feeding and rearing broods of migratory songbirds. Native shrubs planted in abundance in urban areas, in turn, can attract and increase nesting success for songbirds that depend on adequate cover, preferential nesting sites, and protein-rich food sources supplied by the larvae of butterflies and moths (Burghardt et al. 2009, Tallamy 2004). Thus, market promotion for pollinators can also include the benefits for assisting migratory songbird populations.

Marketing Woody Species

Although native bees and bumble bees are the most efficient pollinators, butterflies and moths are often less threatening and more visually stunning (figure 5).

Figure 5. Butterflies, such as this giant swallowtail (*Papilio cresphontes*; Lepidoptera: Papilionidae), with its beautiful colors and wing shapes, can add zest to marketing materials, especially when the butterfly can be specifically matched to a particular woody species. In this case, noting that larvae of this butterfly consume leaves of common pricklyash (*Zanthoxylum americanum*) makes this small tree sound better than its common name suggests. (Photo by Tom Clark, www.Flickr.com, 2007)

Therefore, incorporating images of them into brochures, catalogs, and order forms can be a vibrant addition in concert with plant descriptions. State nurseries may be able to find useful images within their departments of natural resources that often contain amateur photographers willing to share their efforts. New online repositories, such as Flickr (https://www.flickr.com), hold an immense number of images uploaded by professionals and amateurs. These images can easily be searched by scientific and/or common names, and the contact information of the photographers is usually available too. Many amateur photographers are more than willing to allow use of their photos. Some photographers allow downloading of their images without obtaining prior permission, but always respect the photographers by asking for permission and giving proper credit when the image is used. Provide photographers with a copy or link so they can see the final product. If you find an image you like, make sure you note the Web address; the search function can sometimes make it difficult to relocate images.

The U.S. Department of Agriculture (USDA) National Agroforestry Center (http://nac.unl.edu) has several excellent publications connecting the role of woody vegetation and pollinator health including fact sheets for niche species, such as *Asimina triloba* (L.) Dunal (pawpaw), *Sambucus*, and woody florals

(e.g., *Salix* and *Cornus* L. [dogwood]) that support pollinators and have income potential for landowners (figure 6). Linking potential nursery customers with these resources can also encourage sales of woody plants.

Consider marketing your woody plants by offering "packages" that include several species and provide more benefit as a set than they might provide individually. For example, a package might focus on providing pollen and nectar sources throughout the growing season. The package could include species from genera such as *Salix*, *Prunus*, and *Tilia* L. to provide early spring, spring, and early summer pollen and nectar sources, respectively. Or a plant package could include *Kalmia* (laurel), *Zanthoxylum*, and *Aesculus* L. (buckeye) to provide understory, mid-canopy, and overstory sources or different plant forms, such as vines (*Bignonia* L. [bignonia]), shrubs (*Ribes* L. [currant]), and trees (*Catalpa* Scop. [catalpa]) (figure 7).

Figure 6. Some woody plants, such as this *Sambucus* (elderberry), provide nectar and pollen for pollinators and fruits for human consumption. (Photo by Steve Burt, 2010)

Summary

Recovery of declining pollinator populations will require that the woody plant nursery industry promote the use of native tree, shrub, and woody vine species that provide nectar to pollinators and/or serve as hosts for larvae of butterflies and moths. Promoting these plants presents opportunities to showcase woody species currently in production and to bring additional native species into the market. Wetland, forest, and other restoration projects and urban re-greening and home landscapes can encourage and implement the wide-scale use of native pollinator-dependent/pollinator-supportive woody plants.

Native plant nurseries will play a critical role in national pollinator recovery efforts by promoting the pollination ecology of these species to clients and the general public. Multiple environmental and economic benefits to restoration and landscaping markets that result from the wide-scale use of native woody plants can also be used to promote these species. Nurseries can benefit by supplying a large potential market and providing additional native species into the trade, while re-marketing some species that have been long-time standards in the nursery trade.

Figure 7. Consider marketing woody plants in packages that provide a suite of characteristics. Ideally, species in these packages would bloom at different seasons or occur at different levels of the forest canopy, and could include shrubs, vines, and trees, such as this *Catalpa*. (Photo by Karen-Louise Taylor, www.Flickr.com, 2012)

Address correspondence to—

R. Kasten Dumroese, U.S. Department of Agriculture, Forest Service, 1221 South Main Street, Moscow, ID 83843; email: kdumroese@fs.fed.us; phone: 208–883–2324.

Acknowledgments

This work was supported by the USDA Forest Service, Rocky Mountain Research Station (RMRS) and the National Center for Reforestation, Nurseries, and Genetic Resources. The authors especially thank the photographers for use of their images and Deborah M. Finch (USDA Forest Service, RMRS), Thomas D. Landis (Native Plant Consulting), and

Justin B. Runyon (USDA Forest Service, RMRS) for reviewing the manuscript. Specific mention of trade names and titles is for reader information only and does not imply endorsement by the USDA of any product or service.

Resources for Propagating Eastern Native Woody Species

Baskin, C.C.; Baskin, J.M. 1998. Seeds: ecology, biogeography and evolution in dormancy and germination. San Diego: Academic Press. 666 p.

Cullina, W. 2002. Native trees, shrubs, and vines: a guide to using, growing and propagating North American woody plants. Boston: Houghton Mifflin. 354 p.

Dumroese, R.K.; Landis, T.D.; Luna, T. 2012. Raising native plants in nurseries: basic concepts. Gen. Tech. Rep. RMRS-GTR-274. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 84 p.

Native Plant Propagation Database. 2016. http://npn.rngr.net. (August 2016).

USDA Forest Service. 2008. Woody plant seed manual (online version). http://nsl.fs.fed.us/nsl_wpsm.html. (August 2016).

Examples of Reference Guides for Butterflies and Moths

Brock, J.P.; Kaufman, K. 2006. Field guide to butterflies of North America. Boston: Houghton Mifflin. 392 p.

Covell, C.V., Jr. 1984. A field guide to the moths of eastern North America. Boston: Houghton Mifflin. 624 p.

Glassberg, J. 1999. Butterflies through binoculars: a field guide to the butterflies of eastern North America. New York: Oxford University Press. 400 p.

Opler, P.A. 1994. Peterson first guide to butterflies and moths: a simplified guide to the common butterflies and moths of North America. Boston: Houghton Mifflin. 128 p.

Opler, P.A.; Malilul, V. 1998. A field guide to eastern butterflies. Boston: Houghton Mifflin. 512 p.

Wagner, D.L. 2005. Caterpillars of eastern North America. Princeton, NJ: Princeton University Press. 496 p.

Wright, A.B. 1993. Peterson first guide to caterpillars of North America. Boston: Houghton Mifflin. 128 p.

REFERENCES

Alaux, C.; Brunet, J.L.; Dussaubat, C.; Mondet, F.; Tchamitchan, S.; Cousin, M.; Le Conte, Y. 2010. Interactions between *Nosema* microspores and a neonicotinoid weaken honeybees (*Apis mellifera*). Environmental Microbiology. 12(3): 774–782.

Burghardt, K.T.; Tallamy, D.W.; Philips, C.; Shropshire, K.J. 2010. Non-native plants reduce abundance, richness, and host specialization in lepidopteran communities. Ecosphere 1(5): 1-22.

Burghardt, K.T.; Tallamy, D.W.; Shriver, G.W. 2009. Impact of native plants on bird and butterfly biodiversity in suburban landscapes. Conservation Biology. 23(1): 219–224.

Butterflies and Moths of North America (BAMONA). 2015. http://www.butterfliesandmoths.org/. (June 2015).

Cox-Foster, D.L.; Conlan, S.; Holmes, E.C.; Palacios, G.; Evans, J.D.; Moran, N.A.; Lipkin, W.I. 2007. A metagenomic survey of microbes in honey bee colony collapse disorder. Science. 318(5848): 283–287.

Cullina, W. 2002. Native trees, shrubs, and vines: a guide to using, growing, and propagating North American woody plants. Boston: Houghton Mifflin. 354 p.

Dainat, B.; Evans, J.D.; Chen, Y.P.; Gautheir, L.; Neumann, P. 2012. Predictive markers of honey bee colony collapse. PLoS One 7(2): e32151.

Fergusen, D.C. 1975. Host records for Lepidoptera reared in eastern North America. Tech. Bull. 1521. Washington, DC: U.S. Department of Agriculture, Agricultural Research Service. 49 p. http://naldc.nal.usda.gov/download/CAT76667713/PDF. (June 2015).

Gill, R.J.; Ramos-Rodriguez, O.; Raine, N.E. 2012. Combined pesticide exposure severely affects individual- and colony-level traits in bees. Nature. 491(7422): 105–108.

Gleason, H.; Cronquist, A. 1991. Manual of vascular plants of the Northeastern United States and adjacent Canada. New York: New York Botanical Garden Press. 910 p.

Grundel, R.; Pavlovic, N.B.; Sulzman, C.L. 2000. Nectar plant selection by the Karner blue butterfly (*Lycaeides melissa samuelis*) at the Indiana Dunes National Lakeshore. American Midland Naturalist. 144(1): 1–10.

Harrison, M.E. 2006. Unusual native trees. Native Plants Journal. 7(3): 262–266.

Hoss, G. 2006. Propagation protocol for spicebush (*Lindera benzoin*). Native Plants Journal 7(2): 134–136.

Integrated Taxonomic Information System. 2015. http://www.itis.gov/. (June 2015).

Johnson, R.M.; Ellis, M.D.; Mullin, C.A.; Frazier, M. 2010. Pesticides and honey bee toxicity—USA. Apidologie. 41(3): 312–331.

Johnson, R.M.; Evans, J.D.; Robinson, G.E.; Berenbaum, M.R. 2009. Changes in transcript abundance relating to colony collapse disorder in honey bees (*Apis mellifera*). Proceedings of the National Academy of Sciences. 106(35): 14790–14795.

Ladybird Johnson Wildflower Center (LJWC). 2015. Native plants database. https://www.wildflower.org/plants/. (June 2015).

Landis, T.D.; Dreesen, D.R.; Dumroese, R.K. 2003. Sex and the single *Salix*: considerations for riparian restoration. Native Plants Journal. 4(2): 111–117.

Lill, J.T. 2008. Caterpillar-host plant relationships recorded from Plummers Island, Maryland (Insecta: Lepidoptera). Bulletin of the Biological Society of Washington. 15(1): 75–79.

Meyer, S.E. 2005. Intermountain Native Plant Growers Association: a nonprofit trade organization promoting landscape use of native plants. Native Plants Journal. 6(2): 104–107.

Ostaff, D.P.; Mosseler, A.; Johns, R.C.; Javorek, S.; Klymko, J.; Ascher, J.S. 2015. Willows (*Salix* spp.) as pollen and nectar sources for sustaining fruit and berry pollinating insects. Canadian Journal of Plant Science. 95(3): 505–516.

Schweitzer, D.F. 1980. The identity of the plant referred to as *Andromeda* by WTM Forbes. Journal of the Lepidopteran Society. 34(1): 24.

Tallamy, D.W. 2004. Do alien plants reduce insect biomass? Conservation Biology. 18(6): 1689–1692.

Tallamy, D.W. 2007. Bringing nature home: how you can sustain wildlife with native plants. Portland, OR: Timber Press. 288 p.

Tallamy, D.W.; Shropshire, K.J. 2009. Ranking native lepidopteran use of native versus introduced plants. Conservation Biology. 23(4): 941–947 (plus online supplemental file: COBI_1202_sm_AppendixS3-S5.xls). NOTE: Portions of the supplemental file are available from the authors at http://udel.edu/~dtallamy/host/ (March 2016) and a simplified, popularized version is available at http://www.wildones.org/download/NativeCaterpillarsMothButterflies&HostNativeWoodies.pdf. (March 2016).

U.S. Department of Agriculture, Natural Resources Conservation Service (USDA NRCS). 2016. The PLANTS database. http://plants.usda.gov. (March 2016).

U.S. Environmental Protection Agency (EPA). 2015. Wetlands: status and trends. http://water.epa.gov/type/wetlands/vital_status.cfm. (July 2015).

Wagner, D.L.; Nelson, M.W.; Schweitzer, D.F. 2003. Shrubland Lepidoptera of southern New England and southeastern New York: ecology, conservation and management. Forest Ecology and Management. 185(1-2): 95–112.

Wardhaugh, C.W. 2014. The spatial and temporal distributions of arthropods in forest canopies: uniting disparate patterns with hypotheses for specialisation. Biological Reviews. 89(4): 1021–1041.

Webb, J.K. 2008. Beyond butterflies: gardening for native pollinators. Athens, GA: University of Georgia Cooperative Extension. B1349. 7 p. http://extension.uga.edu/publications/files/pdf/B%201349_1.PDF. (August 2016).

White House. 2015. https://m.whitehouse.gov/blog/2015/05/19/announcing-new-steps-promote-pollinator-health.

Whitehorn, P.R.; O'Connor, S.; Wackers, F.L.; Goulson, D. 2012. Neonicotinoid pesticide reduces bumble bee colony growth and queen production. Science. 336(6079): 351–352.

Winfree, R.; Aguilar, R.; Vázquez, D.P.; Lebuhn, G.; Aizen, M.A. 2009. A meta-analysis of bees' responses to anthropogenic disturbance. Ecology. 90(8): 2068–2076.

Wright, D.M.; Pavulaan, H. 1999. *Celastrina idella* (Lycaenidae: Polyommatinae): a new butterfly species from the Atlantic coastal plain. Taxonomic Report of the International Lepidopteran Society. 1(9): 1–11.