Seeing the Lianas in the Trees: Woody Vines of the Temperate Zone

Stacey A. Leicht-Young

STACEY A. LEICHT-YOUNG

Without a support structure to climb, this American wisteria (*Wisteria frutescens,* accession 1414-85) stretches laterally and spills over a rock wall in the Arboretum's Leventritt Shrub and Vine Garden.

In the forests and edge habitats of temperate North America, there is a group of woody plants that is well recognized but often overlooked by both the casual observer and scientific researcher alike. These woody plants are generally described as "vines," but are more accurately called lianas. The ability of lianas to grow and climb in all directions, not just taller and wider like the better-known trees and shrubs, makes them a unique group of plants worthy of further study and appreciation.

What is a Liana?

In the simplest sense, lianas are woody vines. The term liana is better known from tropical climates where they are more abundant. By def-

STACEY A. LEICHT-YOUNG

Virginia creeper (*Parthenocissus quinquefolia*), a common North American liana, climbing up a tree trunk.

inition lianas (and herbaceous vines) are plants unable to support themselves; to grow upwards, they require other plants or structures to support them. The advantage to using other plants for support is that lianas can invest resources into growing a large leaf area for photosynthesis without investing much into stem materials. A disadvantage is that when the support a liana is growing on falls down, it will also fall. However, because of their unique stem anatomy and elastic growth, they can most often resprout from their stems or roots, or simply grow along the ground until they encounter a new support. This flexibile growth habit is perhaps the defining element of lianas. The liana growth form is found in many different plant families, indicating that the climbing habit has evolved several different times. The result is a great diversity of liana species that grow worldwide in varied habitats.

Lianas of the North Temperate Zone

The highest diversity of liana species is in tropical areas where they can make up 25% or more of the total plant species in some forests. Lianas are much less prevalent in temperate North America, though; one estimate from North and South Carolina indicated that lianas constituted just 1.3% of the native plant species (Gentry 1991). Europe has even fewer native lianas than North America. However, southern temperate areas, such as southern South America and Eastern Asia have a higher diversity of species because of differing climate and different evolutionary history. For example, the genus *Celastrus* has only one native representative from North America (American bittersweet, *Celastrus scandens*) while China has at least 25 species

NANCY ROSE

***Celastrus angulatus* is a bittersweet species from China with large leaves.**

MANY WAYS TO CLIMB A TREE

One of the most fascinating aspects of lianas (and herbaceous vines) is the many different methods by which they can climb trees, trellises, and even walls or rock faces. In fact, Charles Darwin was one of the first to publish on the many different mechanisms that vines use to climb objects (Darwin 1867). Although there is some variation in how these groupings are made, the general categories are root climbers, adhesive tendrils, tendrils, stem twiners, and petiole climbers.

Root Climbers

Root climbing lianas use adhesive adventitious roots to climb trees or rock faces. These roots can often look like bunches of hairs along the liana stems. These species grow close to the substrate they are attached to and sometimes form lateral branches that grow out and away from the main stem of the liana. Familiar temperate root climbing species include poison ivy (*Toxicodendron radicans*), trumpet creeper (*Campsis radicans*), climbing hydrangea (*Hydrangea anomala* ssp. *petiolaris*), woodvamp (*Decumaria barbara*), and the evergreens English ivy (*Hedera helix*) and wintercreeper (*Euonymus fortunei*).

JOSEPH LAFOREST, UNIVERSITY OF GEORGIA, BUGWOOD.ORG

STACEY A. LEICHT-YOUNG

(Far left) Hairlike aerial roots of poison ivy attach the vine to the tree. (Left) The shiny, light green foliage of woodvamp (*Decumaria barbara*), a root-climbing species native to the southeastern United States.

Adhesive Tendrils

Like root climbers, lianas that have adhesive tendrils adhere to the tree or surface that they are climbing. However, it is not the roots that are doing the climbing in this case, but modified tendrils that have small adhesive pads at the tips. Adhesive tendril climbing lianas include Virginia creeper (*Parthenocissus quinquefolia*), which is one of the most common lianas in the forests of the Eastern United States; its relative, Boston or Japanese ivy (*P. tricuspidata*); and the showy-flowered crossvine (*Bignonia capreolata*), a species native to the southeastern and south central United States.

STACEY A. LEICHT-YOUNG

STACEY A. LEICHT-YOUNG

STACEY A. LEICHT-YOUNG

(Left to right) Tendrils tipped with adhesive discs cling directly to supports; flowers of a crossvine cultivar (*Bignonia capreolata* 'Tangerine Beauty'); the unique leaves and adhesive tendrils of a wild crossvine climbing a white pine (*Pinus strobus*).

Tendrils

Tendrils are structures that are formed through modifications of the stem, leaves, leaf tips, or stipules (outgrowths at the base of a leaf). Tendrils coil around small objects such as twigs, allowing the liana to climb. The most familiar temperate lianas that use tendrils are grapes (*Vitis* spp.) and porcelainberry (*Ampelopsis brevipedunculata*), another member of the grape family (Vitaceae). Greenbrier (*Smilax rotundifolia*) and other *Smilax* species use tendrils that are actually modified thorns to climb. Although members of the genus Smilax do not technically form woody stems (they are monocots, like lilies), they are often considered to be lianas because their stems persist overwinter and form leaves in the spring.

STACEY A. LEICHT-YOUNG

NANCY ROSE

(Left) Grape tendril. (Above) Crimson gloryvine (*Vitis coignetiae*) is grown as an ornamental for its red to purple fall foliage.

NANCY ROSE

Stem Twiners

Stem twining lianas, as the name describes, use their stems to climb up objects by twining around them. They can also form somewhat self-supporting columns when many stems entwine. Stem twiners include bittersweets (*Celastrus* spp.) , vine honeysuckles (*Lonicera* spp.), wisterias (*Wisteria* spp.), chocolate vine (*Akebia quinata*), and supple-jack (*Berchemia scandens*), a lesser known native liana from the southeastern United States. Another species, the aromatic Chinese magnolia vine (*Schisandra chinensis*), is a stem twiner from one of the more ancient groups of flowering plants.

NANCY ROSE

Twining vines wrap around supports or even their own stems to climb. At left, entwined Oriental bittersweet (*Celastrus orbiculatus*) and Dutchman's pipe (*Aristolochia macrophylla*). Twining climbers include vining honeysuckles such as *Lonicera* × *heckrottii* 'Goldflame' (far left).

Petiole Climbers

Petiole climber lianas use their petioles (the small stalks at the base of leaves) to twine around objects in a manner similar to the tendril climbers. In temperate regions, clematis (*Clematis* spp.) is the most prominent petiole climber. There are hundreds of *Clematis* taxa including showy large-flowered hybrids as well as small-flowered species such as the white-flowered *C. virginiana, C. terniflora,* and *C. vitalba* that bloom in late summer or early fall.

STACEY A. LEICHT-YOUNG

STACEY A. LEICHT-YOUNG

(Right) Twining petiole of *Clematis virginiana.* (Far right) Sweet autumn clematis (*C. terniflora*) is an Asian species that can escape cultivation and closely resembles the native virgin's bower (*C. virginiana*).

STACEY A. LEICHT-YOUNG

Fox grape (*Vitis labrusca*), here showing characteristic matted white hairs on the underside of its leaves, is native to the eastern United States and is a parent species of the cultivated Concord grape.

The main reason cited for the lower diversity and numbers of lianas in the temperate zone is the presence of wide vessels in their stems. Vessels are part of plants' xylem tissue, which transports water from the roots to the leaves. In plants such as trees and shrubs, which are self-supporting, the wood structure is denser and has narrower vessels to provide structural support. Since lianas can have very long, flexible stems (because they use other plants for support), they have both very wide and very long vessels to move sufficient amounts of water to their large leaf canopy. However, there is a disadvantage to wide vessels. Large vessels, coupled with thin stems that do not provide much insulation, are more susceptible to the formation of air bubbles within them when temperatures drop below freezing. These bubbles are known as "freezing-induced embolisms." The embolism will block the flow of water through the liana stem, and potentially destroy the vessel if the air bubble is not dissolved back into the liquid when temperatures warm. If enough vessels are blocked, the liana cannot survive (Schnitzer 2005).

Temperate lianas do have adaptations to offset embolism. Some species, such as grapes (*Vitis* spp.), are able to use positive root pressure to push air bubbles out of vessels in early spring; this is why grape stems "bleed" when cut in the early spring. Other species, such as Oriental bittersweet (*Celastrus orbiculatus*), grow new xylem to replace any that was damaged by freezing in the spring (Tibbetts and Ewers 2000). In the far northern parts of its range in the United States and Canada, poison ivy (*Toxicodendron radicans*) grows as a low, trailing vine, not as the large, more exposed lianas seen in the Midwest and eastern United States (Schnitzer 2005). From a study of lianas in Chile, which has a southern temperate climate that experiences fewer continuous freezing days compared to northern temperate climates, lianas were found to have a mixture of large and small vessels, allowing transport of water in the small vessels even if the large ones became embolized (Jimenez-Castillo and Lusk 2013). Although the temperate zone has a lower diversity of lianas as a result of their susceptibility to embolisms, there are many liana species that do thrive in these habitats and contribute to forest dynamics.

The Ecology of Climbing Type

A liana's climbing method can provide information about the ecology of the species in natural settings (Carter and Teramura 1988). Root climbing and adhesive tendril climbing lianas can attach to supports of any size since they adhere to the surfaces they are climbing on. Often these species will grow in darker forest understories since they attach to larger trees that produce more shade. These species can also be seen growing up rock faces, and on

STACEY A. LEICHT-YOUNG

STACEY A. LEICHT-YOUNG

Grape (*Vitis* sp., far left) climbing on American beech (*Fagus grandifolia*) in mature forest. Oriental bittersweet (light bark) using grape (dark bark) as a ladder to reach the canopy.

stone walls in gardens. Tendril climbers, stem twiners, and petiole climbers all need smaller supports to climb on since the stems or tendrils can only wrap around smaller diameter objects such as twigs. These species are most commonly observed in open forested habitats or along forest edges where there are small supports (e.g., shrubs and small trees) and higher light availability.

However, some of these species—most notably grapes and Oriental bittersweet—can employ other methods to reach the canopy in older forests with larger trees. Grapes often attach to trees when they are younger and continue to grow with them as the trees get taller, spreading across the canopy by means of their tendrils. This is why on a walk in the woods one can see very large grape stems scaling a tree straight from the forest floor to the canopy. Oriental bittersweet, on the other hand, can climb other lianas such as grapes to reach the canopy (this is called "laddering"), or it can "sit and wait" in the forest understory, growing along the ground until a gap forms from a tree fall, resulting in higher light and smaller diameter trees growing in the gap that it can climb (Leicht and Silander 2006). So, although lianas are more abundant in high light, disturbed habitats because of the higher availability of small supports to climb on, they can be present in old-growth forests as well (Leicht-Young et al. 2010).

North American Lianas and Their Asian Relatives

The liana floras of North America and East Asia have many genera in common. For example, *Wisteria, Clematis, Celastrus, Vitis,* and *Lonicera* all have Asian and North American species, but Asia has greater species diversity. Since North America and East Asia share similar latitudes, many liana species (and tree, shrub, and herbaceous species as well) were brought

ROBIN BARANOWSKI

STACEY A. LEICHT-YOUNG

Japanese honeysuckle (left, *Lonciera japonica*), an invasive honeysuckle from East Asia, and trumpet honeysuckle (right, *L. sempervirens*), a native North American species.

from East Asia to North America for both practical (erosion control, wildlife forage) and horticultural (beautifying the landscape) purposes, mostly within the last 150 years. Many of these plant species have not spread because they are unable to move across the landscape via seed, were not planted in high numbers across a large area, or were constrained by climatic conditions (e.g., cold winter temperatures). But others have escaped from their original planting locations and become naturalized and sometimes invasive in the novel environment.

The very attributes of these Asian species that make them desirable horticultural species (e.g., drought tolerance, rapid growth, abundant flower or fruit production) in many cases "preadapt" them for naturalizing in the landscape in adverse conditions. Indeed out of the 12 liana species from East Asia that are listed on state invasive species lists, 11 were introduced for ornamental purposes while kudzu (*Pueraria montana* var. *lobata*) was planted extensively for erosion control (Leicht-Young and Pavlovic 2014). In addition, when plants are brought into a new geographic area they often escape from the herbivores and pathogens that kept them in check in their home range, thus allowing them to grow more prolifically in their new location where they lack these competitors. Invasive lianas are those species that have propagated beyond self-contained naturalized populations (such as through birds dispersing their seeds), and that have been observed to have negative effects on native ecosystems because of their high densities. These lianas have the attributes of other invasive plants, and because most lianas, native or non-native, can grow rapidly up and over objects, invasive lianas can be said to have a "perfect storm" of characteristics, and can cause widespread damage to native ecosystems. This damage includes outcompeting native vegetation, adding weight to tree canopies and increasing the probability of breakage or fall during wind or ice storms, and girdling trees by wrapping around the trunks and stopping the flow of water and nutrients to the tree. Some of the more damaging invasive liana species in the northeastern United States are Oriental bittersweet, Japanese honeysuckle, and porcelainberry. While some native lianas can also damage trees and vegetation, the high concentrations of invasive lianas in a given location can accelerate this process.

These invasive lianas are very challenging for natural areas managers to combat because they can resprout from their roots after they have been cut or treated with herbicide, and bird-dispersed fruits that move over long dis-

STACEY A. LEICHT-YOUNG

Damage to tree trunk from Oriental bittersweet.

ROBIN BARANOWSKI

Porcelainberry (*Ampelopsis brevipedunculata*), originally cultivated for its attractive multi-hued fruit, has escaped cultivation through bird dispersal of seeds and is now highly invasive in edge habitats throughout much of the Northeast and Mid-Atlantic regions.

STACEY A. LEICHT-YOUNG

Japanese hydrangea vine cultivars (*Schizophragma hydrangeoides* 'Roseum [left] and 'Moonlight' [right]) cling to rock walls in the Leventritt Shrub and Vine Garden.

tances can reintroduce the plant to a treated area. Fortunately, due to both research and outreach efforts, the public as well as those working in the horticultural field are more aware of the negative attributes of these and other invasive plants, and they are rarely encouraged for plantings. It is important to note that although there are Asian species that have escaped from cultivation and become invasive, other species, such as climbing hydrangea (*Hydrangea anomala* ssp. *petiolaris*), Japanese hydrangea vine (*Schizophragma hydrangeoides*), and Chinese magnolia vine (*Schisandra chinensis*) have not been observed to escape garden settings.

Changes on the Way?

Non-native invasive lianas have changed the face of our native ecosystems by altering the makeup of species present in the environment and often competing with native species for resources and space. With global changes such as increasing temperatures and carbon dioxide (CO_2) levels along with increasing landscape fragmentation (e.g., hurricane damage [Allen et al. 2005]), the role that all lianas will play in these future ecosystems may become more prominent.

Evidence suggests that with increasing CO_2 lianas will grow more abundantly. Another interesting (but disturbing) change with increasing CO_2 is that poison ivy may contain more urushiol, the compound that causes the allergic reaction (Ziska et al. 2007). In tropical areas, there has been a documented increase in lianas that has been attributed to increasing CO_2 as well as increasing forest fragmentation (Schnitzer and Bongers 2011). This concept has been little explored in the temperate zone, but it could be expected that similar changes will be seen here as the risk of freezing-induced embolisms and severe frost damage from cold temperatures decreases with warming (such as the predicted expansion of kudzu into the northern United States). In addition, the prominence of secondary forests has increased, especially in regions like New England where young forests have grown up from abandoned agricultural land on the edges of developed areas. These disturbed secondary forests are ideal for liana growth because of high light conditions and the presence of small diameter supports. Thus, the combination of warmer temperatures, increasing CO_2, and habitat fragmentation may result in ideal conditions for an increase in the abundance and growth of temperate lianas.

JIL SWEARINGEN, USDI NATIONAL PARK SERVICE, BUGWOOD.ORG

Kudzu (*Pueraria montana* var. *lobata*) clambers up a sign post in Maryland.

Surprisingly little is known about the role lianas currently play in the ecology of temper-

NANCY ROSE

A tangle of wild grape (*Vitis riparia*) and Oriental bittersweet climbs trees in the Arboretum's Bussey Brook Meadow.

ate forests. We know from tropical studies and a handful of temperate studies that lianas compete with trees, not just in the obvious competition for light above ground, but also in the commonly overlooked root zone. In temperate species, researchers have found trees competing with liana roots show slower growth rates than those just competing above ground (Dillenburg et al. 1993). In addition, in seasonally dry tropical forests liana roots are able to tap deep water sources over a wide area, which allows them to continue to grow during drought while trees and shrubs often go dormant (Schnitzer 2005). From what we know about species like Oriental bittersweet, they can form extensive root networks that can compete with neighboring species and contribute to vegetative spread. Thus, roots likely contribute an important part in how lianas are able to successfully colonize and persist in competition with other plant species.

Intense competition from lianas above and below ground in high light situations, such as gaps in forests, may result in "liana tangles." These liana tangles can suppress the ability of trees to regrow into a forest gap or slow the succession of old fields to forests for many years. In temperate areas where the growing season is restricted to the warmer months, regrowth of trees and other species may be slowed for even longer. Additionally, as lianas grow up trees they put additional stress on them, resulting in a higher chance of tree fall. This cycle of lianas increasing the chance of tree fall and resprouting in newly formed gaps may have an important influence on the regrowth of subsequent secondary forests, especially after high-wind events or ice storms. These concepts have been studied to some extent in the tropics but need further observation and research in temperate habitats to increase understanding of how lianas contribute to the composition, structure, and ecosystem dynamics of temperate forests and what their future contribution may be in light of global climate change.

The next time you enjoy cascades of violet wisteria flowers on a pergola in the spring or see scarlet-leafed Virginia creeper on an autumn walk through the woods, consider the unique adaptations for growth that these and other lianas have made. By closely observing the fascinating species of temperate lianas that we often encounter we can better appreciate them and reflect on their important place in our ecosystem.

Literature Cited

Allen, B. P., R. R. Sharitz, P. C. Goebel. 2005. Twelve years post-hurricane liana dynamics in an old-growth southeastern floodplain forest. *Forest Ecology and Management* 218: 259–269.

Carter, G. A. and A. H. Teramura. 1988. Vine photosynthesis and relationships to climbing mechanics in a forest understory. *American Journal of Botany* 75: 1011–1018.

Darwin, C. 1867. On the movements and habits of climbing plants. *Journal of the Linnean Society of London Botany* 9: 1–118.

Dillenburg, L. R., D. F. Whigham, A. H. Teramura, and I. N. Forseth. 1993. Effects of below- and above-ground competition from the vines *Lonicera japonica* and *Parthenocissus quinquefolia* on the growth of the tree host *Liquidambar styraciflua. Oecologia* 93:48–54.

Gentry, A. H. 1991. The distribution and evolution of climbing plants. In F. E. Putz and H. A. Mooney (eds.) *The Biology of Vines*. Cambridge: Cambridge University Press. Pp. 3–52.

Jimenez-Castillo, M. and C. H. Lusk. 2013. Vascular performance of woody plants in a temperate rain forest: lianas suffer higher levels of freeze-thaw embolism than associated trees. *Functional Ecology* 27: 403–412.

Leicht, S. A. and J. A. Silander. 2006. Differential responses of invasive *Celastrus orbiculatus* (Celastraceae) and native *C. scandens* to changes in light quality. *American Journal of Botany* 93: 972–977.

Leicht-Young, S. A., N. B. Pavlovic, K. J. Frohnapple, and R. Grundel. 2010. Liana habitat and host preferences in northern temperate forests. *Forest Ecology and Management* 260: 1467–1477.

Leicht-Young, S. A. and N. B. Pavlovic. 2014. Lianas as invasive species in North America. In S. A. Schnitzer, F. Bongers, R. J. Burnham, and F. E. Putz (eds.) *The Ecology of Lianas*. In press.

NANCY ROSE

Virginia creeper (*Parthenocissus quinquefolia*) in fall color.

Schnitzer, S. A. 2005. A mechanistic explanation for global patterns of liana abundance and distribution. *The American Naturalist* 166: 262–276.

Schnitzer, S. A. and F. Bongers. 2011. Increasing liana abundance and biomass in tropical forests: emerging patterns and putative mechanisms. *Ecology Letters* 14: 397–406.

Tibbetts, T. J. and F. W. Ewers. 2000. Root pressure and specific conductivity in temperate lianas: Exotic *Celastrus orbiculatus* (Celastraceae) vs. native *Vitis riparia* (Vitaceae). *American Journal of Botany* 87: 1272–1278.

Ziska, L., R. Sicher, K. George, and J. Mohan. 2007. Rising atmospheric carbon dioxide and potential impacts on the growth and toxicity of poison ivy (*Toxicodendron radicans*). *Weed Science* 55: 288–292.

Stacey Leicht-Young is a Putnam Fellow at the Arnold Arboretum.