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Nature in a Name: Paulownia tomentosa—Exotic Tree, Native Problem

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Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Paulownia tomentosa, an exotic species in North America, is spreading in fire-opened landscapes of southern Appalachia.

Nature in a Name: *Paulownia tomentosa*—Exotic Tree, Native Problem

Summary

While awareness of fire's importance in dry Appalachian forests, and the application of fire as a restoration tool have increased over the last two decades, so too has the post-fire invasion of *Paulownia tomentosa* (Princess tree). For the last ten years, managers have witnessed *Paulownia* invasion grow following fire events. To understand this better, the team studied five life history transitions for the species: seed dispersal, seed germination, seed survival over time through incorporation in the seed bank, initial habitat requirements, and seedling persistence to maturity. *Paulownia* seeds were found to disperse over two miles from their source tree. Fires of greater severity promote conditions *Paulownia* favors—exposed soil free of organic litter, and openings in the canopy cover that allow ample light. Subsequent persistence by *Paulownia* is greatest in the drier and more exposed areas, such as ridges and steep slopes.

Key Findings

- *Paulownia* seeds were widely dispersed. Though the majority of these wind-dispersed seeds did not travel far from the parent tree, seedlings were frequently encountered two miles from the nearest mature (seed producing) tree.
- *Paulownia* trees had the greatest presence and numbers on high benches, crests and high slopes—places that are drier and experience greater fire intensity.
- Canopy cover was the most significant predictor of *Paulownia* invasion overall.
- *Paulownia* preferred exposure to light, and fires with greater severity, as opposed to other types of disturbance that open gaps in the canopy.
- *Paulownia* has a greater impact on overstory cover across landscapes and over time.
- Fire can damage below ground resources (seeds, roots) that other disturbance types do not.
- Fire (depending on intensity and severity) also assists *Paulownia* establishment by removing organic litter—this species germinates best on exposed soil.
- Although a high level of litter cover may prevent *Paulownia* invasion, it is less important than the amount of sunlight available.

Introduction

"What's in a name?" Juliet mused, dreamy-eyed, besotted, trying to reconcile the enmity between the Montagues and Capulets that would hold any union between her and Romeo as alien and unnatural. "That which we call a rose by any other name would smell as sweet." But what mattered was where Romeo belonged and therefore who Romeo was—an enemy of Juliet's family—not what she called him. While a rose by any other name may indeed smell as sweet, a plant out of place, by any other name—non-native, non-indigenous, exotic, alien, introduced, foreign, invasive, weed—shades in the level of nuisance we perceive it to possess.

A plant may be native to this continent, but growing in a place in which it had not been formerly part of the ecosystem. Its recent appearance may be harmful; it may be benign. As the climate warms and plants can be found growing at latitudes and altitudes above their former range, should we consider them weeds, invasives, aliens? Are they the same as species from other continents, intentionally introduced by us or accidental tourists in our global trade, some of whom cause serious damage to native plant and animal communities? Settling on a word, a name for this thing is tricky, since plants and animals have moved across our planet, throughout time, in myriad ways. Should the damage caused to natives be the measure for the charge leveled against plants that earn the name "invasive"? And what if that level of damage is not yet apparent? Dane Kuppinger, visiting professor of biology at the University of the South, wanted to understand one invasive tree, the Princess tree (*Paulownia tomentosa*), and how it affected the dry pine and oak-pine forests of southern Appalachia. With his team, they looked with eyes wide open.

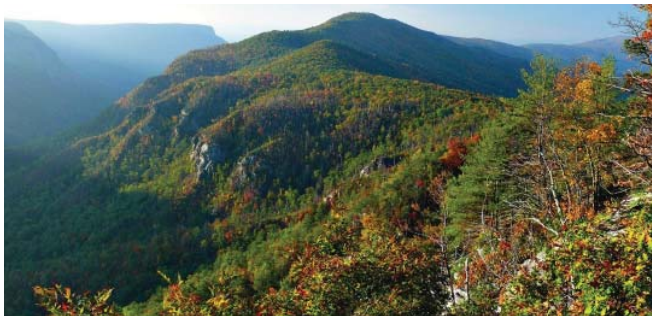
Eyes of the beholder

Large, heart-shaped leaves, clusters of flowers—pale violet and fragrant—*Paulownia* is a much treasured tree

Fragrant, showy, cultivated for beauty, timber and medicinal qualities, *Paulownia* threatens native plant communities and endangered species. (Left) *Paulownia* in bloom and (right) a young *Paulownia* plantation.

by some. Native to China, it is highly prized in Asia for the quality of its timber, for its ability to tolerate harsh environments, for its medicinal offerings. And the Chinese thought the tree beautiful. Europeans did too, and imported *Paulownia* to Europe, and thence to the United States, where one hundred fifty years ago it was a lovely ornamental. Today, some call it by another name—invasive—no less sweet-smelling, no less beautiful, but a recognized by some as a problem.

As fire's importance in the dry pine and oak-pine forests of southern Appalachia has increasingly been recognized over the last two decades, managers have used burning as a management tool to restore forests whose structure and composition have changed with fewer fires. What they have also noticed over the last ten years is *Paulownia*, a tree that doesn't belong. What was enabling the invasion? What characteristics of the post-fire landscape helped promote the establishment and spread of this exotic species? Was it causing harm to native plant communities? Using study sites in the Great Smoky Mountains National Park, the Linville Gorge wilderness area, and the Pisgah and Cherokee National Forests, Kuppinger and the team investigated five life history transitions of *Paulownia*: seed dispersal, seed germination, seed survival over time through incorporation into the seed-bank, initial habitat requirements, and seedling persistence to maturity. Using data from five fires, they examined the role of fire in assisting *Paulownia* invasion at the stand, watershed, and landscape scale.



The Great Smoky Mountains National Park and Linville Gorge embrace spectacular forests of pine and oak-pine. *Paulownia* trees, a foreign invader, are a recent intrusion. Credit: ©Ken Thomas.

Looking, with a critical approach

Plant communities in the study area were accustomed to regular, low-intensity fires that maintained the open character of the woodlands. Every hundred years or so, a higher intensity fire would sweep through after which the majority of pine regeneration occurred. By restoring ecological processes, and returning fire to its habitat, burning also created problems because *Paulownia* liked the results, too. "Growing frequently along road cuts and occasionally in hurricane-cleared patches for the past couple of decades, *Paulownia*'s new invasions after fire was the first time this species was observed in significant numbers following disturbance in plant communities dominated by native species," Kuppinger explained. New populations of *Paulownia* could act as stepping stones, as Kuppinger put it, and allow this species to advance even farther into new areas.

To get to the bottom of things, the scientists undertook field and lab studies. In the field, they used 33 x 33 foot plots along transects cutting across the slope that maximized the range of sampled fire intensities and landscape positions. They recorded ground cover type (rock, leaf litter), herb and shrub cover by species, and the diameter at breast height (dbh) of all trees. They estimated the pre-fire cover by level (understory, mid-story, and canopy) and the number and height of all *Paulownia* trees within the study plots. The team also measured fire severity in each plot by examining the number of dead plants at each cover level, the scorch height and resprouting frequency, and by using satellite imagery. The team conducted experiments (including germination rates over the course of a year under different storage conditions, and temperatures, and the effect of surface cover, light and burial depth) to determine the conditions that supported and promoted *Paulownia* seeds' viability and germination. Finally, they used seed abundance within soil samples and seedling abundance within vegetation plots to assess the distance over which seeds disperse.

Seeing the wrinkles in beauty

In their goal to provide managers with information so restoration doesn't also enable degradation, Kuppinger and his team explain the important drivers of invasion. At the landscape scale, they are seed dispersal and longevity. The team's efforts showed that even though wind pushes *Paulownia* seeds along, the majority do not travel far from the parent tree. However, the team estimated the seeds may disperse up to six miles and given the high number of seeds produced by each tree (about two million annually), significant invasion may still occur two miles from mature trees. The limited number of seeds found in soil samples suggested to the team that *Paulownia's* seedbank is very limited. Seed longevity experiments showed decreased seed viability over time, suggesting that seeds would survive approximately one and a half years from their dispersal. However, other studies have shown, the team offers, that seeds can remain highly viable in the soil for two years, and maybe as long as fifteen. If these other studies are correct, and if the seeds can survive fire, the scientists surmise *Paulownia* can build a large seedbank (seeds that remain dormant in the soil until conditions are favorable) over time.

At the watershed scale, fire severity is the dominant factor influencing invasion rate. On high crests and slopes, places that are drier and therefore frequently affected by greater fire severities, *Paulownia* was there, growing, thriving, often in abundance. At the stand scale (individual plot), the factors that had the greatest influence on *Paulownia's* ability to spread were those that affected its seeds, and their ability to germinate and grow. The most significant factor limiting or enabling *Paulownia's*

seed germination, and the factor most tied to fire severity, is overstory plant cover. *Paulownia* loves the light, and where fire removed the shrub and canopy layers, the seeds germinated and thrived.

"The fact that this is the most important variable in determining the degree of invasion by *Paulownia* (as measured by abundance) and whether *Paulownia* is present at all suggests causal reasons as to why this species is not found more frequently following other types of disturbance—namely that fire often has a much greater impact on shrub and canopy cover across both spatial and temporal scales," Kuppinger explains. Fire can kill large areas of the overstory plant cover, he offers, and fire effects can persist longer than other disturbances because the resources below ground—seeds, roots that resprout—can be killed as well. Other disturbance types may not affect the below-ground resources to as great an extent. *Paulownia* may benefit from this factor by exploiting the release from competition. The only other stand level variable that was a significant predictor of invasion, Kuppinger reveals, was the amount of exposed soil. Because *Paulownia* seeds have few carbohydrate reserves, they don't have the "juice" required to put down a long primary root through thick litter, or push up through it. Buried seeds had much lower germination rates than those on the surface. Fire helps *Paulownia* not only by removing overstory cover, but by removing organic litter cover. Exposed soil helps invasion, litter cover hampers it.

Exposed soil helps invasion, litter cover hampers it.

Fire also played a role in the seeds' ability to germinate through the amount of heat it generated, or intensity of burning. The team's experiments revealed that almost no seeds germinated when the temperature was greater than 100° Fahrenheit. Seeds may therefore survive fire, but only when burning intensity is low (which doesn't create the other conditions *Paulownia* needs to germinate), or when buried. The conditions the seeds encounter, Kuppinger explains, plays a greater role in whether those seeds will survive over time and invasion will occur than how many seeds the single *Paulownia* tree or populations of *Paulownia* trees are producing. No hard and fast rule for a dormant state seems to apply—if seeds find conditions they like when they are sent away from their parent, they will germinate.

Paulownia growing strong after fire. Once established following fires of the right intensity, *Paulownia* persists in the higher and drier portions of the landscape. Credit: D. Kuppinger.

Calling it like it is

More work needs to be done, Kuppinger urges, but the studies he and his team conducted give managers some ability to predict invasion patterns. Similar invasion rates, they predict, can be found across areas that experience the medium-to-high severity burning favorable to *Paulownia*, regardless of native plant compositions or soil differences. Using the variables that relate to *Paulownia* invasion, the team ran models to predict the species' future in Linville Gorge.

Though *Paulownia* may be confined to limited habitat, it presents problems for native plants that like it there as well—the rare and endangered Heller's blazing star (top) and mountain goldenheather. Credit: Nora Murdoch, U.S. Fish and Wildlife Service.

The model predicted the plant's habitat—initially widespread but concentrated on dry, exposed sites that experience high levels of fire severity—would shrink over time. *Paulownia* lost the most where it liked it least—moister sites, lower sites, flatter sites. Where fire severity and topographic preferences decreased, the model predicted a complete loss of habitat for *Paulownia*. Over time, *Paulownia* becomes increasingly limited to the driest and most exposed portions of the landscape, Kuppinger observes. "Only those individuals that have stayed above the regenerating vegetation, or who are in a location where regeneration rates are very slow have managed to survive." This also means, however, that with slow regeneration and limited competition on the steep, dry slopes it favors, *Paulownia* will persist in the Gorge, potentially causing problems to others who like it there as well—the rare and endangered Heller's blazing star and mountain goldenheather. While the studies did not reveal any negative impacts of *Paulownia* on native species, the invasion, Kuppinger explains, has only just begun.

While habitat loss presents the greatest and gravest danger to native plants and communities, next in line are the hazards introduced by invasive species. By calling a foreign tree an invasive rather than an ornamental, we conjure the destructive potential it holds. What is in a name is the import it carries. And that can have a powerful effect on how we see.

Management Implications

- Further studies are needed, but managers planning to use prescribed fire who are concerned about *Paulownia* invasions should consider that *Paulownia* seeds may survive fire, but only under very low intensities. Low-intensity fires though, will not likely create other conditions for *Paulownia* seeds to germinate, such as removing organic litter to expose bare soil, and eliminating the canopy cover to allow increased light.
- With *Paulownia* limited to drier and more exposed areas of the landscape, areas where habitat restrictions are insignificant for this invasive, managers face problems combating *Paulownia's* persistence. These areas are also habitat to two rare, endangered species, Heller's blazing star (*Liatris helleri*) and mountain goldenheather (*Hudsonia montana*).

Further Information: Publications and Web Resources

Barden, L.S. and F.W. Woods. 1973. Characteristics of lightning fires in southern Appalachian forests. *Proceedings of the Tall Timbers Fire Ecology Conference* 13:345-361.

Harmon M. 1982. Fire history of the westernmost portion of Great Smoky Mountain National Park. *Bulletin of the Torrey Botanical Club* 109(1):74-79.

Harrod, J.C., M.E. Harmon, and P.S. White. 2000. Post-fire succession and 20th century reduction in fire frequency on xeric southern Appalachian sites. *Journal of Vegetation Science* 11:465-472.

Kuppinger, D. 2008. Post-fire vegetation dynamics and the invasion of *Paulownia tomentosa* in the southern Appalachians. Doctoral Dissertation, University of North Carolina at Chapel Hill. http://www.unc.edu/depts/ecology/theses/Kupp_PhD.pdf

Newell, C.L. and R.K. Peet. 1998. Vegetation of Linville Gorge Wilderness, North Carolina. *Castanea* 63(3):275-322.

Scientist Profile

Dane M. Kuppinger is a visiting professor of biology at Salem College. His research interests include exotic species invasions, disturbances, particularly fires in the southern Appalachians, and the interactions between disturbances.

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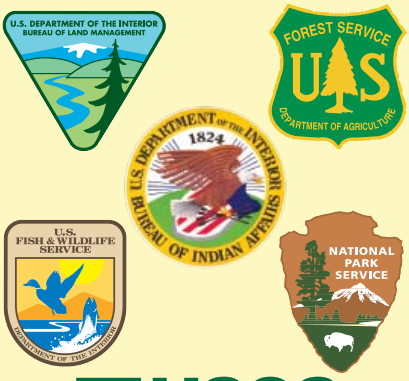

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