Dr. Strange-Olive, or, How I Learned to Stop Worrying and Live with (some) Invasive Species

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I am willing to make a bet that just about anywhere in the world, in any place you might be reading this article, the nearest green plant to you is not native to where you found it.[1] It's alright if you choose not to look right now. At your leisure, wherever you find yourself at any time, any close plant will suffice. It would be a great thing if I lost this bet to more than a few of you. That would be heartening. But unfortunately, I would surely have more than enough money to pay these few debts. Were you to ignore your houseplants I would still come out well ahead. I could even spot you the intentionally planted landscape, forgive you all the street trees, gardens, and planters, and I would still be ahead. The terrestrial world is green, but the green that we are most often surrounded by, when it comes to providing healthy habitat, is a façade.

This thin veil of green, to the extent that we mistake it for a small part of the "natural wild" that exists in parks and natural areas beyond the city and suburban limits, fools us. This green veneer, to the extent that we mistake it for an ecological foundation – food and shelter – for other "naturally wild" things, fools us. I'm sure it's a very good plant that you found. I harbor no grudge, bear it no ill will. Nor do I count anyone a fool for the inherent calm or joy any plant might bring, regardless of its origins. If we wanted to praise the plant you found, I'm sure we could note that it might shade you on a hot day, or if small, it might bind the soil in place. I'm sure it could do these things and much more. As the title of this article indicates, I've learned to live with (some) invasive species. But this plant that you found, if it isn't native, then it probably doesn't do many of the things we would expect. Were we to view your plant through the eyes of a passing bird or butterfly, it likely doesn't look green at all.

There are several terms I need to use here that I haven't defined and might be interpreted in dramatically different ways. "Native." "Natural." "Invasive." These are words you shouldn't say too loudly in a packed theatre of ecologists. But for all the distinctions you could draw among them, how you define these terms matters little to this story. But, for the purpose of clarity, I'll offer some assistance. When biologists speak of organisms as native (or endemic or indigenous) to a particular region, they generally mean that the species in question has a meaningful evolutionary history in that place. It is (or was) adapted there and things there are adapted to it in turn. Disagreements exist about the utility or wisdom of attaching a defined period of time to our meaning of "native." Personally I find this particular practice not very helpful. Are any species brought to North America by the Vikings to be considered native, whereas those that travelled with Columbus are not? Many reasonable arguments about details exist here, but as with other terms that struggle for want of a precise definition that works in all cases, there is little practical difference, and most ecologists are quite comfortable agreeing on a native species when they see one. This may sound very unscientific, but the list of difficult-to-define terms like this in biology alone includes such venerable concepts as "species," "family," "gene," and "life" itself. But if I might make another bet, I would wager that it is of little concern to you that most definitions of "candy" would include your preferred brand of cough drop (a lozenge, by any other name, would sell as a sweet). The same rules apply to a term like "native." In contrast to native species, which have an evolved history in a region, I'll use the term "invasive" to refer to nonnative plants that behave as weeds (these are the kudzus and the purple loosestrifes of eastern North America).

"Natural," as a term and concept, can be similarly sticky. If natural things arise from the natural world, and synthetic things rise from humans (or perhaps other tool-making animals), does the emergence of humans from natural things trump the concept of the synthetic altogether? Logically, no (a Venn diagram helps here), but it certainly muddies things a bit. It seems to make "non-synthetic" a more meaningful term than "natural." But that certainly doesn't sound very natural. The good news here is that the arguments that follow, such as they are, do not critically hinge on any particular definition of "natural," "native," or "invasive."

The real crux of the issue I would like to return to is that, from the perspective of the nature around us, the perspective of the wildlife we share our environment with, not all green is good. We often feel like we live in a green world. Our daily lives often bring many of us in close contact with landscapes that seem green and full of plants. And we want the world to be green, generally speaking. We think of green as being a good thing—lush, life-sustaining—but the green façade of non-native plants does very little to support the other organisms around us. It's an excusable misunderstanding, given our lack of knowledge, to move through our landscapes, see green, and think all is right with the world. In this way, invasive species are one of a number of environmental problems that hide in plain sight.

Despite the introductory exercise that demonstrates the prevalence of invasive species, it is worth pointing out that I firmly believe that beautiful natural areas worthy of protection still exist. There are a lot of beautiful areas across our country and across the globe that still resemble the native communities that existed before industrialization and the global economy altered things so much.

Figure 1: Although the effects of humans and invasive species are pervasive, beautiful natural areas worthy of protection still exist. Although both native tree species are imperiled by nonnative insects and pathogens, there remain amazing stands of eastern hemlock (left) and American beech (right) along the trails in Cook Forest State Park in northwest Pennsylvania. Source: NZ Muth.

A visit to Cook Forest State Park in northwestern Pennsylvania, for instance, is well worth the opportunity. Especially before all the hemlock trees die from Hemlock Wooly Adelgid, and the ash trees from Emerald Ash Borer. And the beeches from Beech Bark Disease, and the elms from Elm Yellows. It's already too late for any mature American chestnut trees. Such is the sad state of a relatively intact natural area. But the place is still very beautiful. Still very much a habitat for native wildlife. Still well worth appreciation and protection.

What is also very much worth pointing out is that we can make our lived-in areas more habitable and worth protecting in their own right. Not only do we have beautiful parks and forests that we can visit, but we can restore our own immediate surroundings, our more lived-in surroundings (urban areas, suburban areas), our front and back yards, bit by bit by adding more "good green." We can remake them to provide the food and shelter needed by the natural wildlife. We can and should strive to make our lived-in areas reflect and represent our beautiful, diverse, and sustaining native communities.

Doug Tallamy, putting forth both a rationale and a guide in *Bringing Nature Home*, has been a great champion of reimagining the green that surrounds us in our lived-in spaces.[2] In particular, Tallamy focuses on how native plant species support native insects, and native insects support native bird species. This occurs for exactly the reasons mentioned previously about how we define native species—species that have a co-evolved relationship with the other organisms in the region. As much as we are often fooled by the green façade of nonnative plants, most of the insects that need plant leaves for food and shelter can only use the leaves of particular native species. If we care to view the vegetation through the eyes of the insects, we would not be so easily fooled, and we might see the value and the opportunity to support an entire ecosystem by planting native species.

It is time that we expand the call of “eat local” and “buy local” to “plant local.” It’s increasingly common for many of us to take a moment to think about where our food comes from, what methods were used to grow it, who is employed by the process, and what are the intervening steps and costs and benefits along the chain. To the extent that we have options, thinking about these intermediate impacts can be a very worthwhile process. If we could only adopt a similar mindset when thinking about landscaping and street trees, we could improve the quality of our own environments at the same time as we reduce the risks posed to our surrounding natural areas. When we use nonnative plants we undercut the food base of our local systems. When we use nonnative plants, we risk their escape into our natural areas where they often outcompete the existing native plants. When we transport plants from across the country, we risk transporting new diseases and pests. But when we buy native plants locally, we provide food and shelter for native wildlife, we extend the reach of natural areas, and we support our regional economy.

So far it sounds as though I’ve not made much peace with invasive species. To get there, it will be instructive to describe a few battles that preceded the peace.

How does someone actually get interested in invasive species? How do you solve a problem like Maria, if Maria were an invasive weed? My own personal introduction to invasive species came when I was a park ranger in the San Juan Islands. That is, the islands north of Puget Sound, not the city on an island in the Caribbean (both have National Historic Sites). The San Juan Islands are a beautiful place to spend the summer, and the National Historic Park there is fantastic. Apart from watching orcas and participating in historical re-enactments, one of the things that I did while I was there, probably not as much fun as the former activities, was to dig up the invasive tansy ragwort.

Tansy ragwort is a weed native to Europe and widespread throughout the Pacific Northwest, where it can dominate a site, often forming a near monoculture (i.e. an area populated by just one species). As I mentioned, the way in which we managed this species was to simply dig it up on the park property. But the curious, or perhaps frustrating, thing to me was that when we got to the park boundary, we had to stop digging. As much as leaving the large patches on the neighboring properties increased my job security, it definitely decreased morale as well as the beneficial effects of our management. (More recently there are Cooperative Weed Management Area policies that exist to try to increase partnerships in scenarios like this).

Figure 2: Tansy ragwort, a biennial native to parts of Europe and Asia, is a highly invasive weed in parts of the United States and elesewhere. Although tansy ragwort can be successfly managed, property boundaries can be a hurdle to efficient long term regional control of invasive species. Cooperative Weed Management Areas (CWMAs) are an attempt to coordinate and leverage resources across property and municipal boundaries. Source: Clackamas Soil and Water Conservation District.

The tansy ragwort case definitely piqued my curiosity. Here was a plant novel to the region that could cover acres of landscape (or hectares, if you found yourself across the strait and the Canadian border). Why did certain species behave this way? How did they outcompete the native species? What were their effects on the invaded ecosystems? These were the questions I took with me into the subsequent fray that was me, invasives, and my Ph.D.

It turns out that some of my questions were answered long ago by that eminent naturalist and *Beagle* lover, Charles Darwin. He just nosed me out by a mere 130 years. In no less than *The Origin of Species*, Darwin talked about species that have been naturalized, species that were from another country and became successful in a new region. In other words, he talked about nonnative invasive species. He says (emphasis mine), "As natural selection acts by competition, it adapts the inhabitants of each country *only in relation to the degree of perfection of their associates*, so that we need feel no surprise at the inhabitants of any one country, although on the ordinary view supposed to have been specifically created and adapted for that country, being beaten and supplanted by the naturalized productions from another land." Darwin is addressing what seems like a paradox: species that are native elsewhere that arrive in a new region and they do better than the native species that are already there. It doesn't make sense to the default hypothesis of Darwin's own time, that of "special creation." In a world where God created species for each particular place, it makes little sense that when they manage to get somewhere else, often with the help of humans, that they do better. The natural philosophers wondered why organisms placed in a region by God should be beaten out by species brought there by man. This was one of many patterns that troubled these early scientists of the time (most of whom viewed their efforts as describing the works of God). But, at first glance, invasive species also didn't square very well with Darwin's idea of natural selection. After all, native species should be the ones best adapted to the region in which they evolved. But ever anticipating the appearance of contrary evidence, Darwin was careful to point out how natural selection, in the details of its actions, actually accounts for invasive species. If species are expected to be adapted "only in relation to the degree of perfection to their associates," then if different regions or continents had different degrees of competitiveness, moving species between these regions would result in our observing "invasive" species. These species, strengthened and trained by strong competitors at home, would sometimes find themselves besting the champions of the comparatively weaker communities elsewhere.[3]

A sports analogy may help to drive Darwin's point home. At the risk of immodesty, I am not the worst basketball player ever. In fact, as a graduate student in Ecology and Evolutionary Biology at the University of Tennessee, our team, Multiple Organisms, won the graduate school intramural championship. After several years of playing against the same competition, eventually we had honed our skills and adapted our plays to beat all our league rivals. Then, fresh off a playoff run where we demonstrated that we were as good as we needed to be to beat all our graduate school rivals, we were given an opportunity to play against the champions of the undergraduate intramural league. While we managed a tie at the halfway mark, it quickly became apparent that the undergraduates had all been shooting left-handed, and they subsequently routed us in short order.

Figure 3: Team photo of "Multiple Organisms," the University of Tennessee—Knoxville Graduate School League basketball championship team of the early 2000s. Source: NZ Muth.

Now this is all fine and good for us so long as the barrier between graduate and undergraduate leagues remained in place. But imagine if this barrier were to disappear. Imagine if it melted away as a glacier, or washed away in the path of a river changing course. Or, imagine if just one team of very good undergraduates all graduated together and chose to enroll the following year in the same graduate program. In any of these scenarios, our status as champions, as the best competitors, evaporates in the face of the new competition (that was adapted to a tougher league of its own). This is why invasive species actually make sense from a viewpoint of natural selection. Natural selection acts in a way that species may adapt to be satisfactory in their own surroundings (and to be more accurate, it leaves behind it species that are adapted to the past environments they experienced). It is neither a perfecting force, nor does it look to the future.

Returning to my own investigations of invasive species, while I was playing basketball at the University of Tennessee I also occasionally worked on my Ph.D. research. In particular I wanted to understand the role of nature and nurture in invasive species. More technically known as "phenotypic plasticity," I wanted to determine how the interplay between genetics and environments contributed to our ability to understand invasive species. Much as Darwin had anticipated some of my questions, other scientists had anticipated this question and 1965 saw the publication of some of Herbert Baker's more influential research on invasive weeds. Perhaps the most influential aspect of Baker's work is his synthesis of the characteristics of weedy nonnative plants and, in particular, a list of the attributes of "the ideal weed."[4] Oddly enough for someone studying plants (as opposed to the exciting world of animals—they move!), I had little trouble recruiting undergraduates in my investigations of "the ideal weed."

Most interesting to me about Baker's list of 14 traits (a number I like to think of as a Herbert Baker baker's dozen) were those traits of weeds that related to nature and nurture. Traits number eight and nine of Baker's became the foundation of my dissertation. Trait number eight states that the ideal invasive plant should have "very high seed output in favorable environmental circumstances." If the environment is good, an invasive plant should be able to produce lots of seeds. That makes sense; you would think that a plant that was very successful would do that. Trait number nine: an invasive plant "can produce some seed in a very wide range of environmental circumstances, and has a high tolerance of, and often plasticity in the face of climactic and edaphic variation." This simply means it should be able to produce seed in almost any habitat it finds itself. When you put traits eight and nine together, the claim is that ideal weeds should be able to produce many seeds in good conditions, and should also able to produce some seeds in almost any environment, including very tough conditions. For decades following the publication of Baker's list, researchers often claimed that we knew invasive plant species were invasive in part because they are plastic, opportunistic in the face of good conditions and robust in the face of poor conditions. But, in reality, there was very little research on the subject.

What I wanted to do in my thesis was operationalize the hypotheses put forward in Baker's ideal weed list. What would his predictions actually look like if you were to collect data? Luckily for me, this wasn't too difficult to figure out, and neither Darwin nor Baker had beaten me to it. Here is the model I used for my dissertation.

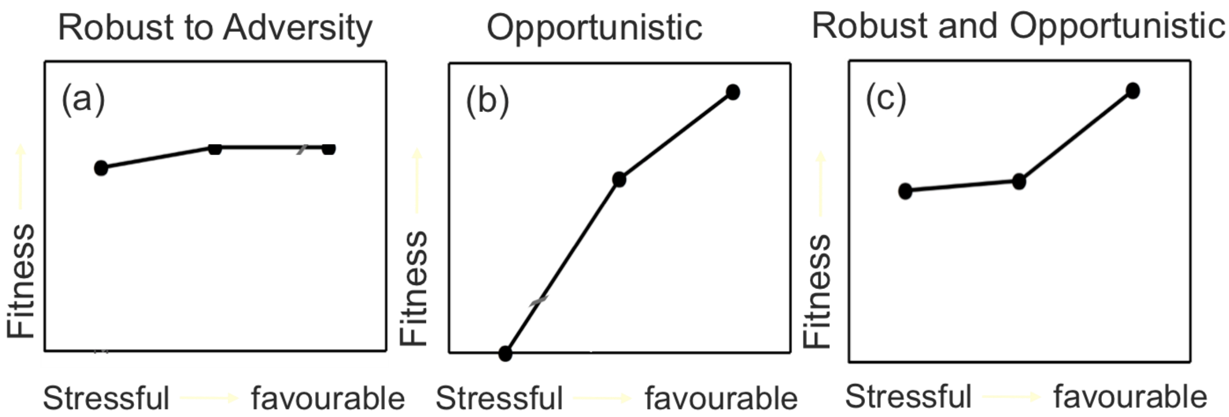

Figure 4: Expectations for fitness response of invasive species: (a) invasive species should be more robust in the face of stressful environmental conditions, (b) invasive species should be able to respond opportunistically to favorable conditions, and (c) some invasive species may be able to be both robust and opportunistic. Source: C.L. Richards, O. Bossdorf, N.Z. Muth, J. Gurevitch, and M. Pigliucci, "Jack of all trades, master of some? On the role of phenotypic plasticity in plant invasions," *Ecology Letters*, 9 (2006): 981-993.

On the y-axis is fitness: seed production, for instance, would probably be the most important component of fitness. On the x-axis we have some sort of environmental variable that would be stressful in some conditions, favorable in others. This environmental x-axis, for instance, could reflect the availability of water, light, or necessary mineral nutrients. From Baker's list, number nine is seen in panel "a," the claim that invasive species can produce seeds in many different (including harsh) environments. Baker's trait number eight is seen in panel "b," where invasive species can increase seed production opportunistically when environments become favorable. My own limited contribution to this scheme was to realize that panels a and b look rather contradictory. But I knew that Baker's hypothesis made sense intuitively, so to make it testable I created panel "c" as a logical combination of Baker's ideas.

Obviously, the next thing you need to know when studying invasive plants and their responses to the environment is where you would want to put reinforced armor on a plane. (Stick with me; this will make sense eventually!) During World War II Hungarian-born Abraham Wald used mathematical models to address the Allies on this very issue. Prior to Wald's models, the way they were determining where to place additional armor reinforcement on planes (a subject very clearly important to understand if you're researching plants) was to look at returning aircraft to see where they had taken damage and place the additional armor there.

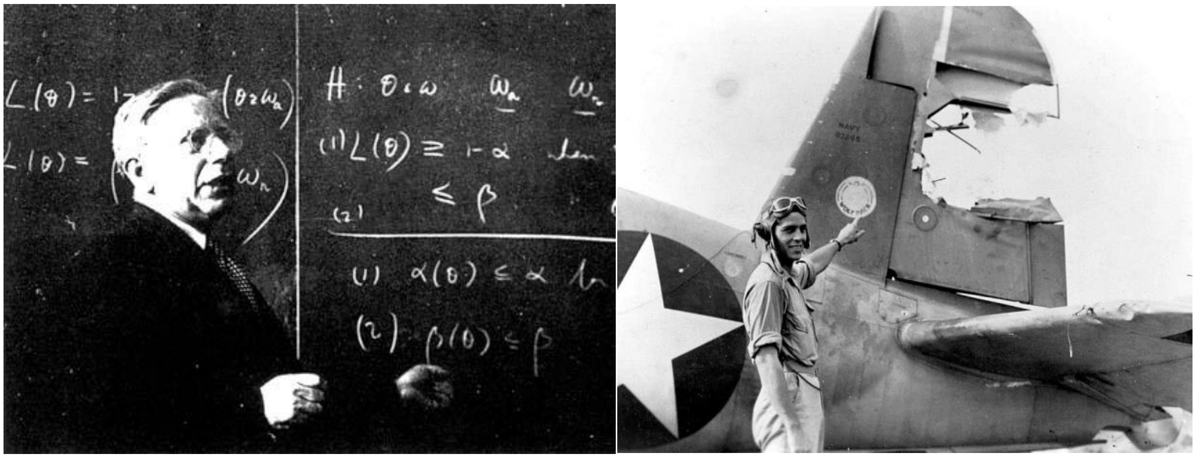

Figure 5: Abraham Wald (left) is credited for saving many American planes and pilots based on his analysis of survivable versus catastrophic damage. Wald's analysis is an excellent example of the importance of understanding "survivorship bias." Sources: MacTutor History of Mathematics archive (left) and Mision4Today.com (right).

But Wald brilliantly argued against this approach. Why? Because this was survivable damage. These planes didn't need reinforcement where they were damaged, because they had survived that damage to return. Wald argued that they needed data from planes that had been shot down and the planes therefore didn't return. This was harder information to come by for sure, but it was critical to efficient placement of the additional armor. Wald was able to recognize that the method they had been using didn't acknowledge what has become known as "survivorship bias." The only data they had were from survivors, and as a result there was an entire category of planes being ignored (not maliciously of course, just as a matter of it being much easier to examine returning planes) that would have helped answer the question.

Obviously, this is important to invasive plants, and here's how. Remembering our interpretation of Baker's traits of the ideal weed, we noted that they would be both opportunistic to favorable conditions and robust in the face of poor conditions. So we made our quantitative model that would allow us to test this hypothesis. But another aspect of the research design was still missing. What researchers had largely done to this point to assess invasive species and figure out what makes them invasive was to look only at invasive species. Many of these species did indeed seem to resemble Baker's ideal weed. But what if all the unsuccessful species also had these traits? What if plants that have low population growth rates and don't cause us any problems are also opportunistic and robust? Well, if this were the case, then these aspects of nature and nurture don't actually explain anything about invasive species, since non-weedy plants would be just as likely to share these traits.

What we needed was an operational model that included invasive species compared to unsuccessful species. We needed to also include expectations for plants that were essentially non-survivors, or at least non-invasive. If Baker's traits help explain why invasive species can be so successful, then species that aren't so successful should produce significantly fewer seeds when stressed, and they shouldn't be able to match the reproductive increase of invasive species when conditions are favorable.

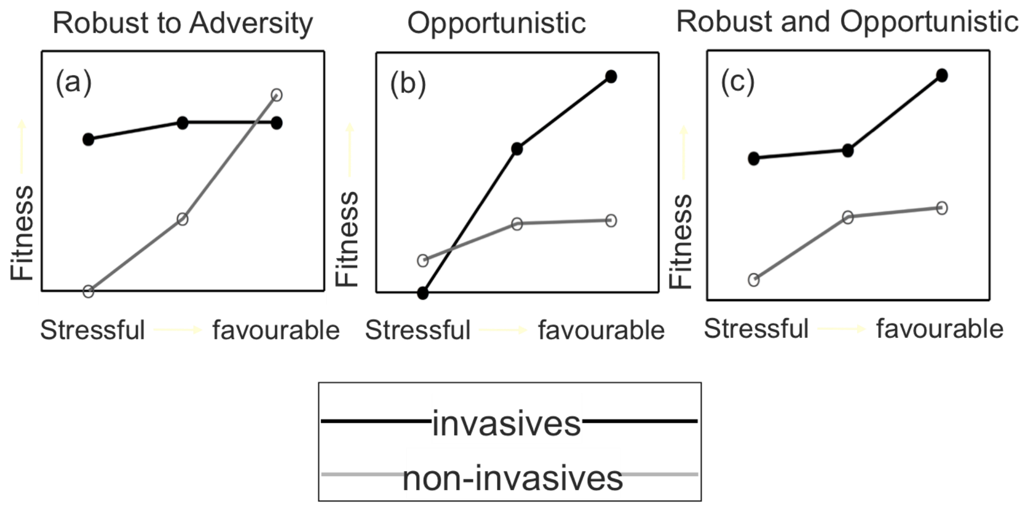

Figure 6: We revisit figure 4 acknowledging the issue of "survivorship bias" by adding in our expectations for fitness response of noninvasive species in addition to the invasive species: (a) invasive species should be more robust than noninvasive species in the face of stressful environmental conditions, (b) invasive species should be better able to respond opportunistically to favorable conditions than noninvasive species, and (c) some invasive species may be able to be both more robust and opportunistic than noninvasive species. Source: C.L. Richards, O. Bossdorf, N.Z. Muth, J. Gurevitch, and M. Pigliucci, "Jack of all trades, master of some? On the role of phenotypic plasticity in plant invasions," *Ecology Letters*, 9 (2006): 981-993.

This proved very useful in testing the hypotheses as they took this broad concept of phenotypic plasticity, the relative contributions and interaction between nature and nurture, and the models parsed out different aspects of this concept and laid it out in a way to test it against species that you predicted wouldn't have these traits. These models allowed the field to move away from generic and inaccurate claims of "we know invasive plants are plastic" to more specific and meaningful claims about where and when plasticity mattered and when it didn't.

It was very gratifying that this thesis work was frequently adopted, and that it spurred further research into the details of how nature and nurture contributed to invasive species problems. But after more than a decade of finding out that the devil was indeed in the details, we determined that some invasives really followed Baker's models and some non-weedy species occasionally did as well. After elucidating that those patterns were rather idiosyncratic once you got below the surface (as they always are in biology), I eventually realized that invasive species were an even bigger, albeit better understood, problem than when I had started my research. There were simply many more invasive species out there now than when I started, and I hadn't helped anybody get rid of invasive species with my work.

Before I share my response to this feeling of having made no meaningful difference as far as the problems invasive species were causing, and before I get to making my peace with (some) invasive species, I hope you will indulge my sharing a bit of my invasive species angst. Perhaps the most irritating thing about nonnative invasive plants is that we often intentionally introduce them and encourage them in cases where we have abundant and beautiful native species that would work just as well. We use nonnative ornamental plants like Japanese Spiraea, which is beautiful, but it quickly spreads into adjacent natural areas. And yet, there are a few different native *Spiraea* species that we could use instead, but they are generally very difficult to find in nurseries. So, instead, we sell ourselves the problem of Japanese Spiraea.

Figure 7: Invasive Japanese Spiraea (left) and the Pennsylvania-native steeplebush, *Spiraea tomentosa* (right). Sources: MidAtlanticHikes.com (left) and NZ Muth (right).

My daily commute used to frustrate me to no end. I drive past endless understories of privet and honeysuckle. In the early spring, people would often comment to me about how they noticed the understory was beginning to “green-up,” and I would just think to myself, “façade.” I knew all of that green was invasive. It’s one of the things that make them successful plants—they green up earlier, and they’re more tolerant to late freezes. But it makes the forest look lush, all green, all nonnative, no meaningful food and shelter for wildlife. Across my entire commute the roadsides are littered with the corpses of native trees that have succumbed to pests spread far and wide by global commerce. Elm was the first species I noticed massively dying back, in 2007 (from Elm Yellows). In 2009 the dead and dying were mostly hemlock (from Hemlock Wooly Adelgid). Around 2015 the roads became littered with skeletal ash (from Emerald Ash Borer). And now I keep a lookout for the first of what eventually will likely be many dead black walnuts (from Thousand Cankers Disease). It can be a frustrating and helpless feeling to see the demise of so many of our amazing native North American trees.

At least I could enjoy seeing all the native mountain laurel on my commute. Some utility right-of-ways were a veritable sea of pink blossoms in May. A utility right-of-way isn’t going to be someone’s favorite thing to look at, usually, but when it’s covered in mountain laurel flowers, it becomes beautiful.

But eventually these right-of-ways are scheduled for vegetation management. Having large trees in these areas can pose a problem. But mountain laurel is a shrub, so it will never pose a problem. But instead of just targeting the large species, the entire right-of-ways were sprayed with herbicide. From edge to edge, for miles and miles. A beautiful landscape full of native plants that were never going to pose a problem got wiped out. What really got to me was that I wanted to plant some mountain laurel by my house, and they are not even that easy to find at the average nursery. An unappreciated wealth of locally produced native plants, all destroyed.

I can see all of these problems on my commute. If I let myself, I can be frustrated to no end. Where others might see green, I see unwelcome invasives; where others ignore leafless trees and shrubs, I see thousands of unnecessarily dead native plants. But, I've realized that it's not useful for me to keep thinking this way. I have to pick my battles. I have to pick battles that are small enough to win, but big enough to matter. That's really what it comes down to when you're thinking about something like invasive species. I'm not going to rid Central Pennsylvania of bush honeysuckles. It's a battle that's too big to win. But there are other things I could do. Japanese Spiraea is invasive, but it's not everywhere. Maybe if I tell people about Japanese Spiraea—stop planting Japanese Spiraea!—maybe we could do something about that. Maybe if I worked with people locally to say, "Let's use something else besides this species that's invasive," maybe we could plant some native alternatives. There are some battles that are small enough that we could win, and important enough to be worth the effort.

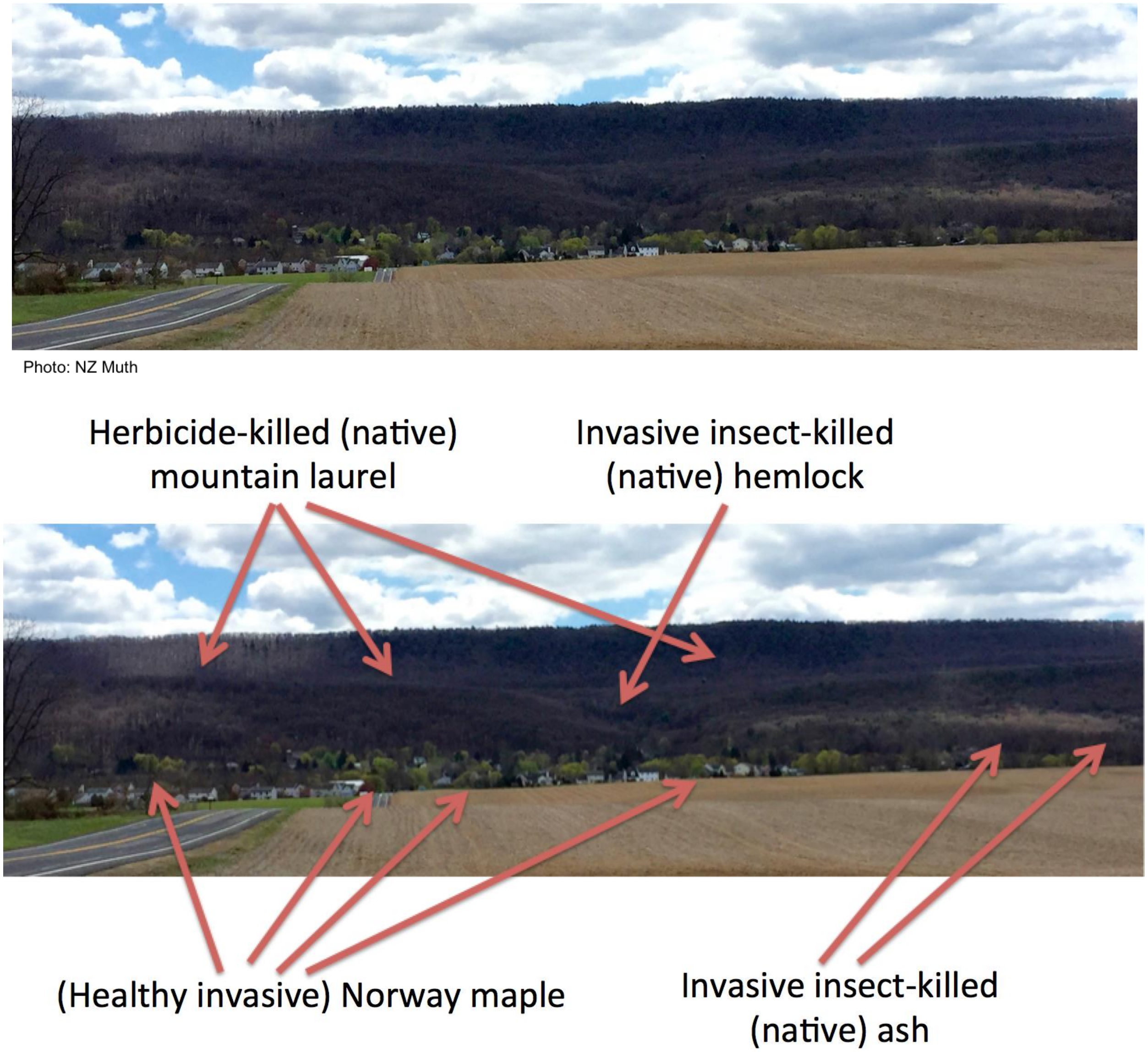

Figure 8: The village of Pine Grove Mills, Pennsylvania (middle ground) and Rothrock State Forest (background), with (lower picture) and without (upper picture) invasive and native species annotations. Awareness of invasive species problems can transform an otherwise beautiful landscape into an environmental wasteland. In applying limited resources to invasive species problems, we may need to make peace with the battles that are irretrievably lost and focus our attention on those invasive species problems that are big enough to matter and small enough to win. Source: NZ Muth.

What I want to do is get myself back to looking at a beautiful landscape without necessarily fixating on all the dead mountain laurel or the dead ash. I want to get past knowing that what really makes this landscape beautiful in early spring is the flowering of invasive Norway maple. Because if I let myself see it otherwise, I become jaded and paralyzed.

But unfortunately, part of the solution to these problems is that more people need to see through the green veil and experience a bit of my former frustration. Doing anything about the battles we can win requires greater awareness. So I try to channel my angst and energies into what I think are more productive areas.

One of the big issues with nonnative plants is that it can be difficult to convince people not to use them. Nobody wants to be told what he or she can't do. People sometimes ask me, "Well, what can I plant?" and I might say, "There are some beautiful native Spiraeas."

"Where can I get those?"

"You can't. There was one place I knew of, and they're sold out. You could try ordering them." (All the while there are thousands of healthy native Spiraeas being dug up in new natural gas pipelines.)

So I try to think of some constructive things that we can do, and this is where the Native Plant Cooperative at Juniata College has come together. One of the things we're doing is working on "rescue plant" projects. It recognizes that with the right support and the right partners, we can help meet some of the demand for native species by getting the mountain laurel before it falls to right-of-way maintenance. There are lots of places that are being developed that are full of native species, where plant rescues could be a positive force. Short of nursery associations stepping up in a big way to improve the availability of native plants, rescuing native plants from development could be beneficial for all involved. We could give these plants to restoration groups, to local tree commissions, to whoever wants them. They're essentially free, apart from the travel and the labor to dig them up. (Note that we do not encourage the indiscriminate collection of plants from natural areas, which is largely illegal, but only permitted collection from areas that will be disturbed by development or vegetation management).

Figure 9: Native Plant Cooperative team members Steven Guetzlaff and Katie Jeffress participate in a native "plant rescue" at Lake Perez (Huntingdon, County, PA). Source: NZ Muth.

The Native Plant Cooperative is also working with Juniata College's grounds management and groups like the Huntingdon Tree Commission to help determine where these groups have nonnative species that could be replaced with natives. We've been going out with students to identify and map the plantings, and coming up with lists of suitable native alternatives.

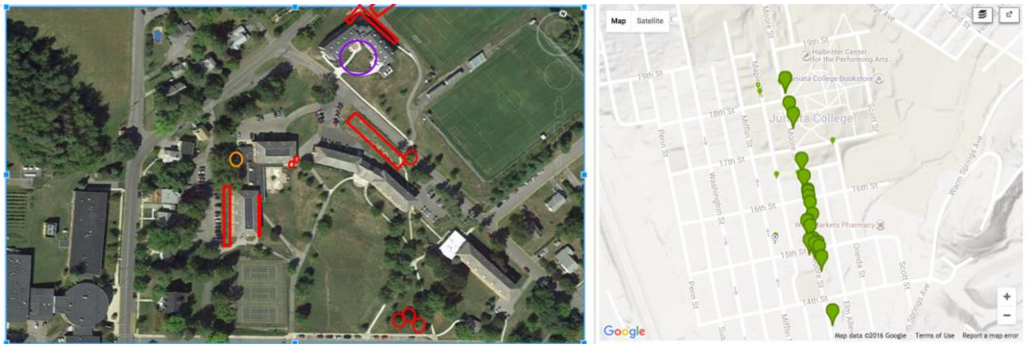

Figure 10: Juniata students have worked with Grounds Services Supervisor Jeff Meadows and with the Huntingdon Tree Commission to map and prioritize invasive species concerns on campus (left) and in the surrounding community (right). Source: NZ Muth.

Not all green is necessarily good. This is a challenging but crucial message to convey to the public. I think most people understand that there are natural areas that are still really worth protecting. But I think that the idea of making our lived-in landscapes more like our existing natural areas and more accommodating to native wildlife is a message that isn't generally out there. It's a very good feeling to plant something green in your yard, and you probably feel like you're doing something good for the environment. But what if you're only planting nonnative species? You're not doing nearly as much good for the environment as you could. You might be doing some harm by bringing in a new invasive species to the area. In other aspects of our lives, we've made great strides in our awareness, thinking about the impact of how we get to work, what we do with our garbage, and where we get our food. Now is the time to take a similarly mindful and intentional approach to the plants we use in our yards, our gardens, and our streets.

NOTES

1. Of course to win or lose the bet, you need to know what kind of plant you found. Luckily there are apps for that. No, there aren't any good apps that tell you directly from a photo (there are bad ones of these that basically don't work), but any request to identify a picture posted on Facebook or other social media doesn't take too long once you find the right group of native plant enthusiast in your region. iNaturalist is a particularly useful application for this task. Your state's cooperative-extension program can also help.
2. Doug Tallamy, *Bringing Nature Home: How You Can Sustain Wildlife with Native Plants* (Portland, OR: Timber Press, 2007).
3. Charles Darwin, *On the Origin of Species by Means of Natural Selection* (London: Murray, 1859).
4. Herbert Baker, "Characteristics and Modes of Origin of Weeds," in H. G. Baker and G. L. Stebbins, eds., *The Genetics of Colonizing Species* (New York: Academic Press, 1965), pp. 147-172.