

Giving Ecological Purpose to Your Landscape by Douglas W. Tallamy

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Intro

As the human footprint continues to expand at the expense of the natural capital that sustains us, there is a growing need and increasing demand for residential, corporate, urban, and suburban landscapes that generate natural resources rather than destroy them. At our current population levels, a culture that segregates humans from nature is not a sustainable option and by whittling away at functional ecosystems, such a culture has led to a reduction in the earth's ability to produce essential renewable resources (aka ecosystem services) by more than 60% (2005 Millennium Ecosystem Assessment). To believe there will always be sufficient oxygen, clean air and water, carbon sequestration, pollinators, and the biodiversity that produces these resources, regardless of how we treat local landscapes – or to suggest that technology can effectively replace them – is folly in its most misguided form.

Fortunately, we already have the knowledge required to integrate human habitats with the natural world. Indeed, the concept itself is ironic because humans are products of the natural world – – one of millions of life forms that natural systems sustain every day – – and we have never been even partially independent of earth's bounty. What types of landscapes are capable of sustaining humans and nature simultaneously? Ones that feature plants that interact with the species around them. Such plants are the key; every ecosystem service required by humans (and most other animals as well) is created either directly or indirectly by plants. We have degraded ecosystem function by removing plants from local ecosystems, or by assuming that all plants function equally well in every environment. It follows that we can quickly repair the damage we have inflicted on the typical built landscape simply by putting the right plants back. And who better to lead the way in this most noble endeavor than gardeners who know and love plants.

Nature equals specialized relationships

A pattern is emerging from conservation efforts around the world: if you want to save a particular species, you have to save the specialized relationships that support that species. If, for example, you want to save the resplendent quetzal (a gorgeous but endangered bird in Central America), you have to restore populations of wild avocado trees, because the fruits of that species are an essential component of the quetzal diet. If you want to save jaguars, you need to protect large populations of palm species that make small palm nuts (as opposed to coconuts). Why these palms? Because palm nuts sustain peccaries, the wild pigs that are jaguar prey. If you want great green macaws in the future, you need to restore populations of wild almond trees because they are the only trees those birds will nest in. Such specialized relationships are so common in the tropics that they are the rule rather than the exception.

What surprises many people, however, is that specialized relationships, particularly involving food webs, are also the rule in the temperate zone, and we cannot create living landscapes if we exclude them. If you want your may apples to spread by seed, you need a population of box turtles. May

apple seeds germinate best after passing through the gut of a box turtle that has eaten the may apple fruit. If you want pileated woodpeckers in your neighborhood, you need trees that harbor large colonies of carpenter ants, because carpenter ants are what these birds feed their young. If you want your *Phlox divaricata* to produce viable seed, you need the plants that support the larval development of day-flying sphinx moths, for these moths are the primary pollinators of *Phlox*.

Even species that do not seem to depend on specialized relationships often do, especially during reproduction. The Carolina chickadee is an excellent example. As anyone with a bird feeder knows, chickadees are seed eaters during the fall, winter and early spring. When it comes time to feed young, however, chickadees join 96% of the terrestrial birds in North America that rear their young on insects (Dickinson 1999). And not just any insect: chickadees feed their nestlings caterpillars. Chickadee parents could feed their young other insects, but the overwhelming majority of their prey during reproduction is caterpillars. And not just any caterpillar, but those that are not covered in hairs or spines. Because chickadees rear their young on caterpillars, there will be no chickadees where there are not enough caterpillars to bring a clutch of eggs to independence from parental care.

How many caterpillars is that? Carolina chickadees bring somewhere between 390 and 570 caterpillars to their nest each day, depending on the number of chicks in the nest (Brewer 1961). Parents feed nestlings in the nest for 16 to 18 days before the young fledge and then for 30 more days after fledging. If we focus only on the caterpillars required to reach fledging, it takes 6,240 to 10,260 caterpillars to fledge a single clutch of chickadees: an astounding number, even to those who study bird behavior. No one knows how many more caterpillars are required during the 30 days after fledging. What's more, chickadees are tiny birds; a Carolina chickadee weighs 1/3 oz, the equivalent of four pennies. In comparison, a red-bellied woodpecker, which also rears its young on insect larvae, weighs eight times more than a chickadee. How many larvae are required to create a red-bellied woodpecker? How many insects are required to sustain an entire population of chickadees and woodpeckers . . . and titmice, and orioles, bluebirds, wood thrushes, catbirds, cardinals, buntings, flycatchers and all of the other birds that signal healthy temperate zone ecosystems? The numbers are mind-boggling.

Consequences of specialization

Suggesting that designed landscapes should produce rather than destroy insects would have been ludicrous, if not heretical, in the past. After all, if plants are simply decorations, we would want them to be forever flawless and untouched by natural processes. In fact, if flawless plantings are really the goal, using silk or plastic plants seems like the more logical option. If our goal, however, is to create landscapes that contribute to, rather than detract from, local ecosystem function, then we must include "the little things that run the world" (Wilson 1987). Decades of research have shown that insects are essential for pollination, nutrient recycling, pest control, and especially for feeding other animals. A world without insects is a world without biological diversity; and a world without biological diversity is – eventually – a world without humans. If insects were to disappear, humans would not last more than a few months (Wilson 1987). Seen in this light, waging war insects where we live, work, farm, and play seems counterproductive at best.

How, then, can we design landscapes that support lots of insects but also stay in a balanced equilibrium with the natural enemies that control them? Before we answer this question, we have to consider the most important and abundant specialized relationship on the planet: the relationship between the insects that eat plants and the plants they eat. Most insect herbivores, some 90 percent in fact, are diet specialists restricted to eating just a few lineages of plants. But plants don't want to be

eaten, so they manufacture nasty chemicals including cyanide, nicotine, pyrethrins and tannins to deter plant-eaters.

If plants are so well defended, how can insects eat them without dying? Because insects like caterpillars necessarily ingest chemical deterrents with every bite, there is enormous selection pressure to restrict feeding to plant species they can eat without serious ill effects. Thus, a female moth will lay eggs only on plants with chemical defenses their hatchling caterpillars are able to disarm. There are many physiological means by which caterpillars can temper plant defenses, and they typically come by these adaptations through thousands of generations of exposure to the plant lineage in question. In short, by becoming host plant specialists, caterpillars can circumvent the chemical defenses of a few plant species well enough to make a living, while ignoring the rest of the plants in their ecosystem.

Monarch butterflies provide a perfect example. They are specialists on toxic milkweeds, which they can readily neutralize. The advantage of this relationship is obvious for the monarch, especially when milkweeds are plentiful; but there are also risks to specializing, especially in today's world. Unfortunately for the monarch, the ability to detoxify the cardiac glycosides that defend milkweeds does not confer the ability to disarm the chemical defenses found in other plant lineages. This means that of the 2137 native plant genera in the U.S., the monarch can develop on only one, the genus *Asclepias*. The evolutionary history of this butterfly has locked it into a dependent relationship with milkweeds and if milkweeds disappear from a landscape, so does the monarch. This is exactly what has happened across the U.S. in recent years. A growing culture that favors neat, manicured agricultural fields, combined with an unwillingness to share designed landscapes with milkweeds, has reduced monarch populations 96% from their numbers in the 1970s. Can monarchs adapt to other plant species? In theory, yes, but – in reality – no. Monarchs have been genetically locked into a relationship with milkweeds for millions of years. Adaptation could conceivably modify this relationship very slowly over enormously long periods, but asking monarchs to suddenly (within 30 years!) switch their dependence to an entirely different plant lineage such as, for example, the euphorbias or candytufts in our rock gardens, is like asking humans to develop wings. The number of genetic changes required to make such a switch reduces the probability of its happening before monarchs disappear to near zero.

Please note that monarchs are not exceptions, either in their specialized relationship with milkweeds, or in their current plight. They are typical of 90% of the insects that eat plants: their evolutionary history has restricted their development and reproduction to only the plant lineage on which they have specialized. And as we have homogenized plant diversity around the world by replacing diverse native plant communities with a small palate of ornamental favorites from other lands, the insects that depend on native species have declined. Data from Europe paint an alarming picture: insects in Germany have declined in abundance and diversity more than five-fold since 1989. This includes the extinction of 46 species of butterflies and moths. Globally, invertebrate abundance has been reduced 45% since 1974 (Schwagerl 2016). We have caused these declines by the way we have designed landscapes in the past. But we can reverse the declines by landscaping differently in the future.

Making Insects

What type of landscape is capable of producing insects in the numbers required to support viable food webs? A landscape created from the plants that have each developed specialized relationships with a diversity of insect species. A landscape occupied by organisms that have interacted with each other over evolutionary, rather than ecological, time spans. A landscape that showcases specialized relationships rather than ignores them. As we have seen, diet specialization is the rule among insect herbivores, not the exception. Without the plant lineages that support insect herbivores, there would

be no insect herbivores. If there were no insect herbivores, all of the creatures that depend on insect herbivores for their nutrition – that is, the insectivores of the world – would also disappear. A world without insectivores would be a world without spiders, insect predators and parasitoids, frogs, toads, and other amphibians, lizards, bats, rodents, skunks, opossums, raccoons, and mammals we don't think of as insect eaters, such as foxes and black bears, both of which get a quarter of their nutrition from insects. And let's not forget that a world without insect herbivores would also be a world without most terrestrial bird species; with the exception of doves, finches, crossbills, and our largest birds of prey, terrestrial birds rear their young on insects (and the spiders that ate insects to become spiders). To reiterate, a world without all of these creatures would not only be a world without biological diversity, it would be a world in ecological collapse that is incapable of supporting humans.

Which plants should we use?

If non-native ornamentals do not support the relationships required to restore ecosystem function to our landscapes, which plants do? Simple logic tells us that using a palate biased toward native species should be sufficient to support robust food webs in our landscapes. However, comparisons among plant genera of host records for moths and butterflies, the backbone of most terrestrial food webs, reveal two striking patterns that suggest this conclusion needs to be refined (Tallamy and Shropshire 2009). First, there are huge differences among plant genera in their ability to make caterpillars and thus support other creatures. Oaks (*Quercus*) in the Mid-Atlantic states, for example, serve as host plants for 557 species of caterpillars, tulip poplars (*Lireodendron*) only feed 21 species, and yellowwood (*Cladratis*) is not used by any caterpillars at all. These are order-of-magnitude differences among plant genera that are all native to eastern North America. Second, a mere 5% of the native plant genera in any North American ecosystem support 73-75% of the caterpillar species. Stated in reverse, 95% of the native plant genera support only 25-27% of the caterpillars that drive local food webs (Tallamy and Shropshire in prep.). We cannot build ecologically rich landscapes if we do not include the core genera – those top 5% – that create the majority of food-driving local food webs.

We don't yet understand why some plant genera are responsible for so much of the life around us, while most pass on minimal energy, and some none at all, to local wildlife. But we do not need to understand the basis of the relationship to use it effectively in landscape design. This pattern is consistent across all bioregions of North America and is not changed by latitude, longitude, or plant diversity levels. Wherever we are in the U.S., we can create plantings that sustain birds, reptiles, amphibians, and mammals by generating tens of thousands of insects. Landscape designers and architects, land managers, restoration biologists, and above all home gardeners can learn which native plant genera contain core species at the National Wildlife Federation website under "Native Plant Finder" (<http://www.nwf.org/NativePlantFinder/>).

Enter your zip code, and a list of plant genera found in your county, ranked from most to least productive, will appear.

Creating trophic balance

Because our past goal in constructing built landscapes has been to create beauty using plants rather than ecological integrity, a primary concern has been the aesthetic appeal of the plants themselves. A perfect specimen unmarred by insect damage has been the ideal. As we have seen, though, a perfect plant is one that has not interacted with other species in our landscapes, and a landscape full of perfect plants is an ecologically barren space devoid of animal life. Is it possible to choose plants that are simultaneously beautiful and productive, plants that can pass some of their energy on to the

insect herbivores that then support a vibrant community of other species? Indeed it is, but to do so we must attract even more species to our landscapes.

When species interact over long periods of time, a balance among plants, herbivores, and natural enemies (predators, parasites, parasitoids, and diseases) emerges that typically keeps any one species from eliminating the others. This is the ideal that we should strive for in our built landscapes. If we use native plants that support dozens of species of insect herbivores, we will create a food resource for hundreds of species of the natural enemies of those insects, so they too will become residents in the landscape and will keep insect populations below the aesthetic injury level. The spiders, assassin bugs, damsel bugs, ladybird beetles, lacewings, predatory stink bugs, digger wasps, parasitic Hymenopterans, bluebirds, tree swallows, cardinals, hummingbirds, catbirds, and many other insectivores all kill tens of thousands of insect herbivores before plants suffer noticeable damage. But natural enemies will not be in our landscapes if there is not enough food to support them. Fortunately, we have some wiggle room here, for studies have shown that people do not even notice insect damage until about 10% of the leaves have been eaten (Sadof and Raupp 1996). Most plants are viewed at a distance; even the oak tree that supports hundreds of caterpillars looks untouched from 20 feet away.

Using more plants

Creating vibrant landscapes that become functional extensions of local ecosystems can only happen if we use the plants that drive those ecosystems. Choosing the right plants is a necessary first step, but we must also put enough of those plants into the landscape to achieve the ecosystem integrity we desire. Today our built landscapes are dominated by turf grass. For example, 92% of the area that could be landscaped in residential neighborhoods in northeast Maryland, southeast Pennsylvania, and Delaware is lawn. Moreover, 90% of the trees are gone from these landscapes, and 79% of the plants that are there are from Asia (Tallamy et al. in prep). We have favored large lawns bearing few plants for two reasons. First, we prefer savanna-like landscapes, presumably because we feel safer in such environments (Falk and Balling 2009). Second, large, flawless lawns have been a status symbol of the rich for centuries. Such landscapes may have met our physical and social needs when we were hunter-gathers, but they are an environmental disaster in today's world of 7.5 billion people. We are converting most built landscapes into lawn-dominated spaces that do not support ecosystem function. We now have over 40 million acres of lawn in the U.S. and we are adding 500 square miles more lawn each year (Milesi et al. 2005, Kolbert 2008).

Raising the bar

To achieve a sustainable relationship with the earth, we must raise the bar for what we ask of our built landscapes. In the past we have asked that they be attractive, well-tended spaces. We have achieved this in grand style. But our need for ecosystem services is now so great that we can no longer rely on the remaining degraded and fragmented "natural" spaces to produce enough. We must now design beautiful landscapes that also support complex food webs, which in turn support the biodiversity that runs our ecosystems. We need landscapes that sequester carbon: lawn sequesters 27 times less carbon than a meadow and 32 times less than a forest (Scwartz 2014). We also need landscapes that clean and manage water. A lawn-dominated landscape impedes infiltration, creates disastrous storm water runoff, and adds nutrient and pesticides pollutants to aquatic ecosystems. Finally, we need to design landscapes that support diverse pollinator populations. Pollinators across the U.S. are in steep decline due in large part to the loss of nesting sites and seasonally abundant forage (Kremen et al. 2007). Manicured lawns provide neither resource. Pollinators, including the 4000 species of native bees that did all of the pollination in North America before the introduction of

the honeybee, are not optional. They pollinate 80% of all plants and 90% of all flowering plants. If we were to lose pollinators, we would lose 80-90% of all plants, including 1/3 of our crop species.

Homegrown National Park

We have it in our power to create a new national park of sorts simply by redesigning the landscapes in which we live, work, and play. If we were to replace half of the area now in lawn with 3-dimensional plantings of powerful native plant communities, we could create over 20 million acres of spaces that generate, rather than destroy, ecosystem services. Our “Homegrown? National Park” will be enormous – – bigger than all of the major national parks combined – – and it will provide us with many of the benefits we derive from visiting our official national parks. Just 15 minutes in the solitude of a well-planted garden can lower blood pressure, reduce stress (cortisol), improve attention span, raise immune responses, and provide unlimited entertainment as we observe the life around us (Louv 2005, 2014, Wolf 2014). We will no longer lament our disconnect with nature because we will be living in its midst. Our new plantings will fill the gaps between fragmented natural areas, creating biological corridors that reconnect them. If habitat fragments are reconnected, they will support populations that are large enough to withstand normal fluctuations without disappearing. Our new park will not perfectly replicate the plant and animal communities that once existed on these sites, but it will reassemble many of the local relationships between plants and animals that coevolved over the eons and that are necessary for ecosystem function. To be sure, this is an optimistic view of our future but it is also a feasible one and will yield enormous ecological payoffs both for humans and our fellow earthlings.

Does contributing to Home Grown National Park mean you have to give up rock gardening? Not at all! A living landscape rich in productive native plants can also include less powerful plants and even plants that are strictly decorative. Informed selection of the canopy and understory trees on your property typically meets the needs of most local wildlife, leaving plenty of room for the perennials and annuals we love so much. Designing a landscape with ecosystem stewardship in mind will not diminish your rock gardening experience; it will enhance it!

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