The Flora of the Future

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The concept of ecological restoration, as developed over the past twenty years, rests on the mistaken assumption that we can somehow bring back past ecosystems by removing invasive species and replanting native species. This overly simplistic view of the world ignores two basic tenets of modern ecology—that environmental stability is an illusion, and that an unpredictable future belongs to the best adapted.[1]

Many landscape architects feel conflicted by the restoration debate, trapped between the profession's idealistic rhetoric about the innate superiority of native ecosystems and the constraints imposed by the financial and ecological realities of a particular site. Over the past 250 years, people have altered the basic trajectory of modern ecology to such an extent that going back to some earlier native condition is no longer possible and is certainly not a realistic solution to the increasingly complex environmental problems that we face.

Landscape architects—and anyone else who works directly with vegetation—need to acknowledge that a wide variety of so-called novel or emergent ecosystems are developing before our eyes. They are the product of the interacting forces of urbanization, globalization, and climate change, and are made up of organisms that have been brought together by the elimination or neutralization of barriers that had kept them separated for millions of years.[2] The concept of a novel ecosystem applies not only our cities and suburbs but also to many landscapes that have been subjected to the disturbance-intensive practices of agriculture, industry, and mining. It is unrealistic to assume that turning back the ecological clock will be any easier than turning back the economic clock that created these landscapes.[3]

Landscape architecture can be a charged discipline, especially when it has to resolve the competing interests of its human clients with those of the other organisms that seek to inhabit the same space. The dichotomies that separate people from nature, and native from non-native species, present problematic contradictions that landscape architects must resolve if they hope to have a lasting impact on the environments they design. All of which brings me to the main purpose of this essay: to articulate an ecologically oriented vision for human-dominated landscapes that does not define them as intrinsically negative, valueless, or alien.

Urban Ecology

The range map from my book *Wild Urban Plants* covers much of the northeast United States and eastern Canada, from Detroit in the west to Montreal in the north, Boston in the east and Washington, D.C., in the south.[4] This is an intensively urbanized area, whether defined by the density of human population (500 to 1,000 people per square mile) or by the percentage of impervious surface. From a plant's perspective, the latter matters more than the former. Recent research by geographers at Boston University has shown that in the greater Boston area, most of the land inside the Interstate 95 beltway (along a westward transect) has an impervious surface coverage greater than 30 percent.[5] This figure is significant because it provides a convenient and easily measurable definition of urbanization from the biological perspective.

The preponderance of buildings and pavement in cities not only reduces the amount of land available for plants and animals but also has a profound effect on hydrology by decreasing water infiltration, increasing runoff, and compacting adjacent soil.[6] More than one study has shown that for urbanized riparian habitats, the number of native species relative to non-natives declines in direct proportion to the amount and proximity of impervious surfaces.[7]

From the ecological perspective, cities display a suite of distinctive environmental characteristics, the most significant of which is the ongoing physical disturbance and fragmentation associated with the construction and maintenance of infrastructure. Such disturbances can drastically alter soil and drainage conditions, which in turn destabilize existing plant communities. In economically vibrant cities, a significant portion of the urban infrastructure fabric is always in the process of being torn up and rebuilt, which tends to create a shifting mosaic of opportunistic plant associations dominated by disturbance-adapted, early-successional species. In economically depressed cities, where portions of the urban core have been abandoned for relatively long periods of time, plant succession has been allowed to proceed without interference (i.e,. maintenance), and stable plant associations of woody plants (forests) have developed. Casual observations in a number of cities suggest that the amount and maturity of spontaneous vegetation that they contain is inversely proportional to their economic prosperity.[8]

A functional wetland dominated by common reed (*Phragmites australis*) has developed in this abandoned factory loading dock in Detroit.

In many ways, urbanization is analogous to the geological process of glaciation—a force that levels everything in its wake and then retreats, leaving behind a substrate of compacted glacial till. From the ecological perspective, a freshly bulldozed urban site exists in a state of primary succession where the biota has to develop from scratch. In contrast, sites undergoing secondary succession contain plants or seeds that sprout back following disturbance.

The urban glacier leaves compacted glacial till in its wake.

Another characteristic of urban environments is their high temperatures relative to the surrounding non-urbanized land. This phenomenon is referred to as the "urban heat island" effect and is a function of the abundance of concrete buildings and asphalt paving. Because such structures absorb and retain heat—to say nothing of the cars, air conditioners, heating units, and electrical equipment that generate heat—the annual mean temperatures of large urban areas can be up to 5° F (3° C) higher than the surrounding non-urban areas, and in extreme cases the temperature difference between the city and the countryside can be as much as 21° F (12° C).[9] One particularly interesting implication of the urban heat island effect is that cities offer us a preview of coming attractions when it comes to climate change. Essentially cities have already warmed up to the extent that the rest of the countryside is predicted to reach over the next twenty to thirty years, and thus they present valuable opportunities to study how climate change will play out in the future.

Soil quality is another important issue facing plants that grow in the urban environment. In some cases, pockets of native soil will support a remnant native ecosystem, but large areas of non-native soil have often been brought in as fill from outside the area. In some cases it is construction rubble, and in others reasonably good soil that has been brought in from adjacent agricultural land. Urban soil quality is thus highly variable and dependent on the history of the site. One of the more serious problems associated with urban soils is the high level of compaction produced by heavy foot or vehicular traffic, or use of heavy equipment. On most construction sites where topsoil has been removed and stockpiled, the underlying subsoil is compacted to a density approaching that of concrete, precluding the growth of all but the toughest plants. Another common problem is the presence of toxic chemicals such as heavy metals, petroleum by-products, and industrial solvents— the legacy of past land uses. When severe, such contamination has the capacity to inhibit plant growth, limit vegetation succession, and damage human health.

Perhaps the most ubiquitous form of urban soil pollution is the widespread use of road salt in areas with cold winters. Sodium chloride (and to a lesser extent calcium chloride) can have a number of negative impacts on both soil and vegetation, including the degradation of soil aggregates, the increase in the osmotic potential of soil (making it harder for plants to get water), and the alteration of basic soil chemistry by elevating its pH.[10] The abundant use of

road salt along our highways selectively favors the growth of plants adapted to alkaline soil conditions—such as mugwort (*Artemesia vulgaris*) and tree-of-heaven (*Ailanthus altissima*). Mugwort is a common inhabitant of vacant lots throughout the northeast United States, especially those that have been mulched with limestone-rich construction rubble.

Taxonomy of Urban Landscapes

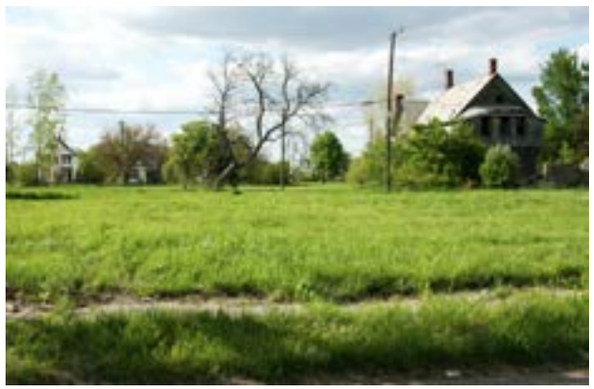
Urban landscapes can be divided into three broad categories based on their soils, their land-use history, the vegetation they support and, by extension, their maintenance requirements.[11] The first type is the remnant native landscape that consists primarily of native plants growing in relatively undisturbed native soils. Given a consistent level of maintenance, they can be preserved as features within the urban context; without maintenance, they are often overwhelmed by non-native species. Second are the managed, functional landscapes, including gardens, parks, ball fields, cemeteries, etc. These are dominated by cultivated plants, with rich manufactured soils, and they have medium-to-high maintenance requirements. And finally there are the ruderal or abandoned landscapes—the least studied of the three types and the focus of the remainder of this essay. These consist of post-industrial or post-residential vacant land, and infrastructure edges dominated by spontaneous vegetation, either native or introduced, on

Mugwort (*Artemesia vulgaris*) growing along a salted street in Watertown, Massachusetts.

relatively poor and often compacted soils. They have extremely low maintenance requirements—so low in fact that they can be considered self-sustaining.

One important research question concerning ruderal landscapes is how much land in any given city does spontaneous vegetation occupy? With the help of my Harvard Graduate School of Design students using GIS technology, we calculated that roughly 9.5 percent of the surface area of Somerville, Massachusetts (one of the most densely populated cities in the state) is dominated by spontaneous vegetation. This is land that no one maintains, and it exceeds the land area occupied by maintained parks.

In Detroit, roughly 40 percent of the total land area has been abandoned —a remarkable figure, equivalent to the total area of the city of Boston. Some of this land consists of abandoned buildings, but about half can be classified as open space. While Detroit is clearly a tragic story from the socioeconomic perspective, it is a paradise for spontaneous vegetation. In a typical residential Detroit neighborhood, not more than a mile from downtown, perhaps only one in five or ten houses are left standing, while the others have been torn down and hauled away. The remaining compacted subsoil may or may not have fresh topsoil and grass seed spread on top of it. Orchard grass (*Dactylis glomerata*) and a variety of other European grasses quickly get established and create a remarkably pastoral-feeling landscape. In areas where this grass is not mowed, trees, shrubs, and vines move in and, given enough time, develop into forests.



An orchard grass (*Dactylis glomerata*) meadow in Detroit.

Ecological Functionality

The plants that grow spontaneously in urban areas—whether native or non-native—are performing important ecological functions. Ecologists refer to these functions as environmental services and they include: excess nutrient absorption in wetlands, heat reduction in paved areas, erosion control, soil and air pollution tolerance and remediation, food and habitat for wildlife, and food and medicine for people (even if we don't use it).[12]

Near the Vince Lombardi exit on the New Jersey Turnpike, for example, one can't miss noticing the extensive stands of common reed (*Phragmites australis*). The plant is a European ecotype of the species, and conservationists tend to consider it highly invasive. But the New Jersey Meadowlands is a landscape of landfills—more than 500 of them occupy the area. From a functional perspective, *Phragmites* is helping to clean up the Meadowlands by absorbing abundant excess nitrogen and phosphorous throughout this highly contaminated site. Nevertheless, some people talk about restoring the native vegetation of the New Jersey Meadowlands, and to them I say: It's really not that hard—just remove the New Jersey Turnpike and reestablish the tidal flow of water, and the *Phragmites* will disappear. The plant is an indicator of impeded drainage and as such, is a symptom of environmental degradation, not its cause.

All plants, regardless of where they originate, can play an important role in stabilizing streams and riverbanks. Along many urban rivers in the northeast, leadwort (*Amorpha fruticosa*) was widely planted at the turn of the last century to control erosion. Land managers appreciate this midwestern native because it can be cut down to the ground in fall and will sprout back up in spring, never getting tall enough to obstruct views of the river. It's a socially and ecologically functional plant throughout New England despite the fact that it's not native to the region.

Common reed (*Phragmites australis)* dominates the Meadowlands along the New Jersey Turnpike.

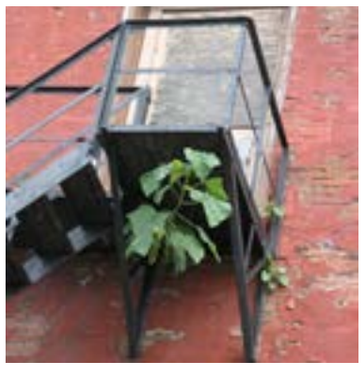
Leadwort (*Amorpha fruticosa*) along the Hudson River north of New York City.

The seaside rose (*Rosa rugosa*) is another plant that people often assume is a native species. It was introduced from northeast Asia and now grows spontaneously just above the high-tide line all along the New England coast. It's easy to recognize because of its beautiful pink flowers and large, edible rose hips, and it plays an important role in stabilizing coastal sand dunes. When I served on the Massachusetts Invasive Species Council, we decided not to list this species as invasive because it wasn't displacing any native woody species in the specialized niche where it typically grows.

A counterexample is the autumn olive (*Elaeagnus umbellata*), which was planted extensively along interstate highway banks in the 1970s and 1980s. It fixes atmospheric nitrogen with the help of symbiotic bacteria that live in its roots, and it produces large quantities of bright red, edible fruit. Twenty years later, the plant has been reclassified as an invasive species—a perfect example of a plant that did its job too well and has spread beyond its planting sites with the help of migratory birds (both native and non-native). It's easy to forget that many of the woody plants now listed as invasive were once considered valued ornamentals and planted by the millions with the encouragement of various state and federal agencies. The spread of these species across the landscape is as much a sociological as a biological problem, and we ignore this fact at our peril.[13]

New Infrastructural Taxonomies

The plants that appear spontaneously in urban ecosystems are remarkable for their ability to grow under extremely harsh conditions—most notably in soils that are relatively infertile, dry, unshaded, and alkaline.[14] Through a quirk of evolutionary fate, many of these plants have evolved life-history traits in their native habitats that have "preadapted" them to flourish in cities. Stone or brick buildings, for example, are analogous to naturally occurring limestone cliffs.[15] Similarly, the increased use of de-icing salts along walkways and highways has resulted in the development of high pH



Princess tree (*Paulownia tomentosa*) colonizing an abandoned building in New London, Connecticut.

microhabitats that are often colonized by either grassland species adapted to limestone soils or salt-loving plants from coastal habitats. Preadaptation is a useful idea for understanding the emergent ecology of cities because it helps explain the patterns of distribution of plants growing in a variety of distinctive urban habitats, including the following:

____The **chain-link fence** is one of the more specialized habitats of the urban environment. They provide plants—especially vines—with a convenient trellis to spread out on and a measure of protection from the predation of maintenance crews. Chain-link fences also provide "safe sites" for the germination of seeds, a manifestation of which are the straight lines of spontaneous urban trees that one commonly finds in cities, long after the fence that protected the trees is gone. Root suckering species such as *Ailanthus* grow particularly well along chain-link fence lines.

Two "bonsaied" American elms (*Ulmus americana*) are well adjusted to their chain-link fence habitat in Hartford, Connecticut.

Tree-of-heaven (*Ailanthus altissima*) root sprouts growing along a fence line in Boston.

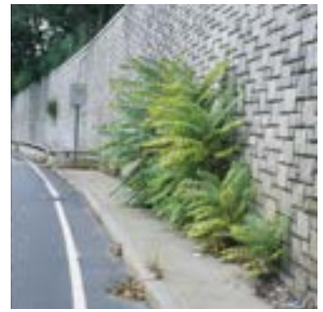
____**Vacant lots** that have been cleared of buildings are often mulched with masonry and construction rubble. Their soils typically have high pH levels, and they are usually colonized by a suite of plants that I like to refer to as a "cosmopolitan urban meadow." Many of these plants, including mugwort (*Artemesia vulgaris*) and curly dock (*Rumex crispus*), are common in the dry, alkaline grasslands of Europe.

A typical urban meadow dominated by mugwort (*Artemesia vulgaris*) and curly dock (*Rumex crispus*).

____The highway **median strip** is typically only a few feet wide, with minimal topsoil above a compacted subsoil layer. Initially these areas may have been planted with lawn grasses, but they usually end up dominated by crabgrass (*Digitaria* spp.). As most homeowners know, crabgrass comes up in lawns in late spring, when temperatures consistently get above 70 or 80 degrees. It's a warm-season grass that thrives when it's hot and dry, and because it is an annual species, the road salt used in winter has no effect on its development. In short, the median strip is perfect for crabgrass.

Crabgrass (*Digitaria* spp.) in the median strip.

____**Stone walls** and masonry building façades provide great habitats for plants—especially when their maintenance has been neglected. From the plant's perspective, these structures are good stand-ins for a limestone cliff, and many cliff species are well adapted to growing on city walls.[16]



Ailanthus altissima on the Great Wall in China (left) and on a lesser wall in Boston (right).

____**Pavement cracks** are among the most distinctive niches in the urban environment. Wherever you have two types of paving material coming together, you have a seam, and the different materials expand differentially in response to summer and winter temperature to create a crack. We tend to think of pavement cracks as stressful habitats, but in fact, as the water sheets off the pavement, it flows right into the crack, making it a rich site in terms of its ability to accumulate moisture and nutrients. With oil from cars as a carbohydrate source available for decomposition by fungi and bacteria, cracks can develop significant microbial diversity.

Grasses growing in pavement cracks in Boston.

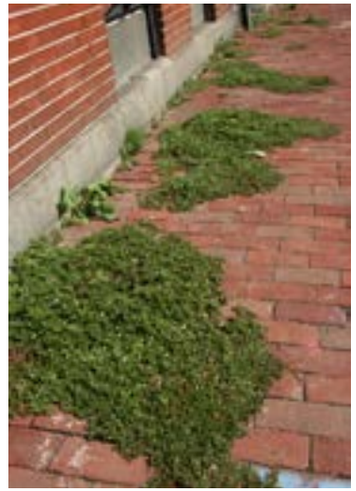
____Specialized microclimates
are as important in cities as they are in natural environments. As an example, carpetweed (*Mollugo verticillata*), a summer annual from Central America, subsists only on air-conditioner drip. Its seeds germinate under a window air-conditioning unit when it is turned on in early summer, and it dries up and sets seed when the unit is turned off in September. Many annuals common in cities display similar capacities to exploit ephemeral urban niches.

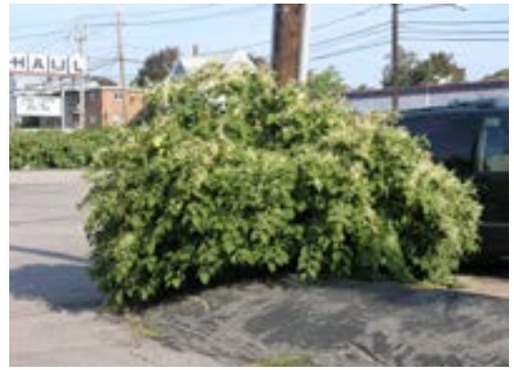
____River corridors, annually disturbed by fluctuating levels of water during the course of the year, are typically dominated by spontaneous vegetation with broad environmental adaptability. They serve as important pathways for the migration of both plants and animals into and out of the city. The same is true for **railway corridors**. At the Arnold Arboretum in Boston, where I have worked since 1979, coyote, deer, fox, and pheasant are commonly sighted, often coming up from the suburban south following the railroad line that borders the eastern edge of the property.

Cultural Significance

Any discussion of urban ecology would be incomplete without a consideration of the cultural significance of the plants that grow in cities. This is an important topic because it explains not only why certain plants were brought here but why so many have spread so rapidly. Most people treat the invasive plant issue as a biological problem, but the introduction and distribution of most of these plants was the result of deliberate decisions by people that reflected specific goals relating to economic, ornamental, or conservation values of the day.[17]
If we fail to take into account their historical associations with people, we can't fully understand their present ecological spread. To put it another way, the invasive species issue is as much a cultural as an ecological problem. Stories to illustrate this point are legion, but I have selected a few examples:

Carpetweed (*Mollugo verticillata*) subsisting on air-conditioner drip in Boston.





____Purslane (*Portulacca oleracea*) is an annual plant of uncertain origin that grows everywhere—in the tropics as well as the temperate zone—and everywhere it grows, people eat it. Specifically, people use the foliage, which is a little mucilaginous, for thickening soups; and because of its high omega-3 oil content, it's very nutritious. Obviously this is a plant that was originally brought here for culinary purposes and has managed to escape and spread on its own.
____Japanese knotweed (*Polygonum cuspidatum*) was introduced into Europe from Asia in the 1860s as an ornamental plant. It spread across the Atlantic to the United States around 1880 and was widely planted for its dramatic presence in the landscape and because it grew well in poor soil. But by the 1920s it was widely considered a weed, and in the 1990s it was reclassified as an invasive species. Despite its checkered history, the plant is cultivated in Asia as the commercial source of resveratrol, the compound in red wine that is thought to promote longevity in humans.

Purslane (*Portulaca oleracea*) with its strong taproot and prostrate growth habit is preadapted to growing in sidewalk cracks and being stepped on.

Japanese knotweed (*Polygonum cuspidatum*) in flower amid a sea of pavement in Boston.

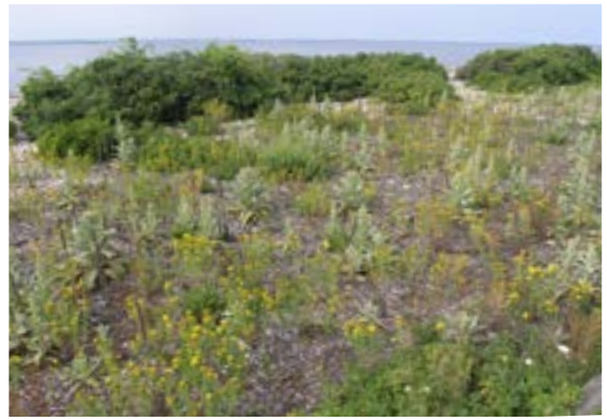
_____And finally, there's Queen Anne's lace (*Daucus carota*), which was featured in the Herbal written by Dioscorides some 2,000 years ago. He noted that when ingested, a decoction of the seeds can have birth-control effects—an organic morning-after pill, if you will. Indeed, modern research has shown that Queen Anne's lace is biologically active and can affect a woman's menstrual cycle. With the invention of the printing press, knowledge of this particular use of the plant was deleted from Dioscorides' Herbal as well as from our culture. Recent research by John Riddle of the University of North Carolina, however, has shown that the information was not lost but merely hiding underground.[18] He discovered that in the 1970s, women in Appalachia learned of this traditional European use of Queen Anne's lace from their mothers, who had learned about it from their mothers, going back to their immigration from Europe.

Changes in urban vegetation over time clearly reflect constantly shifting human value judgments, socioeconomic cycles, and evolving technological advances in transportation, communication, and construction.[19]

Ecology of Aesthetics

Aesthetic issues associated with spontaneous urban vegetation are particularly problematic because such standards are subjective and culturally determined. What looks unkempt to one person can look natural and robust to another. Aesthetics are also context dependent: a plant growing in a vacant lot in Boston is considered a weed, while the same plant growing in a meadow in the countryside is deemed a wildflower. This relativity becomes most apparent when discussing the merits of native versus non-native species. Many of the plants we vilify as unsightly weeds in urban areas of North America are considered dry-meadow natives in their European homelands.

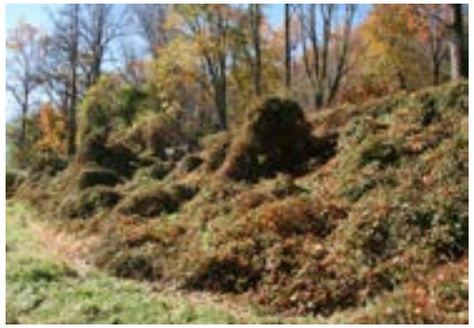
Queen Anne's Lace (*Daucus carota*) and chicory (*Cichorium intybus*) make a stunning combination along roadsides in July and August.



Many spontaneous urban plants (e.g., mugwort) can grow quite tall and become unsightly as they mature. Such plants are typically interpreted by inner-city residents as indicators of dereliction and neglect as well as havens for vermin. This image problem is exemplified by the fact that most people refer to spontaneous vegetation as "weeds"—a term with no biological meaning. "Weed" is simply a word used to describe a plant that a person does not like or does not want in the yard. It is a value judgment that reflects personal preferences. Remarkably, there seems to be no Latin word for an unwanted plant, and in many languages "bad plant" (e.g., *mala hierba* in Spanish) is the only available term.

To counteract this stereotype, I suggest the term "cosmopolitan urban vegetation" as a way of celebrating urban botanical diversity, in much the same way that we celebrate the diversity of the human population. I like to promote the concept of the cosmopolitan urban meadow, which consists of a selection of herbaceous species—both native and non-native—that will flourish in compacted urban soils with minimal maintenance and look good for most of the growing season. By selecting plants that are long lived, that don't get to be too tall, and produce showy flowers, one has a potential strategy for dealing with vacant urban land.[20] It doesn't take a lot of resources to establish such a meadow from seed (the soil should be on the lean side) or to maintain it with one or two mowings per year. Once established, the meadow will hold the ground until another use for the land is implemented.

The beach on Fisher's Island off the coast of Connecticut—not a native plant anywhere.



Working with spontaneous vegetation does not have to be an "all or nothing" proposition. There are some plants that should, if possible, be deleted from the landscape, including toxic native species such as poison ivy (*Toxicodendron radicans*) and ragweed (*Ambrosia artemesifolia*). Vines, in general, are problematic because they aggressively climb up trees, overwhelm them with foliage, and pull them down. In extreme cases, high-climbing vines can flatten whole forests, creating what is politely referred to as a vinescape. The exotic Asian bittersweet (*Celastrus orbiculatus*), porcelain berry (*Ampelopsis brevidunculata*), and the Asian wisterias (*Wistaria* spp.) are especially problematic, as are our native grapevines (*Vitis* spp.).

With spontaneous woody vegetation, the *modus operandi* should be one of management—design by removal of the unwanted rather than insertion of the wanted. The name for this process is "intaglio," from the engraving process, where one creates an image by removing unwanted material.[21] The black locust trees (*Robinia pseudoacacia*) shown here are a beautiful feature because somebody had the sense to leave them alone except to remove the vines that would otherwise have strangled and knocked them down. Learning how to manage vegetation with sensitivity requires a fair amount of experience and skill; it is a promising niche for young, enterprising horticulturists.

Monet with weeds in Detroit: chicory (*Cichorium intybus*), yellow sweet clover (*Melilotus officinalis*), and spotted knapweed (*Centauria biebersteinii*).

Porcelain berry (*Ampelopsis brevipedunculata*) vinescape along the Saw Mill River Parkway north of New York City.

The current leaders in this field are the Germans, and the famous Landschaftspark in Duisburg-Nord is perhaps the best example. In this park designed by Peter Latz, an abandoned steel mill is embedded in a landscape that combines spontaneous vegetation with designed gardens. In Berlin, the Natur-Park Südegelände was established on the site of an abandoned rail yard that had been colonized by spontaneous vegetation following the construction of the Berlin Wall.[22] It's a remarkable landscape with an eclectic mix of native and non-native plants that support a remarkable array of invertebrates. The Germans have a lot to teach us about the appreciation and uses of spontaneous vegetation in the urban landscape, but their approach needs to be modified to fit the conditions—both economic and sociological—of American cities.

The task facing tomorrow's landscape architects is not so much how to eliminate these novel ecosystems but rather how to manage them to increase their ecological, social, and aesthetic values.[23]

This mature stand of black locust (*Robinia pseudoacacia*) has been enhanced through the process of intaglio, or the creation of a landscape by the judicious removal of unwanted plants.

European birch (*Betula pendula*) growing amid abandoned railroad tracks in Berlin's Natur-Park Südegelände.

Notes

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