Ecological Design of Urban Landscapes: Economic, Social, and Ecological Benefits

EM 9107 • March 2015

Signe Danler, © Oregon State University

Figure 1. The downtown Corvallis Riverfront accommodates multiple uses, and incorporates elements of ecological landscaping and green infrastructure.

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Cities of the future, from small towns to huge metropolises, may be much different from the typical city of today. Imagine a city designed with tree-lined boulevards and peaceful, green neighborhoods, with clean air and pure water. Thriving communities are veined with parks, greenways, yards, and creeks, interconnecting and providing life-giving habitat for native plants, animals, insects, birds—and people.

Cities like this, which support both functioning urban ecosystems and human society, need landscape designers, planners, architects, and developers who are knowledgeable about ecological landscaping, in addition to their other skills. An ecological approach to landscape design incorporates natural systems as an integral part of urban landscapes (Figure 1). It differs from conventional landscaping in that buildings, hardscape, and landscape are planned as a unified whole, utilizing native plants and "green infrastructure" (see "What is Green Infrastructure?" on page 4) to provide ecological, economic, and social benefits. This publication explores innovative ways of looking at landscape design, and bringing ecology and design together to form a sustainable urban landscape.

Introduction

Nature operates in cycles. Water, air, and nutrients are all continually circulated in closed, circular systems that waste nothing. Cities built with little knowledge of, or regard for, these cycles are leaky, linear systems that interrupt natural ecosystem functions and create waste that must be dealt with by engineered infrastructure.

In the natural water cycle, for example, rainwater percolates through vegetation and soil, recharging aquifers and eventually evaporating back to the air to fall again as rain. The impermeable surfaces of a

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Oregon State University OSU Extension Service

Figure 2. A water catchment swale (left) at the Oldfield Animal Teaching Facility on the campus of Oregon State University has grasses and clover, and mimics a natural site by slowing and filtering water flowing through the landscape. The rest of the landscaping (right) is conventional, however, and provides few additional ecological services. An ecological design of native plants in both the swale and the rest of the site could have reduced mowing and irrigation, provided wildlife habitat, and created a more interesting and aesthetically pleasing landscape.

city interrupt that cycle, requiring expensive gutters, sewers, and water-treatment systems to manage what nature once did for free. By interrupting these ecosystem functions, we lose the ecosystem services they provide (see "What Are Ecosystem Services?" page 3).

At the same time, intensive human use of the natural landscapes surrounding cities has severely degraded their ability to provide such basic needs as clean air and water.

There is growing understanding that if landscape design ignores the value of the services nature provides, it neglects an important piece of urban structure — the "green infrastructure" (see "What is Green Infrastructure" on page 4). By rethinking landscape design and modifying some of its objectives, we can make use of the many services natural ecosystems freely provide, often more efficiently and economically than built systems. We cannot turn cities back into wilderness, but we can design ecological urban landscapes in which both green and built infrastructure work together.

An Ecological Approach to Landscape Design

We All Live in an Ecosystem

Every city and town is an ecosystem, containing both natural and built components. The biological, physical (as in geology and climate), built, and social components all interact with each other to determine the functions of the urban ecosystem.

Every urban resident and business relies on ecosystem services such as clean air and potable water. These people and businesses also have a huge influence on the ecosystem on which they depend by consuming water and other resources, displacing natural systems, and emitting waste materials.

Human health and economic prosperity depend on the ecosystem services that maintain them, and our future ability to achieve these goals will depend on how well we learn to work in concert with the natural functioning of the ecosystems in which we are embedded.

Landscape Design is Part of the Solution

Designed landscapes often present neatly ordered versions of nature, but rarely take into account the sometimes-messy natural functions and interrelationships of the plants and ecosystem. Most often the original landscape is removed to create a "clean slate," upon which the built infrastructure is installed. Then—often as an afterthought—plants are squeezed into whatever space is left. The resulting landscape may be aesthetically pleasing, but too often consists of lawn and a limited palette of non-native trees and shrubs that provide only a fraction of the ecosystem services that an ecologically designed landscape could (Figure 2).

The initial installation of a landscape is a significant expense, but ongoing maintenance to keep it looking the way it was designed can be even more expensive. By planning for and harnessing natural functions within a landscape, it is possible to minimize the toil and expense of weeding, fertilizing, mowing, pruning, watering, and replacing failed plants. Instead, a more self-sustaining landscape can be created, providing a greater level of ecosystem services. This ecological approach to landscape planning, design, and maintenance provides long-term ecosystem services in urban communities.

It is more challenging to design landscapes that filter stormwater, clean the air, provide wildlife habitat, are pleasurable to look at and walk through, and require less maintenance. In the long term, though, they can be more beneficial and cost-effective than conventional landscapes.

What is Ecological Landscaping?

Ecological landscaping incorporates principles from ecology, horticulture, and the natural sciences into a landscape design that provides ecosystem services while meeting human needs and aesthetic goals (Figure 3). It requires understanding how nature works, not just how it looks.

Ecological landscaping does not necessarily replicate natural landscapes, although it may include parts of them; rather, it incorporates natural systems and processes into a human-centered design. Less water, labor, pesticides, and fertilizers are needed than with conventional landscaping, and both native and compatible non-native plants may be part of an ecological landscape.

What Are Ecosystem Services?

Ecosystem services are functions performed by the natural environment that enhance human well-being and are directly useful to people.

They involve the interaction of living elements, such as vegetation and soil organisms, and nonliving elements, such as bedrock, water, and air.

The four categories of ecosystem services are:

- Provisioning: Products obtained from nature, such as food, fresh water, wood, fiber, and fuel.
- Regulating: Climate, flood, and disease control.
- Cultural: Aesthetics, spirituality, knowledge, and recreation.
- Supporting: Nutrient cycling, soil formation, water cycling, oxygen, and biomass production. Necessary for all other ecosystem services.

An ecological landscape is flexible, not static, and is designed to be adaptable to changing climatic conditions and human needs.

Future Opportunities for Ecological Landscaping

With increasing numbers of people living in urban areas, and the concurrent loss and degradation of natural areas within those areas, the need has never been greater to incorporate nature into

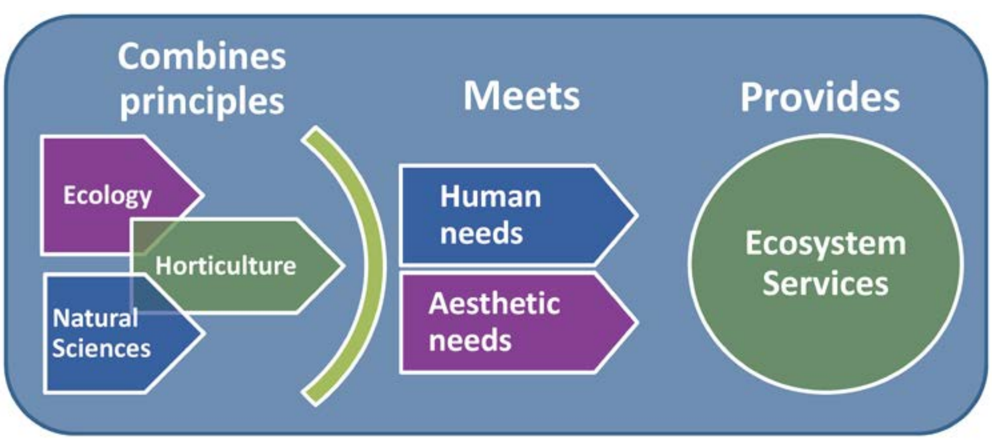

Figure 3. Principles of ecological landscape design

our cities. This is not a new idea. Frederick Law Olmsted, in the late 1800s, almost invented the idea of the public park. He advocated creating "pleasure grounds" in the hearts of cities, accessible to all. In 1969, Ian McHarg influenced today's landscape design with his ground-breaking book *Design with Nature*, in which he advocated applying "ecological planning principles" to analyze the natural condition of a site and design a landscape in harmony with it. More recently, "naturescaping" yards with native plants to attract wildlife has become popular with many urban gardeners.

Since the publication of McHarg's book, we have developed much more comprehensive knowledge—although by no means complete—of how ecosystems work and the services they provide. Technological tools such as computer databases and GIS systems make the design of complex landscapes with multiple functions more feasible. These multifunctional landscapes can meet human needs and desires while also providing ecosystem services.

On new construction projects, it is relatively straightforward to create a landscape design that reflects ecological principles. Case Study No. 1 (page 7), the Pringle Creek Community in Salem, Oregon, is a good example of this. It is daunting, however, to contemplate changing an older infrastructure that was designed with different priorities and now contributes to urban problems, such as unnecessary energy consumption and mixing rainwater and sewage in stormwater systems. But the built environment is not as permanent as it seems; future decades will bring an opportunity to re-imagine the design of existing urban buildings and landscapes.

In the U.S., the current stock of buildings totals about 300 billion square feet. Approximately 5 billion of those square feet are renovated each year, and another 5 billion square feet per year is new construction. Over the next 30 years, in other words, around 75 percent of the buildings in most of our cities will be either new or renovated construction. Each of those construction projects could be an opportunity to improve on past designs. Using current knowledge, technological tools, and expertise, an ecological approach to designing the landscaping around and on these buildings has the potential to transform entire urban landscapes. In the future, they could provide multiple ecosystem benefits, as well as beautiful and healthful surroundings for human residents.

Ecosystem Benefits of Ecological Design

Stormwater Management

Managing stormwater is an increasingly important urban issue, requiring large investments in infrastructure to handle infrequent peak flows and filter out pollutants. Water runoff from roofs and streets is treated like waste, instead of as a valuable resource.

Vegetation (especially trees) and porous surfaces (such as permeable pavers) can slow down the flow of stormwater and allow it to percolate slowly into the ground. This reduces runoff, the pressure on drainage systems, and the amount of pollutants and sediment reaching streams; it also recharges aquifers that supply drinking and irrigation water.

Methods such as tree planting and "green streets," which are landscaped with bioswales to retain and infiltrate stormwater, are three to six times more effective per $1,000 invested than conventional stormwater management systems. On-site water-harvesting systems can store water for irrigation and

What is Green Infastructure?

Green infrastructure is the natural resource base that exists within, around, and between urban areas in streams, lakes, parks, natural areas, schoolyards, cemeteries, and private yards.

The components of green infrastructure include: trees, shrubs, herbaceous plants, grasses, and soil and water biota.

Green infrastructure planning provides ecosystem services and benefits human health through landscape design strategies including:

- Green roofs: Buffer temperatures, save energy, and aid in stormwater management.
- Rain gardens and swales: Vegetated basins or channels that capture rainwater, allowing it to soak in rather than flow into storm drains.
- Water harvesting: Collecting rainwater for use on-site by redirecting downspouts into storage or infiltration sites.

ornamental water features while keeping rainwater out of the wastewater system.

These methods are so effective that the city of Portland, Oregon, recently invested $8 million in green infrastructure in order to save $250 million in hard infrastructure costs.

Temperature

The "heat island effect" is familiar to all city dwellers. The solid, unshaded surfaces dominating cities can increase maximum temperatures by as much as 45°F over shaded areas. Trees and vegetation, which provide shade and evapotranspiration, can reduce peak summer temperatures, greatly increasing human comfort and reducing the amount of energy needed for cooling.

Pollution and Carbon Sequestration

Trees, especially large trees, are excellent at filtering pollutants out of the atmosphere, absorbing carbon dioxide, sulphur dioxide, nitrous oxide, and other pollutants. In addition, they are an important carbon sink, holding up to 45 percent of terrestrial carbon worldwide. In an urban setting, trees help provide cleaner air and reduce carbon pollution.

Landscapes utilizing native plants can be managed differently than conventional landscapes; since the plants are adapted to the site, they need fewer chemical fertilizers and pesticides. Native plants can require less mowing and trimming, reducing the use of pollution-emitting devices.

Wildlife Habitat

Urban forests and diverse understory vegetation provide habitat for native animals. Native plants support native insects, birds, and mammals. Native pollinators supplement honeybee pollination for gardens and farms. Birds, butterflies, and other wildlife provide great pleasure for city dwellers.

Economic Benefits of Ecological Design

A landscape designed with ecological principles in mind can perform multiple ecosystem services more cheaply and effectively than man-made infrastructure. Such a multifunction landscape, simultaneously providing shade, wildlife habitat, and stormwater management, is an investment that tends to increase in value as plants grow and become more self-sufficient.

The green building industry now comprises 25 percent of new construction, and a third of nonresidential construction. Ecologically sensitive landscaping is a growing segment of this industry, and studies have shown that capital costs can be reduced by 15 to 80 percent by using green infrastructure in stormwater management, paving, and landscaping.

Figure 4. A. The Kelly Engineering Building roof at Oregon State University was constructed to hold vegetation, but plants were never installed. What could have been a green oasis with lovely views does nothing to reduce the energy usage of the building. B. A green roof at the National Institutes of Health campus cools the building and filters stormwater.

A study in Washington state calculated all possible costs and benefits of trees alone (not including other vegetation), and concluded that the economic benefits of trees, averaged over 40 years, substantially exceed the costs of planting and management.

Energy Savings

Properly placed trees shade buildings, reducing cooling costs in the summer. A 25-foot tree can reduce the annual heating costs of a typical residence by 8 to 12 percent. In addition, evergreens serving as windbreaks can save 10 to 50 percent on heating costs in the winter.

Green roofs (Figures 4A and 4B, on page 5) not only aid in water management and provide aesthetic benefits, they also cool and insulate buildings, reducing heating and cooling costs. In Chicago, a 20,000-square-foot green roof on City Hall saves about $3,600 per year in energy costs, and on hot days can be as much as 78°F cooler than nearby unvegetated roofs.

Reduced Infrastructure and Maintenance Costs

In Seattle, street designs incorporating green infrastructure, such as permeable pavement and bioswales, cost $329 per square foot less than conventional construction. In addition, they provide traffic calming, pollution remediation, and aesthetic benefits. In Modesto, California, when paved streets were shaded as little as 20 percent by trees, the need for resurfacing was reduced, resulting in long-term savings of up to 60 percent over 30 years. In a housing subdivision, this could greatly reduce long-term costs.

Water Management

Water harvesting incorporated into a building site can collect water for use on-site. For example, 38 annual inches of rainfall collected from a 1,000-square-foot surface adds up to over 20,000 gallons. Multiply that by the local cost of water to calculate the savings. An additional benefit of water harvesting is that less stormwater infrastructure may be required to handle runoff and peak flows.

Reduced Landscape Maintenance Costs

Although the initial installation cost of an ecological landscape can be a bit higher than conventional landscaping, the real savings come during the lifetime of the landscape. Native plants in natural associations require minimal applications of pesticides, herbicides, and fertilizers. Being adapted to local conditions, they have greater drought resistance, so little or no irrigation is needed. They are likely to be winter hardy, so they may need replacing less often. If lawns are replaced with associations of shrubs, trees, and understory plants, the expense of constant lawn mowing, feeding, watering, and edging is also waived.

These benefits are not limited to native plants. Well-chosen, regionally adapted non-native plants in association with natives can provide many of the same benefits, while increasing the season and variety of bloom, and providing a greater selection of tough, attractive plants. In addition, a landscape designed with such a palette of plants will be more able than traditional landscapes to be resilient to the unpredictable weather patterns of the future.

Commerce

People express a strong willingness to shop longer and spend more money in places with substantial tree canopies. One study found that, on average, prices for goods purchased in Seattle were almost 12 percent higher on tree-lined streets than on those without trees.

Property Values

It has been well established that the value of properties with trees and landscaping is greater than those without. In Portland, Oregon, street trees were found to add an average of $8,870 to housing prices. In addition, homes facing or abutting parks are valued 20 percent more, and commercial offices rent for up to 7 percent higher if they have high-quality landscapes. Beyond the general value of trees and greenery, people are willing to pay more for an attractively designed ecological landscape featuring native plants.

At a housing development called Gap Creek in Sherwood, Arizona, the developer found that ecological landscape design led to a reduction in costs and an increase in profits of more than $2 million for a 130-acre subdivision. This was accomplished through less wastewater infrastructure, lower development cost per lot, and a higher sales price per lot because of the desirability of the natural landscaping.

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CASE STUDY #1

An Ecologically Landscaped Community

Where: Pringle Creek Community, Salem, Oregon

What: A residential subdivision that respects and restores natural ecosystems while building community

Ecological Landscaping features: Pringle Creek borders the neighborhood, and continuing restoration work has included removal of invasive species, planting of native species, and placement of woody debris in the channel to create fish habitat. Students from a neighboring school have been involved in this process.

Signe Danler, © Oregon State University

Preserved Oregon white oaks next to the community center at Pringle Creek.

Over a third of the site is community open space, including parks that provide connectivity for wildlife, a trail system, fruit trees, a community garden, a wetland along Pringle Creek, and an upland prairie. More than 80 percent of the existing trees were preserved, including two ancient (over 1,000 years old) Pacific yew trees (*Taxus brevifolia*); groves of 50-year-old sequoias (*Sequoiadendron giganteum*) and Douglas-firs (*Pseudotsuga menziesii*); and 250-year-old oak trees (*Quercus garryanna*). No chemicals are used to maintain the landscape.

More than 85 percent of rainwater is retained on site through the use of permeable paving on many of the roads, and over 100 bioswales containing native plants that filter out contaminants, tolerate saturated soil in winter, and are only lightly irrigated in the dry summer.

Green roofs have been installed on two buildings. They cost the same as metal roofing, but are expected to have twice the lifespan, as well as providing pollinator habitat, keeping the buildings seasonally cooler and warmer, and slowing rainwater infiltration.

Benefits

- A community setting that encourages healthful physical activity and recreation
- Improved stream health, and removal of any toxins from water before it enters streams and aquifers
- Mature tree canopy provides shade for people, the creek, homes, and streets, as well as carbon sequestration and other ecosystem services. Habitat for native fauna is abundant.

Lessons to be learned

Economics trump ecology. The property owner had a vision of a community that would "reflect the most comprehensive thinking and best practices in the field of green infrastructure," but a recession stalled lot sales. As of January 2015, only six of 146 platted lots have been recorded as sold.

CASE STUDY #2

A Green Roof of Native Plants

Rick Martinson, © Winter Creek Restoration

High desert landscaping adorns the rooftop of Moda Headquarters in Bend, Oregon.

Where: Moda Headquarters, Bend, Oregon

What: A rooftop ecological landscape built in 2007 atop the LEED Gold-certified Oregon Dental Association (ODS, now Moda Health) headquarters building

Ecological landscaping features: This roof supports a native landscape. By planning for it during the building's construction, builders allowed rooting depths of 8–32 inches—which would not have been possible if it were retrofitted to a conventional building.

The biggest challenge was finding a landscaper who could fulfill the company's vision for an all-native, functional, beautiful rooftop garden in an arid climate. After interviewing 10 potential landscapers, Winter Creek Restoration was selected. Winter Creek Owner Rick Martinson created the rooftop garden using a custom palette of native and drought-tolerant (xeric) plants. It is one of only a few native plant green roofs in the country.

Benefits

The layer of soil and plants insulates the building from summer sun and winter cold. It captures and filters stormwater when it rains, to reduce runoff and retain it on site.

The plants filter air pollution, and provide habitat for local wildlife.

Accessible to all the building users, the garden serves an educational purpose as well, showing what plants grow together in the arid central Oregon climate, and how they look close up. This gives people an example of low-water, ecological landscaping that can be used in their own yards and gardens.

The diversity of the plant community minimizes the aesthetic impact of any insect or disease damage, which would be more apparent if fewer plant species were used in the design. This also allows less use of chemicals.

A new substrate was developed for the project that may be beneficial for future projects.

Lessons to be learned

Not all landscape designers and contractors understand how to use native plants in an ecological landscape. It is worth taking the time to find the right one to get the results you want.

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Calculating the Savings

Ecosystem services, and their loss through development, have traditionally been ignored when calculating construction costs, rendering them "invisible" economically. Replacing lost ecosystem services through built infrastructure is a considerable expense and increasingly is being taken into account through direct economic valuation. Tools have been created that can put a dollar value on various aspects of green infrastructure (see "Digging Deeper" section, on page 13). This information is essential for demonstrating that making changes to conventional landscape design methods will be money well spent and will have long-term benefits.

Human Benefits of Ecological Design

Health

Researchers are increasingly studying and documenting the benefits to human health of regularly experiencing and viewing nature. Stress, blood pressure, and anger are all reduced when people experience nature, while feelings of well being increase. Asthma rates are lower in areas with trees and greenery, due to the ability of trees to filter pollutants from the air, and obesity is less prevalent where people have the opportunity to get outdoors and walk in pleasant green spaces. In Japan, the practice of Shinrin-yoku, or "forest bathing" (walking and immersing oneself in a forest environment), has been found to improve many measures of physical and psychological health.

Productivity

People who work in environments with views of nature through the windows have been shown to have fewer sick days and experience less frustration. One study showed that college students with natural views from their dorm windows score higher on attention tests and are able to focus better.

Community

Social bonds within communities grow stronger where there are trees and natural areas nearby. People report that they enjoy better relations with their neighbors, feel more connected to the landscape, have a stronger feeling of unity and cohesion, like where they are living more, and feel safer than residents who have little greenery around them.

Table 1. Summary of Benefits of Ecological Design Using Green Infrastructure

	Benefits	Green roof	Tree Canopy	Native plants	Bioswale	Water harvesting	Permeable pavers
Ecosystem	Reduces stormwater runoff	√	√		√	√	√
	Reduces heat island	√	√	√	√		√
	Cleans the air	√	√	√	√		
	Reduces CO2	√	√	√	√		
	Provides Wildlife Habitat	√	√	√	√		
	Reduces flooding and erosion	√	√	√	√	√	√
	Reduces pollution		√				
Economic	Improves water quality	$	$	$	$		$
	Reduces energy use	$	$			$	
	Increases property value	$	$				
	Reduces infrastructure costs	$	$				
	Saves money on water mgmnt.		$	$	$	$	$
Human	Provides beauty and pleasure	x	x	x			
	Gives recreation opportunity	x	x				
	Contributes to human health	x	x	x	x		
	Helps build community		x		x		
	Buffers noise	x	x				x

Noise Buffering

Vegetated windbreaks or hedgerows can reduce urban noise levels by close to 50 percent, and the visual screening also reduces the psychological effect of noise. Trees and shrubs are especially good at absorbing the high frequency sounds that are most distressing to human ears.

Pleasure

Biophilia, a term coined by biologist E. O. Wilson, is defined as "an innate and genetically determined affinity of human beings with the natural world." This may be one of the oldest reasons why people have surrounded themselves with plants: They bring us beauty and enjoyment. The more people are surrounded by plants, the happier they tend to be.

Steps to an Ecological Landscape

The basic tools for incorporating ecological landscaping into a building project are the same as those used in planning a more conventional landscape, with allowances for different goals and perspectives.

Plan the Landscape First, Not Last

Check the local zoning, landscaping, and construction codes early in the process. In some communities, there will be help and support available for ecological landscaping. In others, local codes may limit the available options.

Perhaps the major difference between planning an ecological versus a conventional landscape is that with ecological landscaping, ecosystem services and native plantings are integrated into the design right from the start. The Sustainable Sites Initiative lists some important planning steps:

Conserve existing features and plants of value; once lost, replacing them can be difficult and expensive, or even impossible. Establish areas to protect before the buildings, paving, and other hardscape are placed. Maximize the contiguous areas containing native trees and understory, if present, and use secure fencing and explicit signage to make them off limits during construction.

Preserve resources wherever possible. Design the landscape to reduce unnecessary runoff and retain water on site as much as feasible. Minimize outside resource inputs by preserving existing plant communities, and by saving and reusing materials from the site, such as topsoil and rock, rather than importing them. If the site is being redeveloped, there are even more opportunities for reuse of concrete, buildings, building parts, and existing subsurface infrastructure.

Regenerate natural systems that have been lost or damaged so they can provide natural ecosystem services. Restore degraded streams or wetlands and incorporate them into the design. Loosen compacted soils and add organic mulch so plants will be able to thrive. Plant site-appropriate trees and shrubs to begin a forest canopy and understory.

Do No Harm

Minimize changes to the site that will degrade the surrounding environment. Construction is by its nature disruptive, but clustering development in smaller portions of the site can reduce the disruption. Heavy equipment compacts the soil over tree roots, which can kill them. Avoid damage by designating and enforcing separate protected zones and work zones, and securely fence the protected areas to keep out heavy equipment, dumping, and other damaging uses. Additional protection can be provided by the use of self-supporting walkways and wooden decks to raise traffic off the ground.

Integrate the Built Environment with the Landscape

Thinking in systems can help you understand the interrelationships in an ecosystem. Every member of the system relates to and influences others. Whether an existing landscape can be preserved or a new landscape must be created, it should be planned simultaneously with the buildings so that spaces and functions can be integrated. If natural ecosystem processes and green infrastructure are included from the start, they can often perform multiple functions. For example, trees provide shade, soften rainfall to prevent soil compaction, transpire water from soil to air, sequester carbon, provide wildlife habitat, hold the soil in place, reduce noise, diffuse wind, and give aesthetic pleasure.

Different parts of a building can perform multiple functions as well. The roof can be planted to provide insulation, water retention, and beauty, and perhaps hold solar panels and skylights to let in natural daylight. These reduce the need for insulation, energy, and lighting, and the roof still performs its basic function of protection.

Connect the building(s) to the landscape. Rainwater collection can connect to water features that manage stormwater and provide enjoyment, and perhaps a reservoir for irrigation water. Thoughtful design can bring nature close, both physically and visually, and provide opportunities for viewing and interacting with the surrounding landscape.

Communicate

Including all stakeholders early in the planning process will go a long way towards mitigating concerns they may have about trying different methods and make for a more successful project. Professionals with expertise in specific areas can smooth out changes that may be confusing. When new or different construction standards and methods are to be used, it is of utmost importance to communicate clearly to contractors why these standards and methods are important, particularly when protecting existing trees or natural areas.

Planting the Landscape

Plants used in ecological landscaping should thrive with little maintenance and be non-invasive. They should be chosen for more than merely aesthetic appeal, with emphasis on plant communities that grow well together and the services they can provide. Using locally adapted plants will give the best results. Lists of suitable plants for the Pacific Northwest are readily available (See page 14).

Plant a Community

Plants with similar cultural needs will perform best together, wherever the landscape is located. They should be of sufficient variety to fill the various roles in a natural ecosystem. A landscape that performs its natural ecological functions well is more important than exactly which plants are used. Native plants are the first and best choice in many cases (Figure 5), but sometimes it may be appropriate to substitute non-native plants that are adapted to the conditions and perform the same functions. For instance, a forest is structured with canopy trees

Signe Danler, © Oregon State University

Figure 5. A. Native landscaping combined with seating and decorative stonework. B. Young native shrubs as alternative foundation planting. C. Native shrubs segue into mature forest. D. Rapid ground cover by perennials and shrubs: *Potentilla canadensis, Limnanthes douglasii, Geranium oreganum, Aronia melanocarpa* (a compatible eastern U.S. native).

(which create the microclimate), understory trees, shrubs, perennials, ground covers, and vines, each performing its own function. Together they form a community. Planting a variety of species, of differing ages and sizes, increases the resilience of the community by reducing the impact of pests and diseases, and providing redundant coverage for every function. In addition, such variety is interesting and aesthetically pleasing.

Plant Densely

In conventional landscape design, it is considered good practice to specify exactly where each plant is to go, allowing room for its mature size. This leaves bare areas that, since nature abhors a vacuum, tend to fill with weedy plants that must then be removed (perhaps repeatedly) until the desired plants reach maturity. This practice makes sense for specimen plants, but others can be grouped more densely, as nature does. Within those groups, attrition and competition will decrease the numbers of plants as their size increases. Meanwhile, weeds are suppressed, since all available space is quickly filled. This method also more quickly provides a pleasing view (Figure 5D, page 11); since the space is filled with green rather than bare mulch studded with tiny plants. This approach is particularly effective when used with spreading evergreen shrubs and groundcovers, which will suppress most weeds.

Allow for Change

Instead of planting a static landscape and expending time and energy trying to keep it exactly the same, allow plants to complement each other and vary according to the seasons and yearly weather changes. In a natural community, one species may dominate in a wet year, while in a dry year a different species may dominate, but the space will always be filled and the necessary ecological functions will be performed.

Use Natives When Possible

Native plants, in addition to being adapted to the climate, generally do a much better job of providing food, nesting places, and habitat for native species than their exotic counterparts. A study in Canberra, Australia, showed that landscapes with at least 30 percent native trees supported a higher diversity of bird species than those with exotic trees. Research in Tucson, Arizona, showed that the presence of native plants correlated strongly with the presence of native bird species, while exotic plants only increased exotic bird species.

Normalizing Ecological Landscaping

In recent years, "backyard habitats" and wildlife gardens have become popular on a residential scale. This is a fine thing, but can create a patchwork of widely separated oases that are of limited use to wildlife and do little to enhance ecosystem services. It can also be very difficult for individual home or business owners to overcome social pressure to conform to conventional landscape norms.

Signe Danler, © Oregon State University

Figure 6: At the Pringle Creek Community in Salem, Oregon, water-filtering bioswales and permeable pavement make for attractive landscaping while controlling runoff.

Ecological landscaping can look much like conventional landscaping (Figure 6). However, the common perception that landscaping with native plants is "messy" is not entirely unwarranted. In the dry summer of the Pacific Northwest, many native plants go dormant. Also, to provide full benefits as wildlife habitat, seed heads and winter foliage should be left standing, rather than tidily trimmed away. To eyes accustomed to mowed lawns and neatly trimmed hedges, this can be disconcerting.

Choosing native plants for year-round attractiveness, and perhaps adding a few appropriate, structural non-natives, can help an ecological landscape meet conventional norms. Clean edges send the message that the planting is intentional and cared for. Plants that provide a strong evergreen structure, such as *Ceanothus* and *Arctostaphylos*, can carry the site when deciduous and perennial plants are not at their best.

A better way to surmount this barrier in the long term is to "normalize" ecological landscaping. A landscape perceived as "different" becomes more socially acceptable when the scale is expanded beyond individual lots or buildings to entire complexes, campuses, and neighborhoods. People are most comfortable when the landscape around them looks cohesive and conforms to the local norm.

That norm is fluid, though, and can be almost anything. If all or most of the visible landscape shares the same ecological aesthetic, it becomes acceptable, even expected, in a way it does not if only one or a few buildings feature an ecological landscape.

Ecological landscaping on a larger scale also increases its effectiveness at providing ecosystem services and linking with other natural patches to provide wildlife habitat. A piecemeal approach to creating ecological landscaping is difficult and may not succeed. The larger the area involved, the more likely it is to be well received and to be ecologically successful.

This is why it is so important for landscaping professionals and planners, who deal with larger landscapes, to be aware of the benefits and possibilities of ecological landscaping.

A future in which cities are designed to work with, instead of against, nature is a future worth imagining, and designing for.

Digging Deeper

Resources and Tools for Ecological Landscaping

■ Guide To Nature-Friendly Development

(http://www.oregonmetro.gov/guide-nature-friendly-development)

A series of fact sheets and presentations on how to create a sustainable landscape that saves money and adds value to your project. Includes case studies, technical guidance and information on products, permits, and codes.

■ City of Portland, Environmental Services (http://www.portlandoregon.gov/bes/4446)

Case studies of water management projects in the Portland area.

■ ***Managing Wet Weather with Green Infrastructure Incentive Mechanisms, Municipal Handbook***. June 2009. EPA-833-F-09-001.

An overview of various incentive mechanisms offered by Pacific Northwest municipalities to encourage the use of green infrastructure for managing stormwater. Includes case studies and links to further information. http://water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_incentives.pdf

■ Federal funding sources for green infrastructure projects (http://water.epa.gov/infrastructure/greeninfrastructure/gi_funding.cfm)

■ National Association of Homebuilders Green Building Program **(NAHB)** (www.nahb.org)

Articles on dozens of topics relating to green building and land development, and links to further resources and regulations.

■ Green Models for Site Development**: Applying the National Green Building Standard to Land and Lots.** (http://secure.builderbooks.com/cgi-bin/builderbooks/958?id=DsSSWSvN&mv_pc=35?;;NAHB00)

Resources for builders and managing projects.

■ The Sustainable Sites Initiative **(SITES)** (http://www.sustainablesites.org/)

A voluntary national rating system for sustainable landscaping. Extensive website and publications provide "guidelines and performance benchmarks for sustainable land design, construction and maintenance practices", geared to professionals in those fields. Detailed procedures and checklists apply to sites both with and without buildings.

■ ***The Sustainable Sites Handbook: A Complete Guide to the Principles, Strategies, and Best Practices for Sustainable Landscapes***. 2012. Meg Calkins. John Wiley & Sons, Inc.

■ LID Implementation Guidance Template **– Draft.** *Comprehensive resource of how to design water management using Low Impact Development methods* (http://greengirlpdx.com/Publications.htm#ImpGuide)

Tools for Economic Valuation of Green Infrastructure and Ecosystem Services

■ **Ecosystem Valuation Toolkit by Earth Economics** (http://www.esvaluation.org/index.php)

Includes SERVES (Simple and Effective Resource for Valuing Ecosystem Services), a subscription-based service for estimating the value of a specific area's ecosystem services, and The Researcher's Library ,containing ecosystem service valuation publications.

■ **Green Infrastructure Toolkit for Developers** (http://www.greeninfrastructurenw.co.uk/climatechange/)

Developed for the Northwest of England, this downloadable Excel spreadsheet allows customizable calculations of the green infrastructure score of an existing site or planned development, and potential interventions to maximize the benefits that green infrastructure can provide.

■ **iTree: Tools for Assessing and Managing Community Forests** (http://www.itreetools.org/)

Geared specifically to urban trees, this website quantifies the ecosystem services provided by individual or groups of trees, and puts an economic valuation on them. Helpful for justifying tree preservation, and selecting species to plant.

■ **Stormwater Toolbox, Center for Neighborhood Technology** (http://greenvalues.cnt.org/)

Calculators allow user to input details about their site, then provides estimates of the costs and benefits of various scenarios.

■ *Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting*. McPherson, E. G., Maco, S.E., Simpson, J. R., Peper, P.J., Xiao, Q., VanDerZanden, A.M. and Bell, N. 2002. Center for Urban Forest Research. U.S. Forest Service, Pacific Southwest Research Station. (http://www.ufei.org/files/pubs/cufr_164.pdf)

Useful booklet contains dollar values and methods of calculating the ecosystem services trees provide. Values may be outdated, but the information is thorough and can be updated.

■ **Resource Conserving Landscaping Cost Calculator.** (http://www.epa.gov/solidwaste/conserve/tools/greenscapes/tools/index.htm)

EPA Greenscapes tools. Excel spreadsheet for comparing the watering and maintenance costs of a conventional versus water saving landscape.

Resources for Choosing and Growing Native and Adapted Plants for the Pacific Northwest

■ ***Gardening with Oregon Native Plants West of the Cascades***. EC 1577. McMahan, L. 2008. Corvallis, OR: Oregon State University Extension Service.

■ ***Native Plant Communities for Urban Areas of the Pacific Northwest***. Anderson, C. 1997. Seattle, WA. Native Plant Alliance. Cascade Biomes, Inc. (http://www.wnps.org/landscaping/herbarium/native_alliance_urban_complete.pdf)

■ ***Native Plant Guide. Create your own customized native plant list***. King County, Washington. (https://green.kingcounty.gov/gonative/index.aspx)

■ ***Plants of Western Oregon, Washington and British Columbia***. Kozloff, E. 2005. Portland, OR: Timber Press.

■ ***Pacific NW Native Plants by Plant Community***. (http://extension.oregonstate.edu/4hwildlifestewards/School%20Garden%20Resources/Creating%20Your%20Wildlife%20Garden/native.htm) Albert L. 4-H Wildlife Stewards.

■ ***Selecting Native Plant Materials For Restoration Projects***. EM 8885. Withrow-Robinson, B. and R. Johnson. 2006. Corvallis, OR: Oregon State University Extension Service.

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Published March 2015.