BIOMIMICRY OREGON

Nature's STRATEGIES FOR MANAGING STORMWATER in the WILLAMETTE VALLEY

GENIUS OF PLACE PROJECT REPORT

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Introduction

What if we addressed local challenges with local solutions learned from the organisms and ecosystems that also call this place home?

Local "geniuses" are exceptionally well-adapted to this place through strategies that have been honed for success over millions of years. Biomimicry Oregon, with generous support from the Bullitt Foundation, recently completed a "Genius of Place" pilot study, researching nature's strategies for managing stormwater flows in the northern Willamette Valley.

Genius of Place — What's That?

Biomimicry is the practice of learning from and emulating life's best ideas to create a sustainable world. Genius of Place is a practice within the discipline of biomimicry that looks to the organisms of a particular place to provide guidance and models for establishing locally attuned and sustainable strategies for design. Locally attuned and sustainable design leverages "a site's unique natural systems attributes" (Lazarus and Crawford, 2011) to optimize resource use in life-friendly ways, which is what other organisms do.

The Genius of Place practice can address a wide range of challenges at various scales, including how buildings can reduce energy consumption and how city infrastructure can reduce or eliminate environmental toxins. The practice has been valuable in inspiring innovative, locally-attuned design strategies around the world. The information developed through a Genius of Place study may also be used to engage the public, school children and k-12 teachers, academics, and other professionals. Not only can it develop sustainable strategies, it can also inspire kids to study science and technology, build stronger support for conservation, and inspire a greater sense of connection to place.

The Genius of Place process is defined by the following steps:

- Identify local design challenge(s);
- Conduct biological research: discover ways local organisms and ecosystems (the geniuses) address the challenge;
- Translate the biological research into design principles that architects, engineers, planners, and policymakers can use to inspire innovative, sustainable designs; and
- Ideate locally attuned design strategies based on the design principles.

The practice of drawing inspiration from nature in design is not new. Landscape architects may recognize the phrase "Genius of Place" as the title of a recent biography of Frederick Law Olmsted's life. Stretching back to the 18th century, students of poetry may recall the line by Alexander Pope, who wrote: "Consult the genius of the place in all." This verse laid the foundation for one of the most widely agreed principles of landscape architecture: landscape designs should always be adapted to local environmental conditions, or "context."

Biomimics posit that all architecture and infrastructure design should be adapted to the local context, and the Genius of Place practice is one way to accomplish this.

Biomimicry is the practice of learning from and emulating life's best ideas to create a sustainable world. Visit Biomimicry 3.8's website to learn more about biomimicry.

A Genius of Place study looks to the organisms of a particular place to provide guidance and models for establishing locally attuned and sustainable strategies for design. The practice has been valuable in inspiring innovative, locally attuned design strategies around the world.

The Project in a Nutshell

The project team of six individuals investigated the following research questions:

- How can we reduce the volume of peak water in the city combined sewer system?
- How can we manage peak stormwater flows at building, district, and city scales?

Through a "bio-brainstorm" with local biologists and a literature review, the team identified 80 local organism and ecosystem strategies for managing stormwater. Seven strategies were selected for in-depth research in order to fully understand the mechanisms at play… just how *does* star moss absorb water, or how do beavers intercept and slow flows? The strategies from nature were shared in an "ideation" workshop with 44 stormwater designers, researchers, policymakers, and entrepreneurs, who enthusiastically participated in a brainstorming session drawing inspiration from the biology.

Workshop participants developed 30 novel ways to manage stormwater based on the lessons they learned from nature. Ideas to absorb rainwater ranged from "spongewood" to permeable sidewalks to "living signs", and stormwater "trees" that could capture and re-distribute water. Green roof promenades could both intercept rainwater and provide the added benefit of helping people below to stay dry. There were ideas inspired by all of the local genius mentors that were described - beaver, downed wood, forest canopy, mistletoe, hydraulic redistribution, moss, and mycorrizhal fungal networks.

Written feedback showed that workshop participants believe the Genius of Place process is a useful approach to innovation and has real, applicable value to their work. During the workshop, one participant exclaimed, "I have an idea that I'm going to get working on as soon as I get back to my desk!"

Explore the workshop presentation and/or check out the graphic recorder's notes.

Northern Willamette Valley
GENIUS OF PLACE

Focusing on stormwater, the challenge today is how to replicate the ecosystem functions of absorbing, collecting, storing, slowing, and transporting stormwater flows in a vastly altered landscape. Identifying functions provides a "portal" into nature to help guide discovery of the various ways nature may respond to a challenge.

The Place

Before roadways and buildings, the northern Willamette Valley was predominantly comprised of fir forest or fir mixed with deciduous trees, in a closed canopy. The valley was open oak savannah with coastal Douglas fir groves, and closer to the Willamette and Columbia Rivers, a mosaic of riparian and wetland complexes mixed with open prairie. There were multiple vegetation layers and each layer played a role in managing water, as shown in Figure 1.

Ecosystems could easily manage heavy storm events through infiltration, wetland storage and drainage via an expansive connected network of seeps, streams and rivers. From the mountains to the sea, there was high connectivity in waterways, enabling aquatic systems to easily share high volume storm events.

Fast forward to current times and stormwater management issues have been compounded by impervious surfaces like roadways, parking lots, and buildings. Figure 2 shows that in urbanized areas, more than half the shallow infiltration found in natural environments, and 80% of the deep infiltration, is lost. Instead of recharging the ground water aquifer, rainwater is sheeting off impervious surfaces at the ground surface. This amounts to a 500% increase in stormwater runoff (FISRWG, 1998).

Looking ahead, climate models suggest that summers will be warmer and dryer, with less precipitation, and winters will be wetter with less precipitation falling as snow. The average effect of climate change on stream flows is that winter flows will increase by approximately 15% (2040) and that late spring flows will decrease by approximately 30% (Palmer and Hahn, 2002).

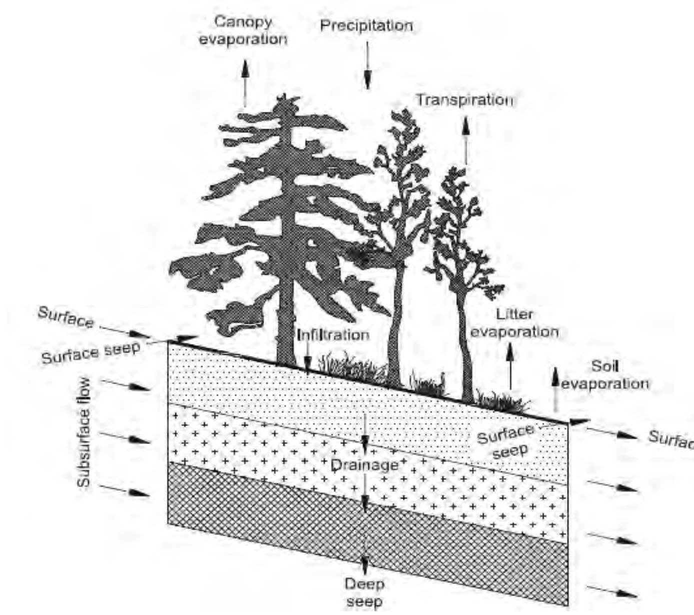

Figure 1. Water Movements (Lowrance et al., 2002)

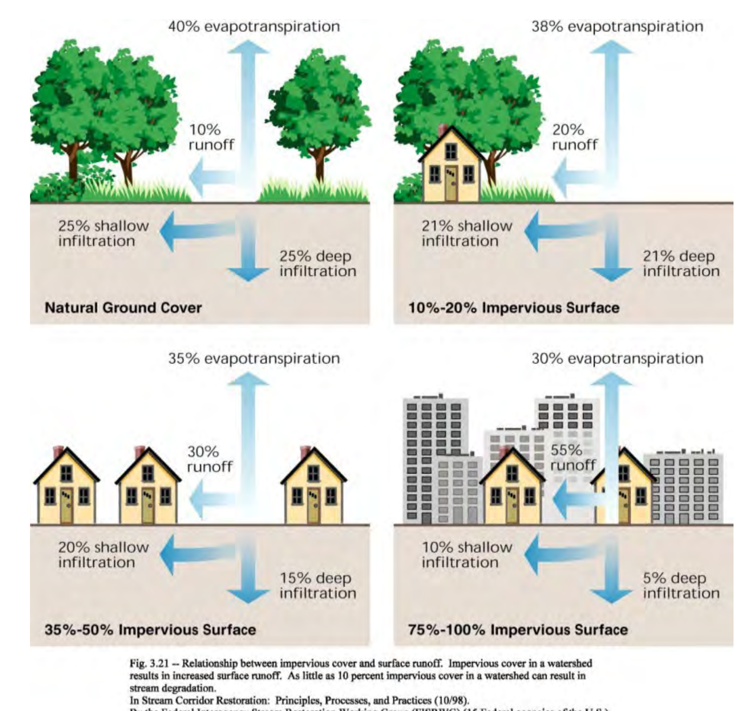

Figure 2. Relationship between impervious cover and runoff (FISRWG , 1998).

Ecosystem Patterns

Species evolve in response to the surrounding environmental conditions, or "selection pressures," in which they live, and good design is also context-specific. Table 1 summarizes selection pressures in the northern Willamette Valley that plants and animals leverage to live successfully in the region.

Condition	Resulting Pattern
Seasonal rainfall	High runoff in rivers & waterways connecting mountains to ocean. Wet & dry forest types dominated by species that tolerate periods of abundant rainfall & drought.
Moderate temperatures	Relatively long growing season, high productivity, & high biomass.
Suitable growing conditions	High vegetative diversity & multiple layers: trees, shrubs, ground cover, mosses, lichens, and vines.
Abundance of species	Cooperative relationships among plants and animals.
Relatively wet, warm conditions	Rapid nutrient cycling & high soil fertility.

Table 1. Selection Pressures in Northern Willamette Valley

Focusing on stormwater, the challenge today is how to replicate the ecosystem functions of absorbing, collecting, storing, slowing, and transporting stormwater flows in a vastly altered landscape. We know natural systems and "green infrastructure"—engineered wetlands, rain gardens, green roofs, and bioswales, for example—work to capture and filter stormwater, and there is certainly room to do more of this. However, in densely populated urban areas, there may well not be enough space to meet all stormwater management needs with green infrastructure, even if there were the political will to do so. What can we learn from nature to design stormwater management systems to be more effective - perhaps treating higher quantities of stormwater in the same amount of space, or solving maintenance issues? Can we learn to design "grey infrastructure", i.e. concrete facilities, to be more sustainable by consulting nature? Will innovation inspired by nature help build public support for more sustainable ways of managing stormwater?

The project team searched for local organisms that manage stormwater flows by developing functional questions they could ask nature:

- How does nature collect water?
- How does nature store water?
- How does nature absorb water?
- How does nature attenuate water… slow it down, thereby reducing kinetic, and potentially erosive, energy?
- How does nature transport or move water?

The functions, or verbs, in the questions provide a "portal" into nature to help guide discovery of the various ways nature may respond to a challenge.

Focus on Function

Although 80 organism / ecosystem strategies were identified, the team researched only 7 in depth due to the limited scope of the project (Table 2). After the biological strategies were fully understood, the team translated them into easily understood "design principles." A design principle uses words that no longer contain reference to the biology that designers (e.g., architects, engineers, policy-makers, product designers, teachers) can use to inspire innovative design ideas. Seven design principles derived from the biological research are shown in Table 2. These seven design principles inspired 30 innovative design concepts during the ideation workshop.

Organism / Ecosystem Attribute	Design Principle
Canopy Structure	Overlapping, redundant surfaces at multiple layers above the ground intercept and store water, reducing erosive force and increasing the potential for evaporation.
Downed Wood	Bundles of hollow cylinders transport water. Holes in the walls between hollow cylinders allow water storage, absorption, and evaporation.
Hydraulic Redistribution	A subterranean network transports water along a water potential gradient.
Beaver	Interlocking matrix of mixed material spanning an arch perpendicular to water's flow creates a high cavity surface area that slows water for storage and increased absorption.
Mistletoe	1) Optimize water uptake and resource sharing using multiple inline channels; 2) Enhance a relationship by exchanging complementary resources at appropriate locations and times.
Moss	Overlapping concave units with water repellent lower surface and hydrophilic concave upper surface absorb water and capture energy.
Mycorrhizal Fungal Network	Optimize water uptake using network architecture that increases surface area over which osmosis occurs.

Table 2. Design Principles

The research and design principles were compiled into one-page Local Genius Summaries which can be found below and on Biomimicry Oregon's website.

Included in the Local Genius Summaries are the top three to five "Life's Principles" illustrated by each organism or ecosystem strategy. Life's Principles are overarching deep patterns found uniformly across most organisms living on earth. They are an important part of biomimicry thinking, as guidelines to both generate and evaluate the sustainability and appropriateness of all sorts of designs, from products to organizational practices.

Life's Principles are overarching deep patterns used as guidelines to both generate and evaluate the sustainability and appropriateness of all sorts of designs, from products to organizational practices. Visit Biomimicry 3.8's website to learn more about the Life's Principles.

Nature's Strategies

Local Genius Summaries describe biological strategies, resulting design principles, and a few application ideas.

Canopy Structure

Canopies of old growth forests intercept, store, and slow water

Biology

The multi-layered architecture of a forest canopy not only contains the branches of a variety of large trees, but also plays host to many species of lichens and bryophytes. The canopy can hold about 264,000 gallons per acre, which is equivalent to 1 ¼ inches of precipitation (Franklin et al., 1981). This can account for approximately 10-20% of annual interception loss in a typical Pacific Northwest forest (Allen, 2012). Interception loss is the amount of precipitation that does not reach the soil through interception, temporary storage, and eventual evaporation by the canopy.

The canopy provides the forest floor with leaf and bark litter, absorbing up to 150% of its dry weight in water. The forest floor is also covered in downed rotting wood, which can be responsible for collecting up to 5% of a total rainfall event (Pypker, 2004).

Champion

Mature temperate rainforest

Allen, Scott T. 2012. Trickle-down ecohydrology : complexity of rainfall interception and net precipitation under forest canopies. OSU thesis.

Bond, B. J., Meinzer, F. C. and Brooks, J. R. 2008. How trees influence the hydrological cycle in forest ecosystems, in Hydroecology and Ecohydrology: Past, Present and Future (eds P. J. Wood, D. M. Hannah andJ. P. Sadler), John Wiley & Sons, Ltd, Chichester, UK. doi: 10.1002/9780470010198.ch2.

Franklin, Jerry, et al. 1981. Ecological Characteristics of Old Growth Douglas Fir Forests. Forest Service General Technical Report PNW -118.

Pypker, Thomas G. 2004. The influence of canopy structure and epiphytes on the hydrology of douglas fir forests. Dissertation abstract.

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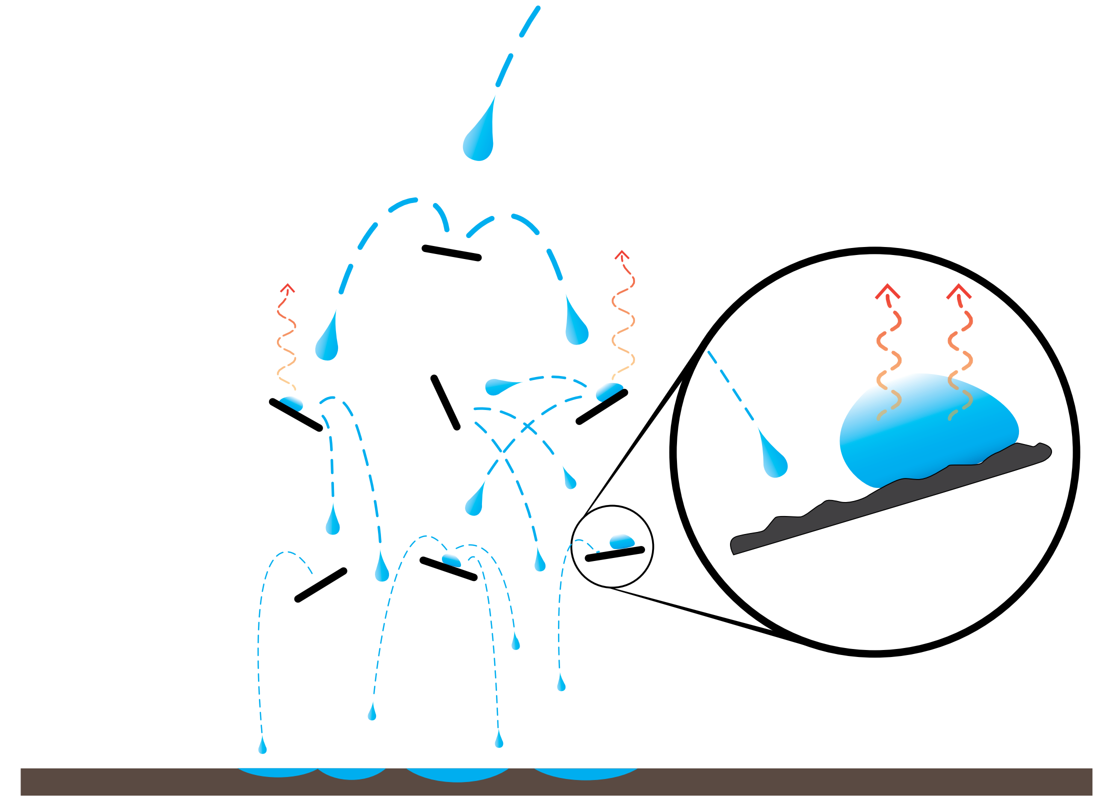


Mechanism

The multi-layered architecture of an old growth canopy intercepts, stores and breaks up water droplets, slowing the rate at which water hits the ground and increasing the potential for evaporation.

Design Principle

Overlapping, redundant surfaces at multiple layers above the ground intercept and store water, reducing erosive force and increasing the potential for evaporation.

Key Life's Principles

- Combine modular and nested components
- Use low-energy processes
- Use multi-functional design

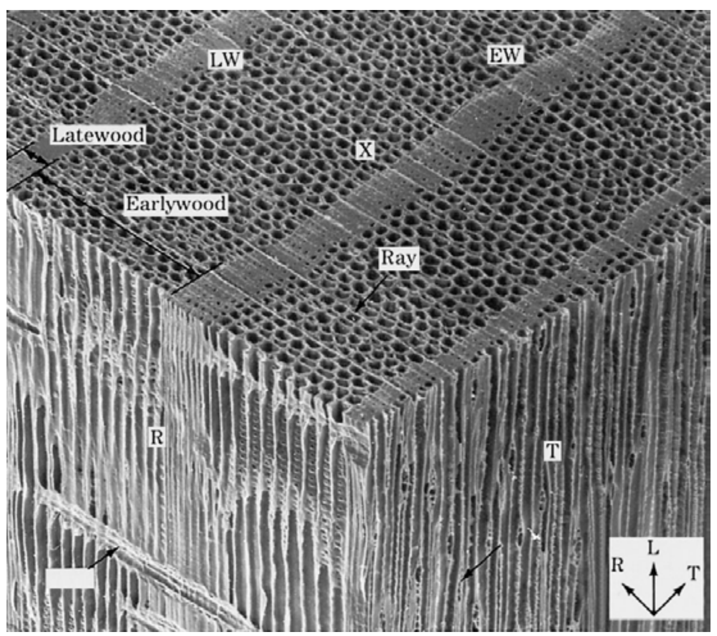
Application Ideas

Integrate a series of overlapping canopies and roof structures over existing impervious surfaces to delay runoff and maximize surface area potential for evaporation. These structures can play host to elements that help absorb water, further reducing the amount of water that reaches the ground during storm events.

Require a certain amount of canopy cover per area for new developments.

Downed Wood

Downed logs in old growth forests intercept, absorb, store, and evaporate water



Biology

Downed wood is dead wood – essentially fallen trees. The function of downed wood with regard to the stormwater challenge is to intercept water, thereby reducing overland flow. This function is a result of its form and the internal structure of wood.

Up close, wood is a collection of long thin pointed cells that are hollow. Most of these cells have their long direction parallel to the direction of tree growth. Think of them as a bundle of drinking straws, which makes since because we know that the cells' job is to transport water, nutrients and sugars up and down the trunk. There are also evenly-spaced holes in the cell walls called pits, which allow the passage of water or air between cells, and ultimately between the inside and outside of the wood.

Wood is hygroscopic, which means it can absorb water vapor from the atmosphere. When standing, a tree is constantly balancing its moisture content, but when a tree falls, it loses the ability to regulate water and its cells become fully saturated. All of those drinking straws fill with fluid.

In an old-growth Douglas fir forest, 25% of the forest floor is covered by downed wood. In a single storm event, downed wood is estimated to intercept and store 2-5% of the precipitation reaching the forest floor (Sexton and Harmon, 2009).

Ephraim Segerman. 2001. Some Aspects of Wood Structure and Function. For publication in the Journal of the Catgut Acoustical Society. URL: http://www.nrinstruments.demon.co.uk/wood.html. Accessed Fall 2012.

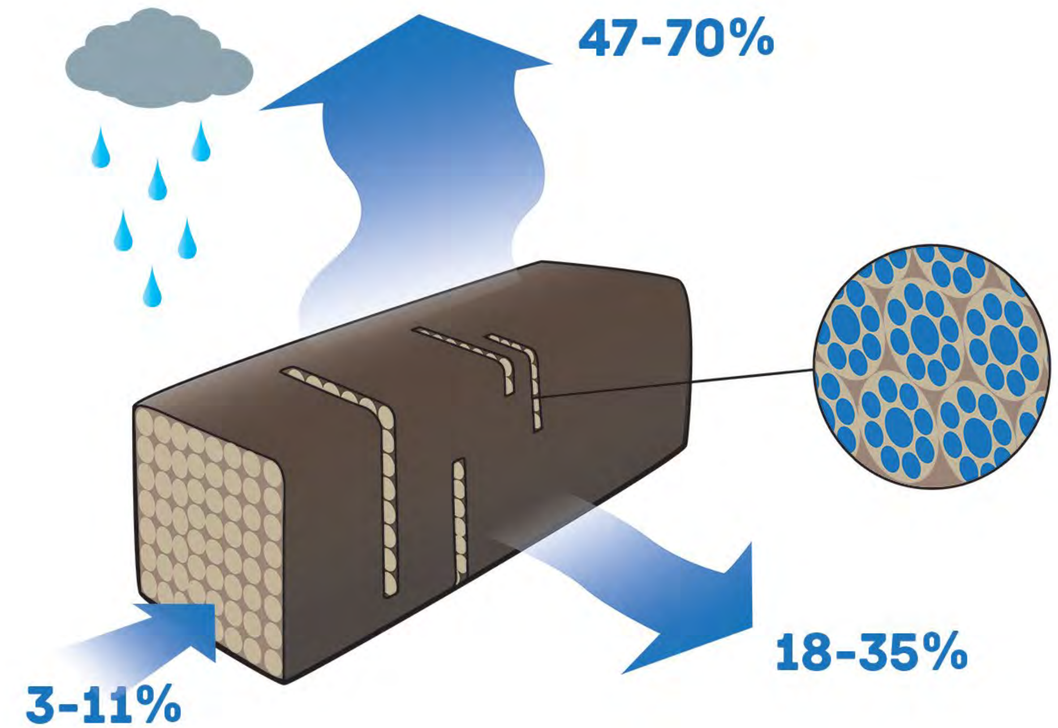
Franklin et al. February 1981.Forest Service General Technical Report PNW 118. Ecological Characteristics of Old-Growth Douglas fir Forests. Page 33. Data: http://www.bioone.org/doi/abs/10.3955/046.083.0204. Accessed Fall 2012.

Sexton, Jay M. and M.E. Harmon. 2009. Water Dynamics in Conifer Logs in Early Stages of Decay in the Pacific Northwest, U.S.A. (Abies amabilis [Pacific silver fir], Pseudotsuga menziesii [Douglas fir], Thuja plicata [western red cedar], and Tsuga heterophylla [western hemlock]). Department of Forest Ecosystems and Society. Oregon State University. URL: http://www.bioone.org/doi/abs/10.3955/046.083.0204. Accessed Fall 2012.

University of California at Berkeley. Introduction of Wood. PowerPoint presentation by instructor Paulo Monteiro. URL: PPT http://www.ce.berkeley.edu/~paulmont/CE60New/wood.pdf. Accessed December 2012.

University of Kentucky Cooperative Extension Service. 1997. An Introduction to Wood Anatomy Characteristics Common to Softwoods and Hardwoods. College of Agriculture. URL: http://www.ca.uky.edu/forestryextension/Publications/FOR_FORFS/for59.pdf. Accessed December 2012.

Genius of Place Project Report > Nature's Strategies > Downed Wood



For a given volume of precipitation that intercepts a Douglas fir log, research has shown that 47–70% evaporates, 18–35% flows through the log and leaches out, 3–29% runs off the surface, and 3–11% is absorbed (Sexton and Harmon, 2009).

Mechanism

Wood is a modular form comprised of long, thin, pointed, hollow cells that lie parallel to the direction of growth. Water and air enter cells via evenly-spaced holes in the cell walls.

Design Principle

Bundles of hollow cylinders transport water. Holes in the walls between hollow cylinders allow water storage, absorption, and evaporation.

Key Life's Principles

- Combine modular and nested components
- Use life friendly chemistry
- Leverage cyclic processes
- Use readily available materials and energy

Application Ideas

A streetlight that widens at the lamp to intercept water for storage and energy production. Could the street furniture that lies around our city like downed wood in a forest act as a sponge, locking water inside in a modular structure for slow release into the soil?

Storm interceptors in streets divert flow like downed wood slowing water in a stream.

Root Structure

Plant roots passively transport water to where its needed most

Biology

Plant roots transfer water between soil layers of different water potential, significantly affecting the distribution and availability of water in the soil profile. Usually occurring at night, water is transferred from wetter to drier portions of the soil. This relocation of water can work in two directions.

'Hydraulic lift' occurs when the top layers of the soil are dry, and water from deeper layers is pulled up through the tap roots by capillary action, exiting through lateral surface roots. This water movement benefits the plant, as well as nearby seedlings and other organisms. It is a key strategy for resisting drought and maintaining a healthy undercover.

'Hydraulic redistribution' occurs when there is a steady availability of water at the surface. Water is redistributed from the surface to drier, deeper portions of the soil to maintain the lower plant structure and to store for later use. Hydraulic redistribution partially bypasses the process of infiltration. Water moves through the root xylems in a mostly passive manner, relying on the balancing of water potential gradients (water moves from an area of higher water potential to an area of lower water potential).

Champion

Douglas fir (*Pseudotsuga menziesii*) & Ponderosa pine (*Pinus ponderosa*) forests

Brooks, J. Renee, Frederick C. Meinzer, Rob Coulombe, & Jillian Gregg. 2002. Hydraulic redistribution of soil water during summer drought in two contrasting Pacific Northwest coniferous forests. Tree Physiology 22, 1107–1117.

Burgess, Stephen O., Mark A. Adams, Neil C. Turner and Chin K. Ong. 1998. The redistribution of soil water by tree root systems. Oecologia 115 (3). 306-311.

Genius of Place Project Report > Nature's Strategies > Root Structure

Mechanism

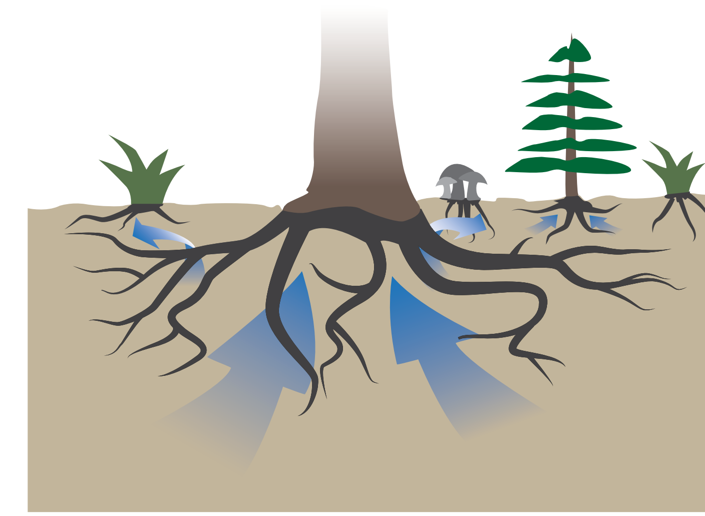
Redistribution of water occurs whenever a water potential gradient exists across soil layers.

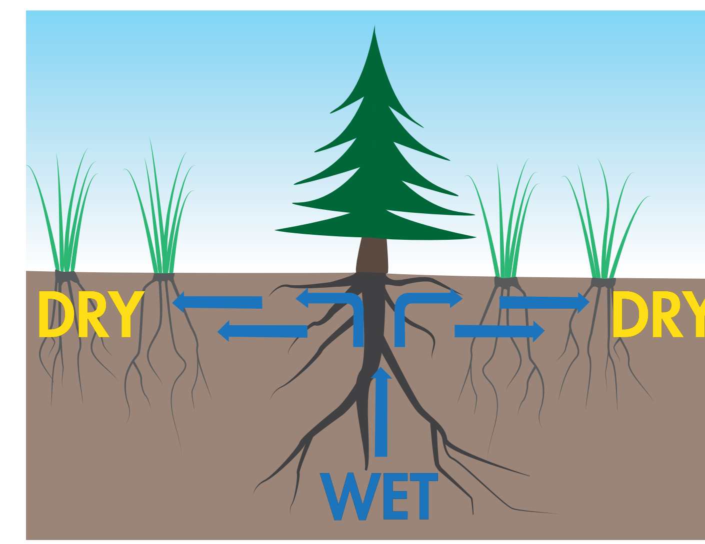
Design Principle

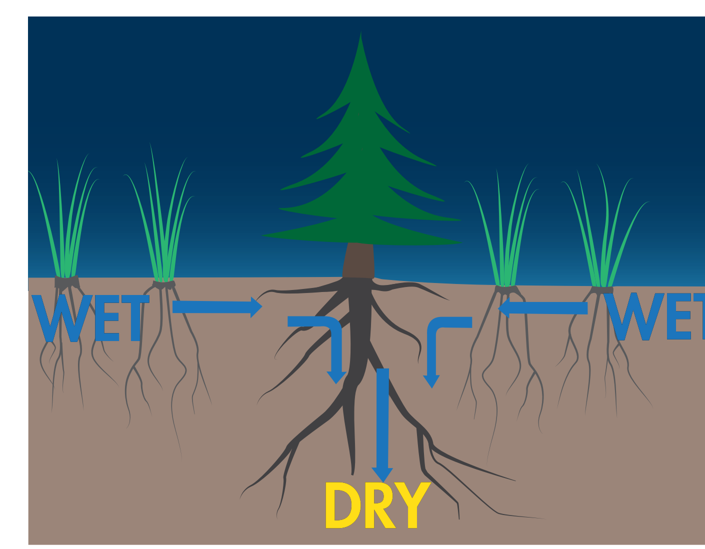
A subterranean network transports water along a water potential gradient.

Key Life's Principles

- Use feedback loops
- Use readily available materials and energy
- Leverage cyclic processes







Application Ideas

Create distribution networks that can transfer water between them using passive mechanisms.

Design piping that can transfer water using capillary action.

Beaver Dams

Beaver dams intercept water and slow its flow

Biology

Nothing matches the work of beavers (*Castor canadensis*) for controlling flooding and erosion via the creation of wetlands, and providing settling ponds for sediment and habitat for fish and wildlife. The mere sound of moving water, or even seeing or feeling the flow of water, stimulates beavers to build dams.

Beavers start construction by diverting the stream to lessen the water's flow pressure. For example, they may dig channels branching out from the stream. Branches and logs are then driven into the mud of the stream bed to form a base, and an interlocking matrix of mixed material – trees, sticks, bark, rocks, mud, grass, leaves, and masses of plants - slows water and traps particulates.

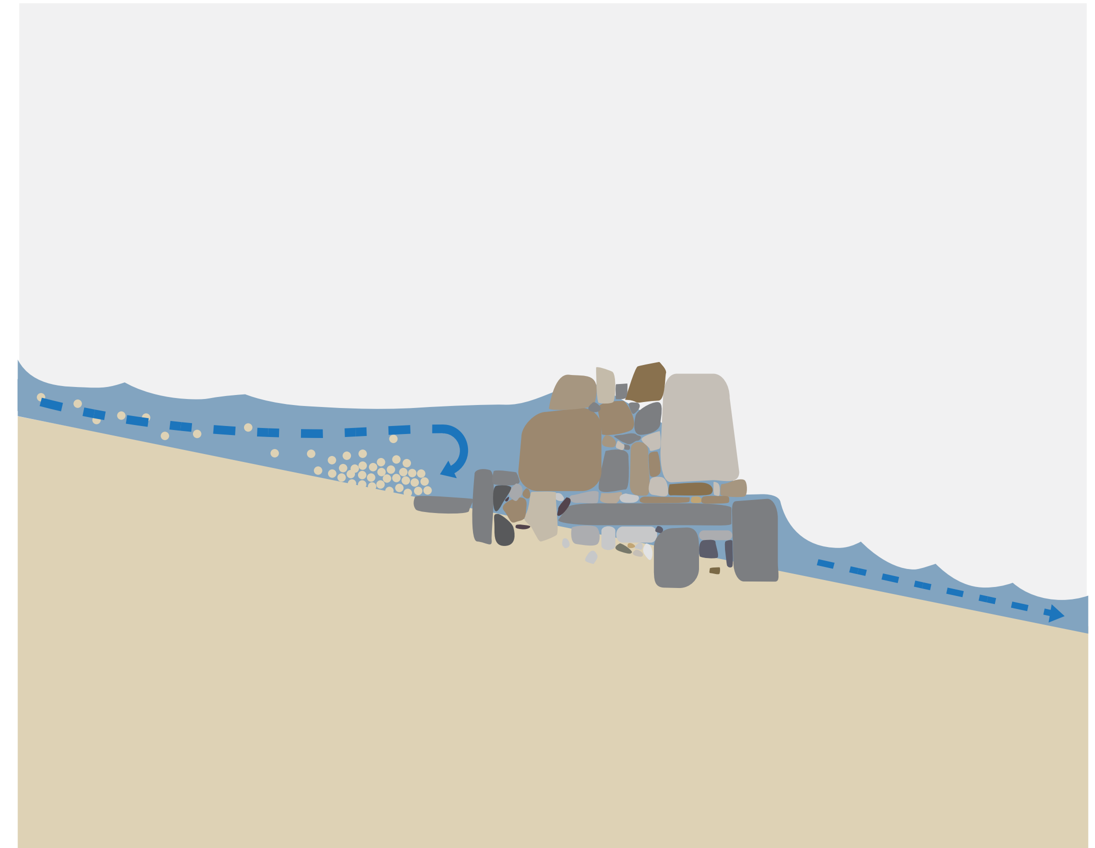
Champion

American beaver (*Castor canadensis*)

AskNature. Stream remodeling alters ecosystems: American beaver . Provided by the Biomimicry 3.8 Institute. URL: http://www.asknature.org/strategy/fe-336fe9a62943d43701a6ed c1f2be69. Accessed September and December 2012.

Fall, Samuel W. 2007. Beaver Facts and Natural History / Dams. URL: http://fohn.net/beaver-pictures-facts/index.html. Accessed November and December 2012.

Wikipedia. Beaver. URL: http://en.wikipedia.org/wiki/Beaver. Accessed November and December 2012.



Mechanism

Interlocking matrix of mixed material slows water and traps particulates by spanning perpendicular to the water's flow. It is shaped wider at the bottom than at the top, is curved against the force of water, and contains emergency spillways or passageways for high water levels.

Design Principle

Interlocking matrix of mixed material spanning an arch perpendicular to water's flow creates a high cavity surface area that slows water for storage and increased absorption.

Key Life's Principles

- Fit form to function
- Integrate the unexpected
- Use low energy processes
- Build from the bottom up

Application Ideas

Use shallow physical blockades to divert water (but not traffic) into bioswales that are adjacent to roads.

Terraced parking lots capture stormwater produced in high rainfall events for "off-channel" temporary storage.

Parasitic Resource Sharing

Mistletoe exchanges complementary resources with its host

Biology

Pacific Mistletoe is a stem hemiparasite. This type of parasite is photosynthetic, producing its own chlorophyll, but it relies on a host for water and dissolved nutrients. In order to obtain water and nutrients, it uses haustorial roots to connect into the host plant's xylem. Hemiparasites attach to a host plant in one of two ways:

- Through several runners that grow like a vine and produce secondary haustorial roots that penetrate into the host plant's xylem; or
- Via a bulbous connection to the host that branches into 'cortical strands' once it has penetrated the host plant's xylem.

Both methods result in multiple connection points within the host.

While mistletoe acts as a parasite, it contributes back to its host and local ecosystem in other ways. One genus of leafy mistletoe transfers sugars back to its host during the leafless winter months. Since leafy mistletoes do not withdraw the nutrients from their leaves before they drop, the leaf litter produced by mistletoe usually has higher nutrition value than that of their host, supporting the proliferation of microbes in the soil. Mistletoe also acts as a home and food supply for many woodland bird species.

Champion

Pacific mistletoe (*Phoradendron villosum*) &
Oregon white oak (*Quercus garryana*)

Barlow, Bryon. 2011. Haustorial structure. Australian National Botanical Gardens. http://www.anbg.gov.au/mistletoe/haustoria.html.

Nickrent, D.L. and Musselman, L.J. 2004. Introduction to Parasitic Flowering Plants. The Plant Health Instructor. http://www.apsnet.org/edcenter/intropp/pathogengroups/pages/parasiticplants.aspx.

Pain, Stephanie. 2012. Marvellous mistletoe: Giving forests the kiss of life. New Scientist, issue 2896.

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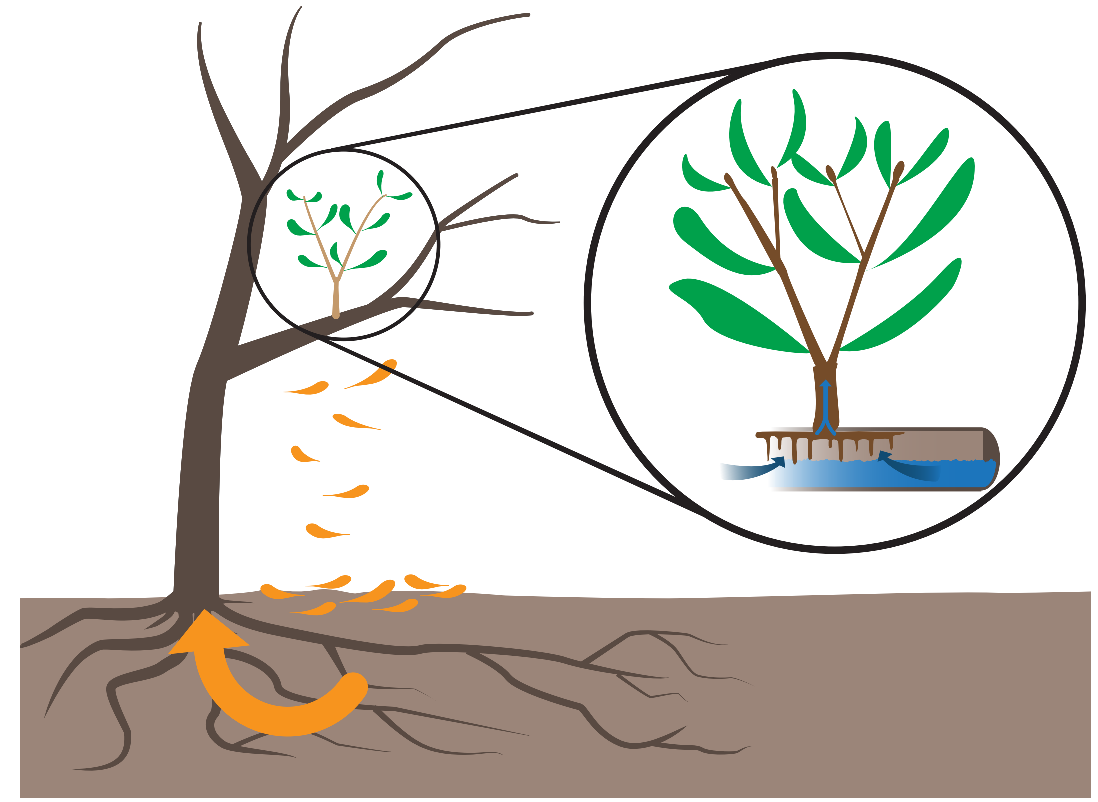


Mechanism

1. Create a limited draw from resource conduit via multiple inline intake channels.

2. Share resources with cooperative partner when and where they are needed most.

Design Principle

1. Optimize water uptake and resource sharing using multiple inline channels.

2. Enhance a relationship by exchanging complementary resources at appropriate locations and times.

Key Life's Principles

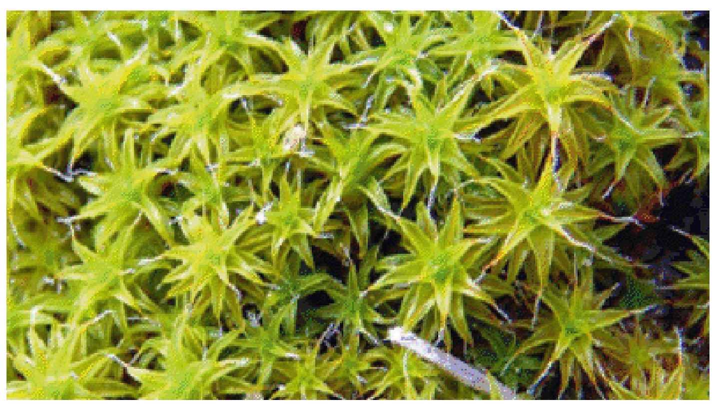
- Use readily available materials and energy
- Cultivate cooperative relationships
- Integrate the unexpected

Application Ideas

Irrigate greenhouses, aquaponic systems, and vegetable gardens with water collected from surrounding buildings, using piping and filtration systems connected inside the host buildings.

Leaf Absorption

Mosses absorb water while performing photosynthesis



Biology

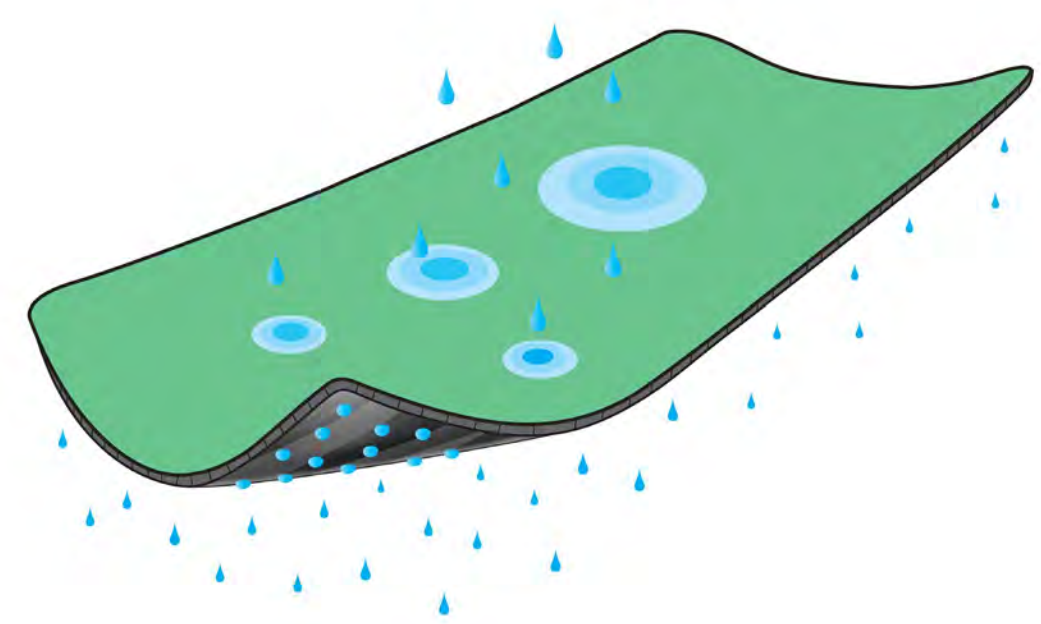
Mosses are an abundant part of temperate coniferous and broadleaf forests. Since mosses lack vascular tissues, they must absorb all water and nutrients at the surface and pass them from cell to cell. Their water content tends toward equilibrium with the water status of the environment: under wet conditions they become hydrated and active, and under dry conditions they dry out and become dormant. Mosses that grow in dense turfs or cushions capture the most water and hold onto it for the longest. In fact, sphagnum moss can hold 2,000 times its dry weight in water!

Mosses have concave leaves with a water repellent lower surface to carry out gas exchange and a hydrophilic concave upper surface where water is absorbed and stored. Shoot systems are arranged with closely overlapping concave leaves, the inner surfaces functioning for storage and the outer for capturing energy through photosynthesis.

Champion

Star moss (*Tortula ruralis*)

Green, T.G. Allan, Leopoldo G. Sancho, and Ana Pintado. 2011. Chapter 6 Ecophysiology of Desiccation/Rehydration Cycles in Mosses and Lichens.



Mechanism

Concave leaves feature a water repellent lower surface where gas is exchanged and a hydrophilic upper surface where water is absorbed. Leaf cells contain 'compatible solutes' such as sucrose that cause absorption via osmosis. The water repellency is often a result of wax deposits.

Design Principle

Overlapping concave units with water repellent lower surface and hydrophilic concave upper surface absorb water and capture energy.

Key Life's Principles

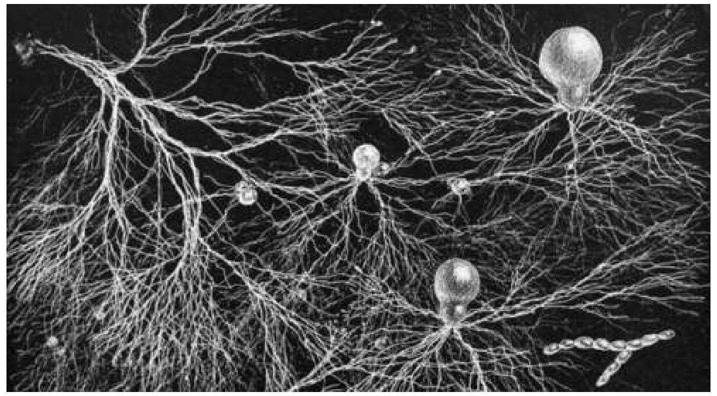
- Combine modular & nested components
- Use multi-functional design
- Leverage cyclic processes

Application Ideas

Design water absorption and energy capture into rooftop gardens; vertical surfaces, such as the sides of buildings, light posts, and street lights; rain gardens by adding structural diversity to increase water capture; and pervious pavement.

Absorbent Networks

Mycorrhizal fungal networks absorb water



Biology

Mycorrhizal fungal networks connect trees in a forest, allowing them to exchange nutrients, water, and chemical alarm signals. They create decentralized, yet interdependent, networks of multi-functional structures.

Mycorrhizal fungi form mutualistic relationships with roots of most plant species. More than 2,000 species of mycorrhizal associates live symbiotically with Douglas fir and at least 250 with western hemlock. The fungus colonizes the host plant's roots, obtaining carbohydrates from the plant while increasing absorptive capacity for water and mineral nutrients, leading to more rapid growth and increased resistance to disease. Because ectomycorrhizal mycelium grow beyond the plant's roots, they bring distant nutrients and moisture to the host plant, extending the absorptive zone well beyond the root zone. Absorptive capacity is increased due to the comparatively large surface area of the mycelium to root ratio, and to cell membrane chemistry.

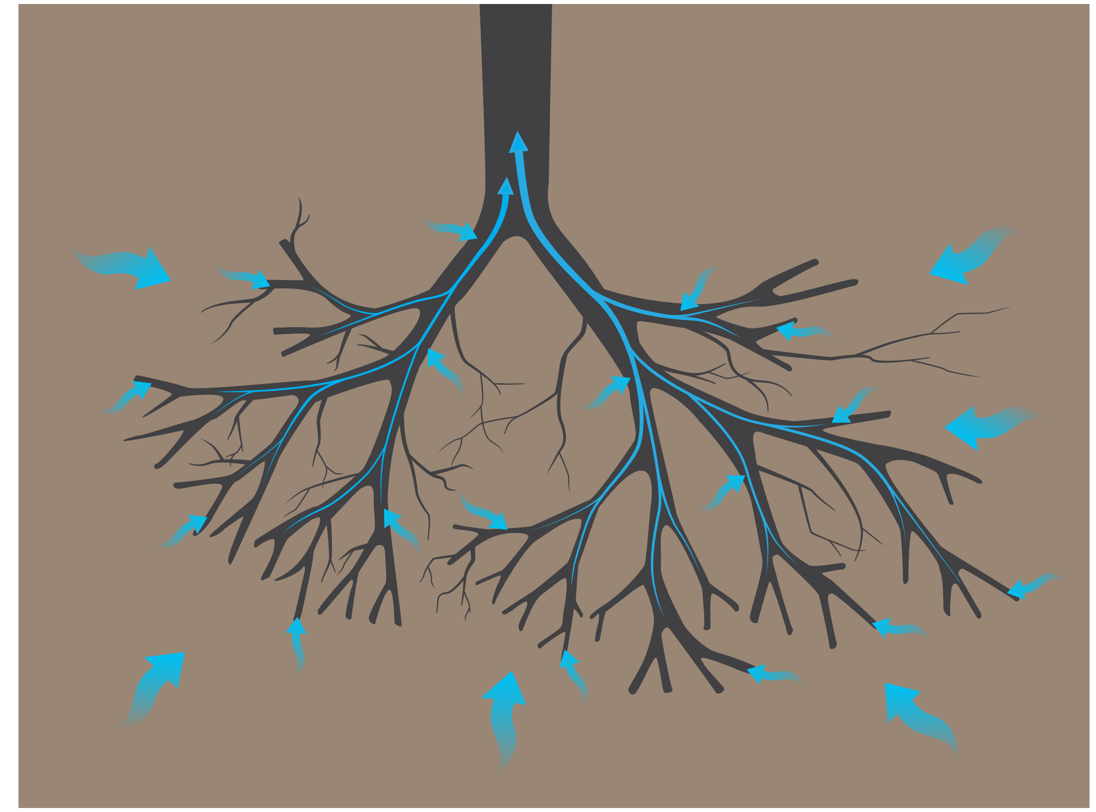
As an evolutionary strategy, mycelial architecture is amazing: one cell wall thick and so pervasive that a single cubic inch of topsoil contains enough fungal cells to stretch more than 8 miles, when placed end-to-end. A forest's vitality is directly related to the presence, abundance, & variety of mycelial associations. Stamets (2005) estimates 1/5 - 1/10 of the total biomass in the topsoil of a healthy Douglas fir forest in the Pacific Northwest may be made up of mycelium.

Champion

Ectomycorrhizal fungi (many species), including Chanterelle (*Cantharellus sp.*)

Stamets, Paul. 2005. Mycelium Running: How mushrooms can help save the world. Berkeley: Ten Speed Press.

Genius of Place Project Report > Nature's Strategies > Absorbent Networks



Mechanism

Absorptive capacity is increased due to comparatively large surface area of mycelium to root ratio and to cell membrane chemistry.

Design Principle

Optimize water uptake using network architecture that increases surface area over which osmosis occurs.

Key Life's Principles

- Use multi-functional design
- Cultivate cooperative relationships
- Embody resiliency through variation, redundancy and decentralization
- Replicate strategies that work

Application Ideas

Inoculate plantings with mycorrhizal fungi (bio-utilization).

Incorporate high surface areas in structures designed to reduce runoff / absorb peak flows.

Reduce urban runoff by integrating a diversity of rooting depths – in raingardens, bioswales, etc. – to increase the surface area for absorption throughout the soil profile.

Application Ideas

"The whole is greater than the sum of its parts."

While all of these design principles have value on their own, combining them all together in the built environment can create its own ecosystem - multiplying the benefits. The applications needn't be stand-alone products; they really hold the most value when they are integrated with each other as a holistic system. Taking advantage of each other's multi-functional designs, they develop redundancies within the system that act as a safety net for a resilient environment.

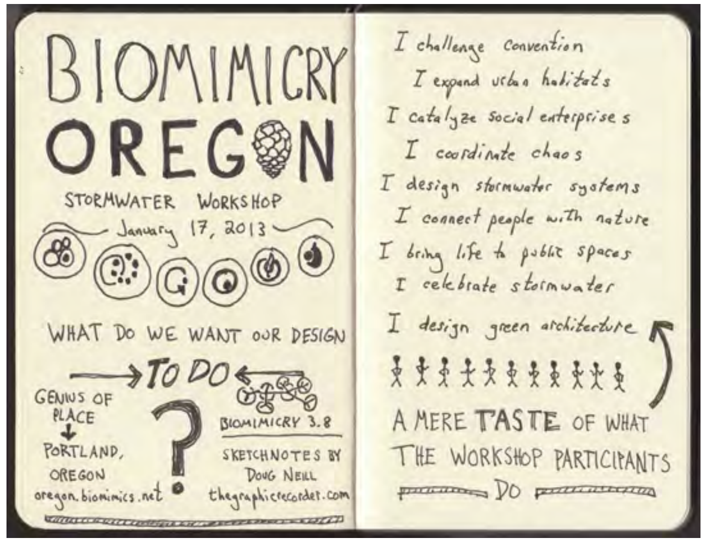
Integrate stepped wetlands into parking lots of local parks, and other outdoor venues, by using prunings from local trees to create a series of "check dam lots" that fill when the rain reaches each level. Downed wood or other absorptive elements can be used as parking bumpers to help control stormwater flows.

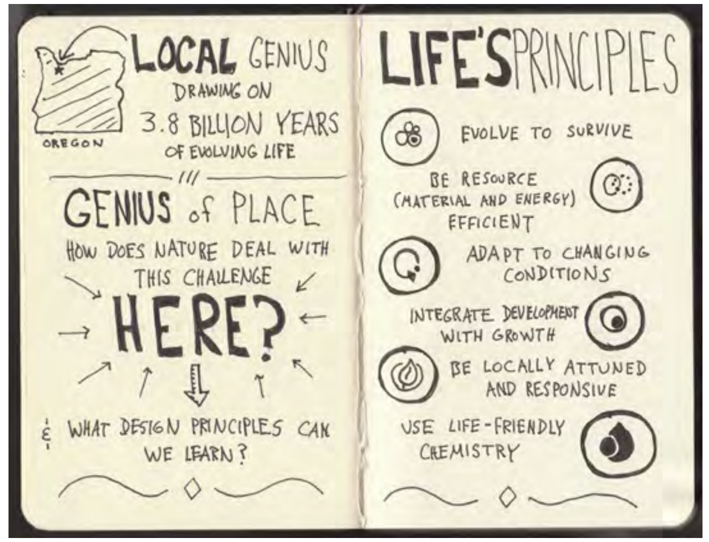
Center lines in roads could be replaced with pervious rumble strips that lead to speed bumps with a similar texture. These bumps would slow traffic and collect and divert water to stormwater planters.

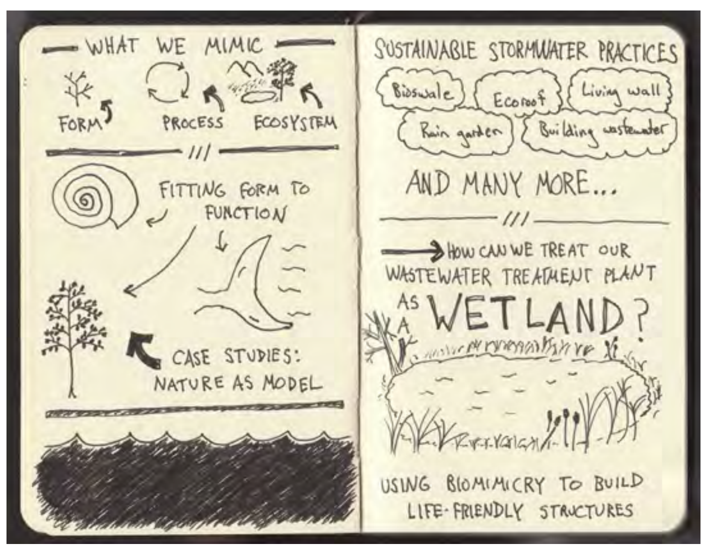
Integrate adjacent water systems. Overlapping building canopies and roof surfaces can slow and collect water for later use. Traffic circles become water intercepts. The center may contain a structure that collects and stores water, releasing it to power a street light. It might contain a weather station, able to communicate with similar structures in the local area. All of the collected water from the surrounding area could be stored for later use or redistributed to other uses to where it is needed most. Auxiliary structures such as greenhouses, aquaponic systems, and Accessory Dwelling Units could be nodes in the system, using what is distributed to produce valuable resources – a deep pattern found in nature.

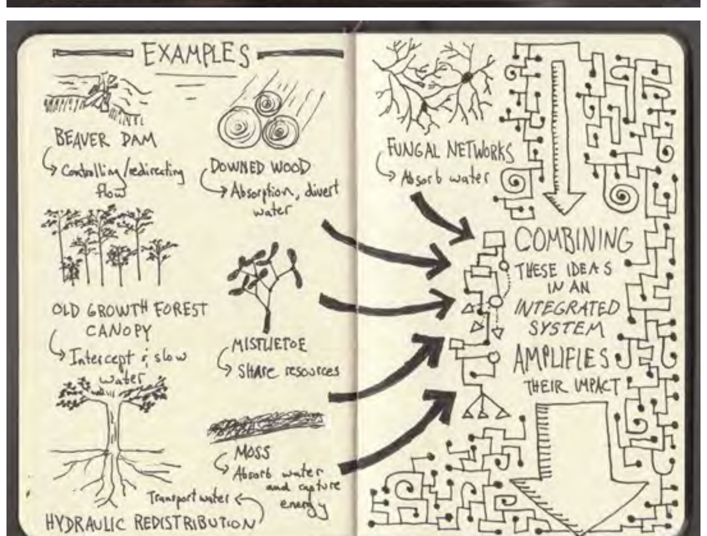
Concept rendering by Sarah Steinberg, *strikeforcedesign.net*

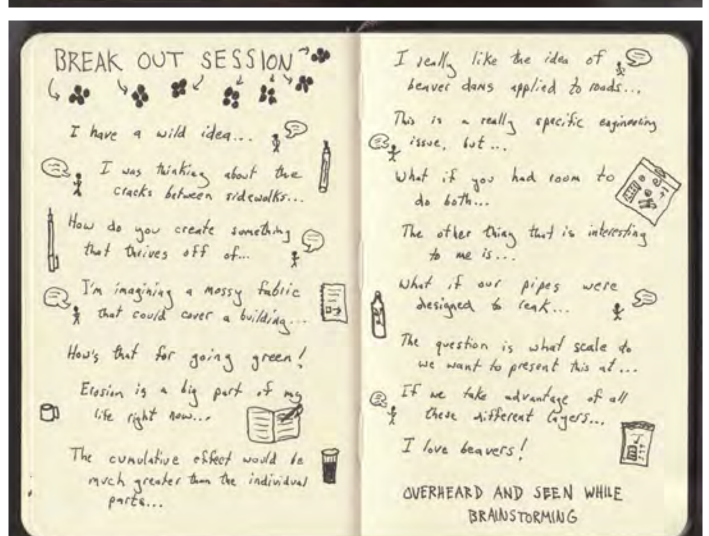
Ideation Workshop











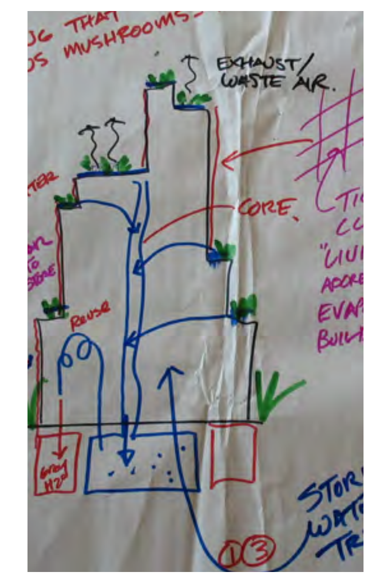
The team hosted 44 participants for a 4-hour interactive workshop focused on learning about biomimicry thinking, the Genius of Place process, and the stormwater flow management strategies of local organisms and ecosystems.

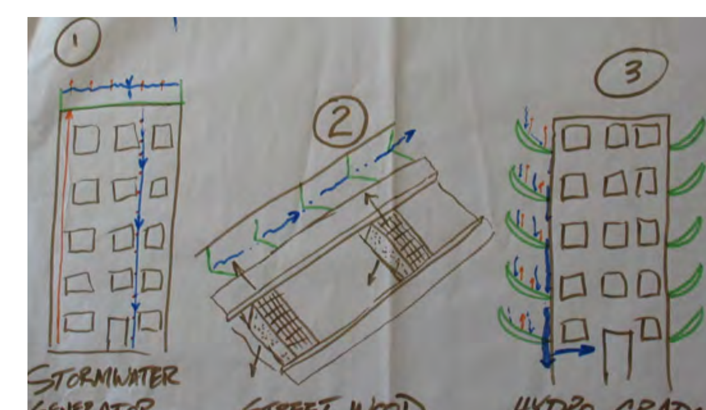
After the team shared their research and examples of application ideas, workshop participants brainstormed their own tangible design concepts inspired by the biology stories told. Approximately 30 design concepts were generated. Ideas to absorb rainwater ranged from "spongewood" to permeable sidewalks to "living signs", and stormwater "trees" that could capture and re-distribute water. Green roof promenades could both intercept rainwater and provide the added benefit of helping people below to stay dry. There were ideas inspired by all of the local genius mentors that were described - beaver, downed wood, forest canopy, mistletoe, hydraulic redistribution, moss, and mycorrizhal fungal networks.

Written feedback showed that workshop participants believe the Genius of Place process is a useful approach to innovation and has real, applicable value to their work. During the workshop, one participant exclaimed, "I have an idea that I'm going to get working on as soon as I get back to my desk!"

Explore the [workshop presentation] and/or check out the [graphic recorder's notes].

Visual notes provided by Doug Neill,
The Graphic Recorder





Retrospective

The Genius of Place practice proved effective to generate innovative, locally attuned, and sustainable concepts for managing stormwater flows.

There is still a universe to learn from nature about managing stormwater, as well as a host of other challenges to explore. We practiced a proccess developed by Biomimicry 3.8 and refined the tools needed to begin this exploration. As we continue on this journey, we must not forget that with every new design challenge, the first question to ask is simply, "What would Nature do?"

Conclusions

This pilot project is part of a grander vision to:

- Develop place-based data to improve the triple bottom line performance of projects;
- Develop a databank of design principles abstracted from nature to inform local planning, design, and policymaking; and
- Integrate biomimetic strategies and learning into Science, Technology, Education, and Math and environmental education.

This pilot project was designed to introduce the Genius of Place practice to a practitioner audience and test its effectiveness in producing innovative ideas. There is a growing interest in applying biomimicry as an innovation approach to develop more resilient and sustainable solutions. This practice promises to be an effective way of applying biomimicry to generate innovative, locally attuned, and sustainable concepts to plan and design buildings, infrastructure, and policies governing the built environment.

Below is a summary of written feedback from the workshop:

- 57% (25/44) of workshop participants completed written evaluation forms.
- 84% of respondents (21/25) see how biomimicry can catalyze inspiration in their work.
- The Genius of Place Process rated at an average 4.5 on a scale of 1-5 as being useful (1 = not useful; 5 = useful & user friendly).

Next Steps

The team has convened a small group of stormwater practitioners to filter the design concepts generated in the workshop to identify the most promising ideas to explore potential for implementation.

Although this project started with a design challenge and then looked to nature for solutions, a school doing a Genius of Place study might want to flip the approach. Children could research local organisms in their schoolyard, discover and research strategies of local organisms to solve a functional challenge posed by the environment, then generate sustainable design concepts inspired by nature to solve similar human challenges.

The team documented a process and developed seven Genius of Place worksheets that Biomimicry Oregon will leverage as the centerpiece of its 2013-2015 strategic plan. The plan focuses on raising awareness of biomimicry by identifying and connecting existing networks with biomimicry resources, and seeding additional Genius of Place projects to address different challenges.

Biomimicry Oregon is also actively looking for funding to leverage the Genius of Place study in k-12 education. The Biomimicry Education Collaborative will empower students as stormwater designers, problem solvers, and community conveners.

The need has never been greater for life-friendly, innovative design. We have barely scratched the surface in consulting nature's genius as a mentor to help. This project tested a Genius of Place process to determine its effectiveness in inspiring innovative design concepts, and it appears a valuable approach. The limited scope of the project has left a treasure trove of strategies for future exploration… for example, what other secrets does the Douglas fir hold for managing water? How does the delicate lacewing shed water from their wings to maintain their light weight for flight? What can we learn from mushrooms about creating value from abundant rainfall?

There is still a universe to learn from nature about managing stormwater, as well as a host of other challenges to explore. We have practiced a process developed by Biomimicry 3.8 and refined the tools needed to begin this exploration. As we continue on this journey, we must not forget that with every new design challenge, the first question to ask is simply, "What would Nature do?"

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