BIOMIMICRY OREGON

Genius of Place

PROCESS REPORT

Nature's
STRATEGIES FOR MANAGING
STORMWATER
in the
WILLAMETTE VALLEY

The Biomimicry Oregon Genius of Place project team sincerely thanks all of our sponsors, volunteers, and workshop participants, without whom this project could not have been successful! Special thanks to the Bullitt Foundation for their generous financial support, and to Biomimicry 3.8 for developing and sharing the Genius of Place practice, and providing mentoring throughout the project. Many thanks also to other sponsors: Glumac, the City of Portland Bureau of Planning and Sustainability, ESA, and piazza italia. A full list of project sponsors and volunteers is found in Appendix A.

Introduction

Purpose

What if we addressed local challenges with local solutions that have been tested and successfully used over eons by the local organisms, processes, and ecosystems (the "geniuses") that also call this place home? Biomimicry Oregon, a regional network affiliated with Biomimicry 3.8, with generous support from the Bullitt Foundation, recently convened 45 stormwater designers, researchers, policymakers, and entrepreneurs to share a few of the strategies employed by local geniuses to manage rainwater flow. Workshop participants ideated 30 novel ways to manage stormwater based on these lessons from nature.

The purpose of this report is to tell the story of developing a Genius of Place (GofP) study for the northern Willamette Valley, where Portland, Oregon is located. Project objectives were to:

- Catalyze the application of biomimicry in the Portland, Oregon area by developing a GofP study;
- Inspire tangible, sustainable design applications;
- Introduce 50-100 design and research professionals to biomimicry;
- Develop a process to guide further development of GofP studies in Oregon and other regions;
- Foster working collaborations among diverse partners; and
- Build the Biomimicry Oregon network.

This is a pilot project that 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, Engineering and Math (STEM) and environmental education.

What is a Genius of Place?

Landscape architects may recognize the phrase "Genius of Place" as the title of a recent biography of Frederick Law Olmsted's life. Those in sustainable agriculture may remember it in the title of a book Wes Jackson wrote a couple years ago, *Consulting the Genius of the Place: An Ecological Approach to a New Agriculture*. 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".

Biomimicry is the practice of learning from and emulating life's best ideas to create a sustainable world. Biomimics posit that all architecture and infrastructure design should be adapted to the local context. We can learn how to do this by starting with a simple question, "How does nature deal with this challenge *here*?"

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. The practice analyzes "a site's unique natural systems attributes and what local organisms are doing to leverage their environment." (Lazarus and Crawford, 2011)

The Genius of Place practice can address a wide range of existing challenges at various scales, including how buildings can reduce energy consumption or how city infrastructure can reduce or eliminate environmental toxins, and it has recently been identified as a potential focus area to help build regional biomimicry networks. 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 to develop sustainable strategies, but also to inspire kids to study science and technology, build stronger support for conservation, and inspire a greater sense of connection with the place they call home.

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.

Team Background

The Biomimicry Oregon Genius of Place team was multi-disciplinary, with a relatively high level of training in biomimicry, as shown in Table 1.

Name	Discipline	Project Role(s)	Formal Biomimicry Training
Ethan Smith	Design	Graphics Lead	Certified Biomimicry Specialist
Karen Allen	Biology	Biology Research Lead, Workshop Facilitator	Certified Biomimicry Professional
Lauren Bruschi	Student	Outreach & logistics, all around support	N/A
Mary Hansel	Business	Project Manager, Fundraising, Outreach Lead, Report Lead	Certified Biomimicry Professional
Matt Piccone	Design	Research: all project phases, Workshop Presentation Lead	N/A
Nicole Isle	Biology, Design	Research: all project phases, Fundraising, Workshop Presenter	Biologist at the Design Table & 3-day Workshop

Table 1. Biomimicry Oregon Genius of Place team.

Methods

Preparation

Before embarking on a Genius of Place study, review existing examples to get a feel for the process, identify a team, develop a work plan and schedule, and define the project's deliverables.

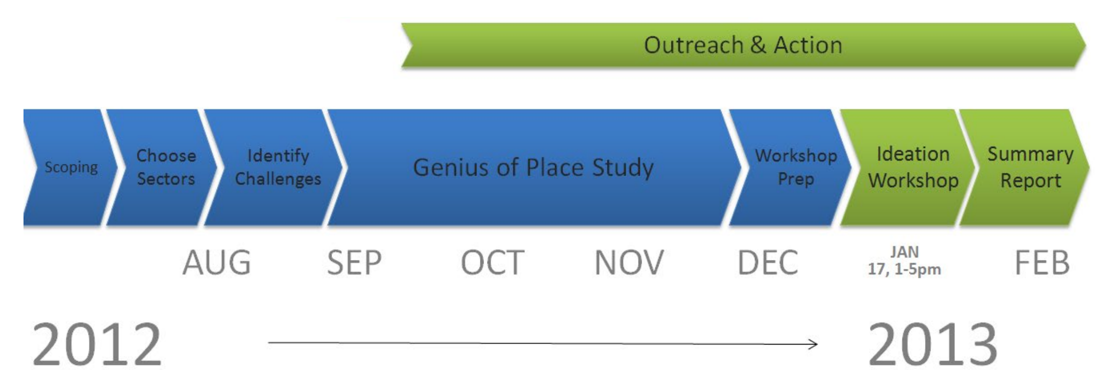
Identify a Team

In order to build an effective team, take the time to get to know one another's strengths, skills, and level of expertise in various aspects of the project. Share what each hopes to learn and contribute. Team members likely have differing levels of training in biomimicry, and it is important to be discerning about what roles and tasks each person takes on to leverage their strengths.

Develop a Work Plan

Before beginning the Genius of Place study, the Biomimicry Oregon team studied Biomimicry 3.8 examples from the Kyle Canyon and Lavasa projects. Karen also interviewed Biomimicry 3.8 staff for best practices and tips, and conducted a brief training on the GofP process for the rest of the team.

Biomimicry Oregon's work plan and schedule evolved throughout the project in response to on-going discovery and learning (Appendix B). The adapted process is documented below in hopes it will be helpful as a roadmap for others undertaking a Genius of Place study. The team completed this project in about eight months as shown in the schedule below, but a similar project could be done in a considerably shorter time.



Define Project Deliverables

It's helpful to have a final deliverable in mind in order to focus research efforts. The team agreed early on to develop one-page "Local Genius Summaries" for each organism and strategy, modeled on the Kyle Canyon project (Aldrich Pear and Biomimicry B3.8, 2011), as well as this report on the project process and results.

Each Local Genius Summary includes the relevant function, organism name and photograph, a short biology story, description of the strategy and mechanism, the design principle, the top two or three relevant Life's Principles, and references.

The Local Genius Summaries (Appendix C) were used in an ideation workshop, and the team plans to repurpose them for use with other practitioners and k-12 students.

Identify Local Design Challenge

After the team is assembled, and the work plan and deliverables defined, identify the project challenge. If the Genius of Place study is for a client, work with the client to identify their greatest challenges. If the project is not for a specific client, search for appropriate sectors and corresponding challenges that can be informed by place-based biological/ecological research. The latter was the case for Biomimicry Oregon's GofP study. With no specific client, the team looked to different industry sectors and their known challenges to form a basis for the study.

This step is critical for the following reasons:

- Builds a constituency who cares about the project (excellent for funding purposes);
- Focuses biological research; and
- Facilitates translation of design principles from nature that provide possible solutions to the design challenge.

Steps to identify a challenge:

1. Identify important sector(s) in your place (e.g., built environment, advanced manufacturing, agriculture).
    a. Establish criteria to select a sector.
    b. Select the sector(s).
2. Identify local environmental conditions that drive local species' adaptations (e.g., climate, topography).
3. Identify the challenge(s).
    a. Solicit ideas from the selected sector.
    b. Establish criteria to select the challenge(s).
    c. Check the relevancy of the challenge(s) against local environmental selection pressures.
    d. Select the challenge(s).
4. Learn enough about the challenge to identify a research question or questions that you can use to begin looking for biological solutions.

Identify the Sector(s)

To begin this process, the Biomimicry Oregon's Genius of Place team chose to map the current economic development priorities for the Oregon Innovation Council and the City of Portland against several criteria:

- Is the sector included in Bullitt Foundation grant funding application?
- Are we likely to find enthusiastic project partners and participants in the sector? Partners are needed to help identify and refine challenges, as well as to participate in the ideation phase.
- Is the sector likely to benefit by learning from locally adapted species? What is the applicability of place-based data to the sector?
- Is the sector newsworthy and attractive to media? Will we be able to gain the level of exposure needed to successfully expand interest in biomimicry?
- Is there potential for break-through innovation in the sector? Does momentum already exist within the sector to seek solutions to the challenge?

Results of the analysis are shown in Table 2.

To the Biomimicry Oregon team's knowledge, the Genius of Place process has only been applied to the built environment, specifically architecture and landscape design. Since a GofP study looks to the living world for design inspiration, relevant challenges must inherently be place-based. For this reason, the team decided to focus the project on the built environment, while expanding the focus to explore how it might apply to city policy-making and planning.

To focus our project, we reviewed:

- Current economic development priorities for the Oregon Innovation Council and the City of Portland;
- The potential for interested partners; and
- The applicability of place-based data.

Per this review, we decided to focus the project on the built environment, city planning, and policy sectors.

Sector	Included in Bullitt Grant application	Oregon Innovation Council economic priority	City of Portland economic priority	Applicability of place-based environmental data
Advanced manufacturing	•	•	•	Low
Alternative energy	•	•	•	Medium
Built environment (policy, planning, architecture)	•	•	•	High
Clean technology and industries	•	•	•	High
Food processing	•	•		High
Software			•	Low
Outdoor & Active wear Industries	•		•	Medium

Table 2.Genius of Place Sector Analysis

Identify Local Environmental Conditions

Species evolve in response to the surrounding environmental conditions in which they live, and good design is also context-specific. To help focus the challenge and future biological research, it is important to identify the predominant environmental conditions (selection pressures) that plants and animals have adapted in order to live successfully in the region. The Biomimicry Oregon team summarized local climate, topography, and dominant vegetation types, as well as pre-development conditions, urban stresses, and anticipated changes in future environmental conditions. Studying pre-development conditions and dominant ecotypes helped the team better understand what habitats to research.

Table 3 is a summary of key environmental conditions and resulting patterns in the northern Willamette Valley.

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.

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 3. Environmental Conditions and Resulting Patterns in Northern Willamette Valley

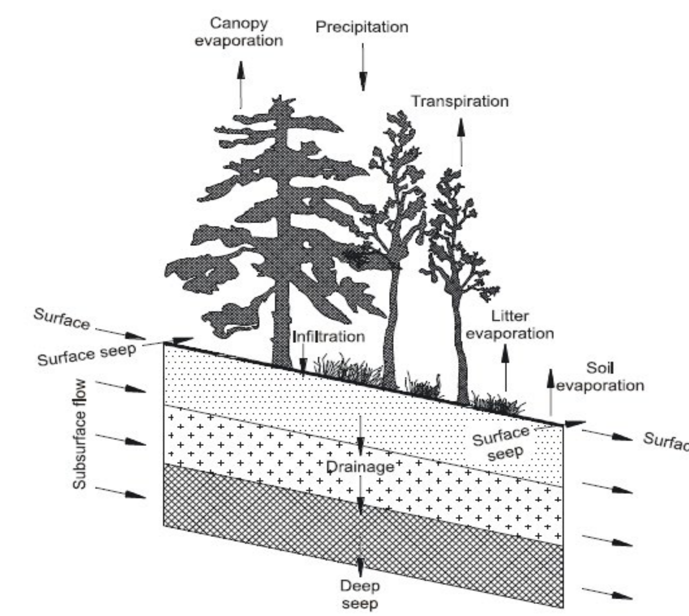


Figure 1. Water Movements (Lowrance et al., 2002)

Fast forward to current times and stormwater management issues have been compounded by impervious surfaces like roadways 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).

The team also identified anticipated future impacts from climate change to highlight the fact that solutions to the challenge should be resilient and adaptable. 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).

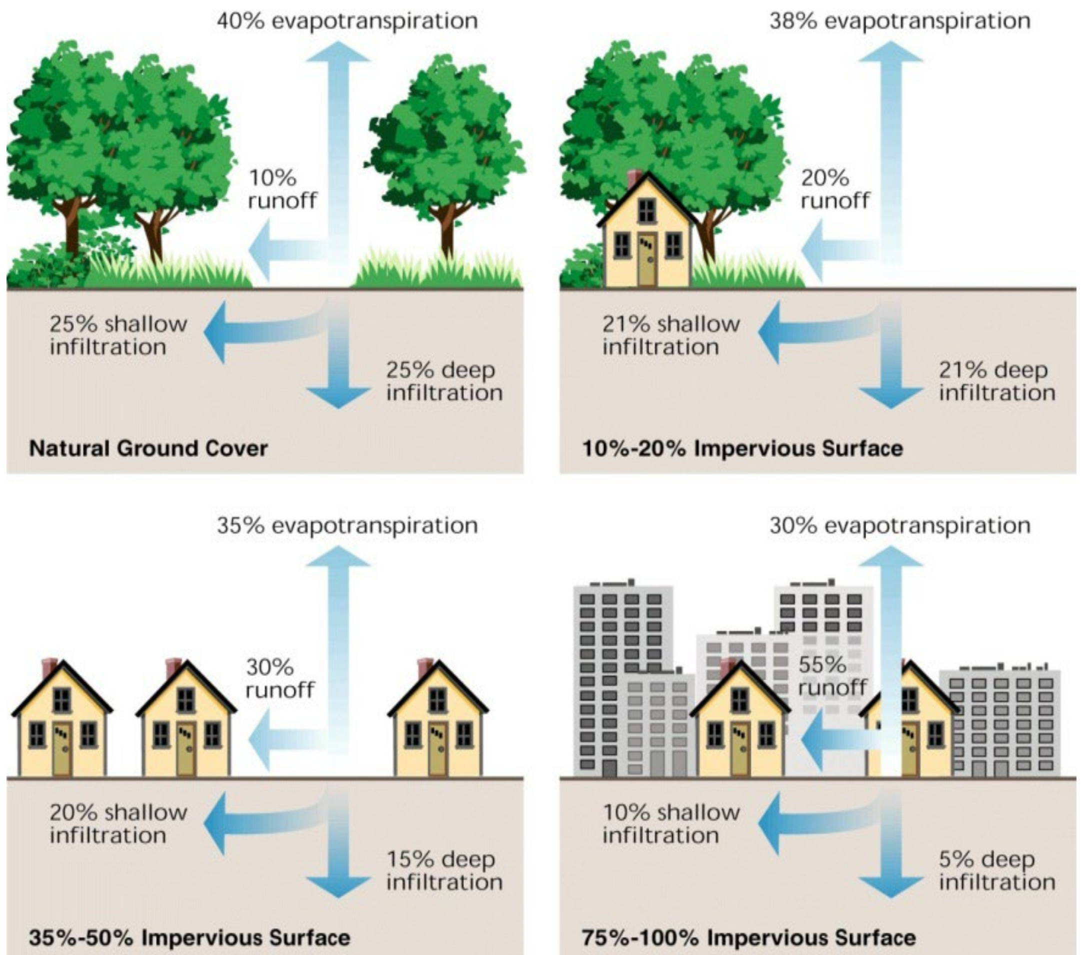


Figure 2. Relationship between impervious cover and runoff (FISRWG, 1998).

Identify the Challenge

To identify a specific challenge to research, the team convened a meeting of Biomimicry Oregon's multi-sectoral Advisory Group plus some additional guests to solicit their ideas for challenges, as well as names of other people to engage in the process. After the meeting, the team conducted several individual interviews, as well as an online survey (Appendices D & E).

Biomimicry Oregon used the following criteria to select their design challenge:

- Is the challenge related to major policy issues in the region (i.e., the Portland Plan)?
- Can the challenge be addressed at various scales to attract a diverse group of project participants (e.g., product, building, development, city, watershed, policymaking)?
- Are there enthusiastic champions of the challenge who will help us learn about it and help us attract participants for the ideation workshop?
- Are funds already being directed to this challenge? (i.e., Does the challenge matter to people now?) Can we tap into these funding sources to support our project?
- Is the challenge newsworthy and attractive to media? Will we be able to tell compelling stories about it?
- What is the applicability of place-based data to the challenge?
- Based on the results of this evaluation process, the team decided to dedicate the Genius of Place Study to the challenge of managing stormwater flows, believing the study could bring a fresh perspective to an issue that impacts all sectors of the built environment in our region and around the world.

The team chose managing stormwater flows as the focus for this study, an issue that impacts all sectors of the built environment.

Learn About the Challenge

The team conducted a literature review and several interviews with industry professionals to understand how the stormwater challenge has been defined in the region and what management strategies are already in place. Based on this research, the team refined several initial research questions into the following:

- How do 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?

Details from the research can be found in Appendix E.

Summarizing how the challenge most impacts the sector into a series of research questions provides focus for the biological research team.

Develop Genius of Place Study

Once the challenge is identified, begin the biological research process by following these steps:

1. Dig into the biological research.
2. Translate the biological research to design principles.
3. Identify the most relevant Life's Principles for each strategy.
4. Brainstorm application ideas.
5. Review biological research and design principles.
6. Develop graphics.

Conduct Biological Research

The biological research phase is designed to discover how local organisms and ecosystems respond to the challenge.

1. Establish a Data Collection Framework

In this step, set up an information sharing tool to collect the team's biology research data.

Information to collect may include:

- Common Name (organism / process / system).
- Scientific Name.
- Function (What does the organism / ecosystem *do*?).
- Strategy (1-2 sentence description of the specific strategy used by the organism to achieve the function).
- Mechanism (Specifically how the strategy works).
- Translated design principle (One sentence description of the basic, underlying principle at work, without reference to the biology).
- Source / citation.
- Photo link(s).
- Application idea(s).
- Who added / revised.
- Date added / revised.

We found it extremely important at this stage in the process for everyone to understand the difference between a function, a biological strategy, a mechanism, and a design principle (described below). The Biology Research Team Lead took responsibility to ensure that everyone was entering data properly since the accuracy of this data is essential to the next steps of a Genius of Place process and becomes a part of the final report.

Steps to complete biological research phase:

1. Establish a data collection framework and tool to consolidate the data (e.g., a shared spreadsheet).

2. Distill the challenge into functions where you can ask, "How does nature do X?"

3. Develop a list of organism and ecosystem strategies.

4. Select a subset of organism and ecosystem strategies to research further.

5. Do in-depth research on the selected strategies.

2. Distill Challenge into Function(s)

After identifying the challenge, distill it into a *function*, or functions, to focus the biological research. In biology, a *function* is a verb that describes what life is doing (Biomimicry 3.8, 2012). Examples include adhere, filter, or protect. In design, a function is what you want your design to *do*, e.g., illuminate, not what you want it to *be*, e.g., a light bulb. *Function* is the bridge between biology and design. Identifying the function you want to achieve allows you to explore how nature achieves that function. You can identify functions by asking "What do you want your design to do?" and "Why?"

A **function** is what you want your design to *do* and is the bridge between biology and design.

For the stormwater challenge, the Biomimicry Oregon team formed the following research questions from the functions they had identified:

- 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 research questions provide a portal into nature to help guide discovery of the various ways nature may respond to a challenge.

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3. Develop a List of Organism and Ecosystem Strategies

With research questions in hand, begin biological research by developing a list of organism and ecosystem strategies that achieve the identified functions. The purpose of this task is to produce a long list of nature's strategies that will later be filtered to a shorter list for more in-depth research. Generating this list will help identify common patterns and help ensure a variety of strategies are discovered.

Ideas to generate this list:

- Go outside to experience nature firsthand. Go to places where the challenge is occurring and study how nature is responding.
- Develop an initial brainstormed list. What does the team already know?
- Consult the AskNature database to find more ideas.
- Convene a bio-brainstorm meeting with local biologists and naturalists to collect more ideas.
- Perform a literature search. Use what you have learned already to decide how wide to cast your net.

AskNature is a free, online database of thousands of biological strategies, searchable by design function. It also includes hundreds of design ideas inspired by nature. AskNature is a great resource for any Genius of Place Study. (www.asknature.org)

A valuable source of information about local organisms can be found outside! One benefit of studying and selecting local organisms is that it enables team members to get out into the natural environment for inspiration and education. This can anchor the team in its understanding of the local environment, while also inspiring curiosity and attention to things often not experienced in daily life. This can be a great opportunity to involve people in the community, students and professionals alike, to join the team in order to learn more about the natural world.

Following is a list of written resources that, while not all-inclusive, provides a starting point for any Genius of Place study:

- AskNature database: http://www.asknature.org/.
- Encyclopedia of Life: www.eol.org.
- Scientific literature:
  1. Web of Science (electronic database available through universities).
  2. Google Scholar.
  3. Local or regional Research Forest publications.
  4. Leads from collaborating with local biologists.
  5. Leads from contacting university faculty.
- Books that:
  1. Specialize in 'champion adapters', organisms whose survival depends on solving the challenge well.
  2. Focus on the challenge (i.e., abundant water).
  3. General biology books:
     a. Exploring the Way Life Works (Hoagland, 2001).
     b. The Way Nature Works (Bailey, 1992).

Biology research resources will vary, depending on the ecosystem type(s) and selected challenge.

The Biomimicry Oregon team refined its research question as follows:

- What local organisms have an effect on evapo-transpiration, infiltration, collection / storage / absorption, or reduced runoff rates (including flood attenuation, or slowing down flow)?

Biologists on the team conducted an initial biology brainstorm and literature review. The research on local context and ecosystem types helped the team identify resources for the literature review. This was followed by a bio-brainstorm with local biologists and naturalists.

Using the "How does nature…?" questions identified above, the core team was joined by six biologists / naturalists to brainstorm organisms and strategies that helped solve the questions. The local biologists proved very helpful in both surfacing new ideas and suggesting references for the research. It also served as an opportunity to introduce biomimicry to a new audience.

A literature search was performed by three of the team members. In addition, a few of the biologists who attended the bio-brainstorm sent follow-up research findings.

The researchers brainstormed a list of resources to investigate, divided it amongst the team members, and reconvened periodically to evaluate the findings.

Findings from general internet searches were confirmed in the biological literature, since not all information on the internet is accurate. In fact, conflicting explanations were repeatedly found on the internet, highlighting the importance of grounding this phase in accurate, scientifically-based research. Citations were noted in the biology research data table.

The team identified 80 local organism and ecosystem strategies that manage stormwater flows (Appendix F).

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4. Select a Subset of Organism and Ecosystem Strategies to Research Further

More in-depth research is required to fully understand the mechanisms, or how the strategies identified in the previous task work. Steps to selecting a subset of strategies:

1. Identify re-occurring patterns across the strategies and consolidate strategies into groups.
2. Establish criteria to select which strategies to move forward with.
3. Select the subset of strategies for further research.

It is important that selection of organism and ecosystem strategies is based on strategies and design principles from nature rather than from human cleverness of an application idea. The process flows from biological strategy to design principle and then to application ideas.

The Biomimicry Oregon team planned to select five strategies to explore more deeply. First, the Biology Research Team Lead reviewed the long list of strategies and grouped like strategies together. Then, all team members voted on the strategies and organisms they thought should be further investigated. Each team member voted by marking their top choices in the Google research spreadsheet using numbers (i.e., 1 = top choice, 2 the 2nd choice, etc.). After group discussion, seven strategies were selected for deeper investigation. Some criteria driving these selections included covering multiple scales, public familiarity, and personal inspiration taken from the strategies, design principles, and / or application ideas.

Although the team did not actually identify objective selection criteria and map the favored organisms against them, we recommend this step to ensure only champion adapters are targeted for the challenge, and to reduce the risk of selecting biological strategies to support a pre-conceived application idea.

5. Do In-Depth Research on Selected Strategies

The objective of in-depth research is to develop a deep understanding of how an organism achieves the relevant function.

The steps in this phase:

1. Dive into the research to better understand how the organism achieves the function. Identify how the organism achieves the function (its strategy), and how the strategy works (the mechanism). A *strategy* is how an organism or ecosystem achieves a particular functional challenge. The *mechanism* is how the strategy works (Biomimicry 3.8, 2012).
2. Summarize the research, and translate the biology into a brief description of the strategy and mechanism that is understandable to a non-biologist.
3. Find images to help convey the information. Search for images with a creative commons license or obtain permission to use, if copyrighted.

A **strategy** is how an organism or ecosystem achieves a particular functional challenge. The **mechanism** is *how the strategy works.*

Translate Biological Research to Design Principles

Once the biological strategy and mechanism are understood, the next step is to translate the mechanism into a "design principle" that a policy-maker, architect, engineer, or product designer can use.

A design principle uses words that no longer contain reference to the biology, and developing concise and accurate design principles is perhaps the most difficult part of practicing biomimicry and doing a GofP study.

To maintain the integrity of the practice of biomimicry, the biology has to be accurate, and design principles must flow from biological mechanisms. A critical review of the research, design principles, and application ideas should be done by someone with a deep understanding of biology and biomimicry process, especially if the researchers have differing levels of biology backgrounds and experience with biomimicry. It is most efficient if this occurs prior to transmission of the research to the Graphics Lead.

Design principles developed by the Biomimicry Oregon team:

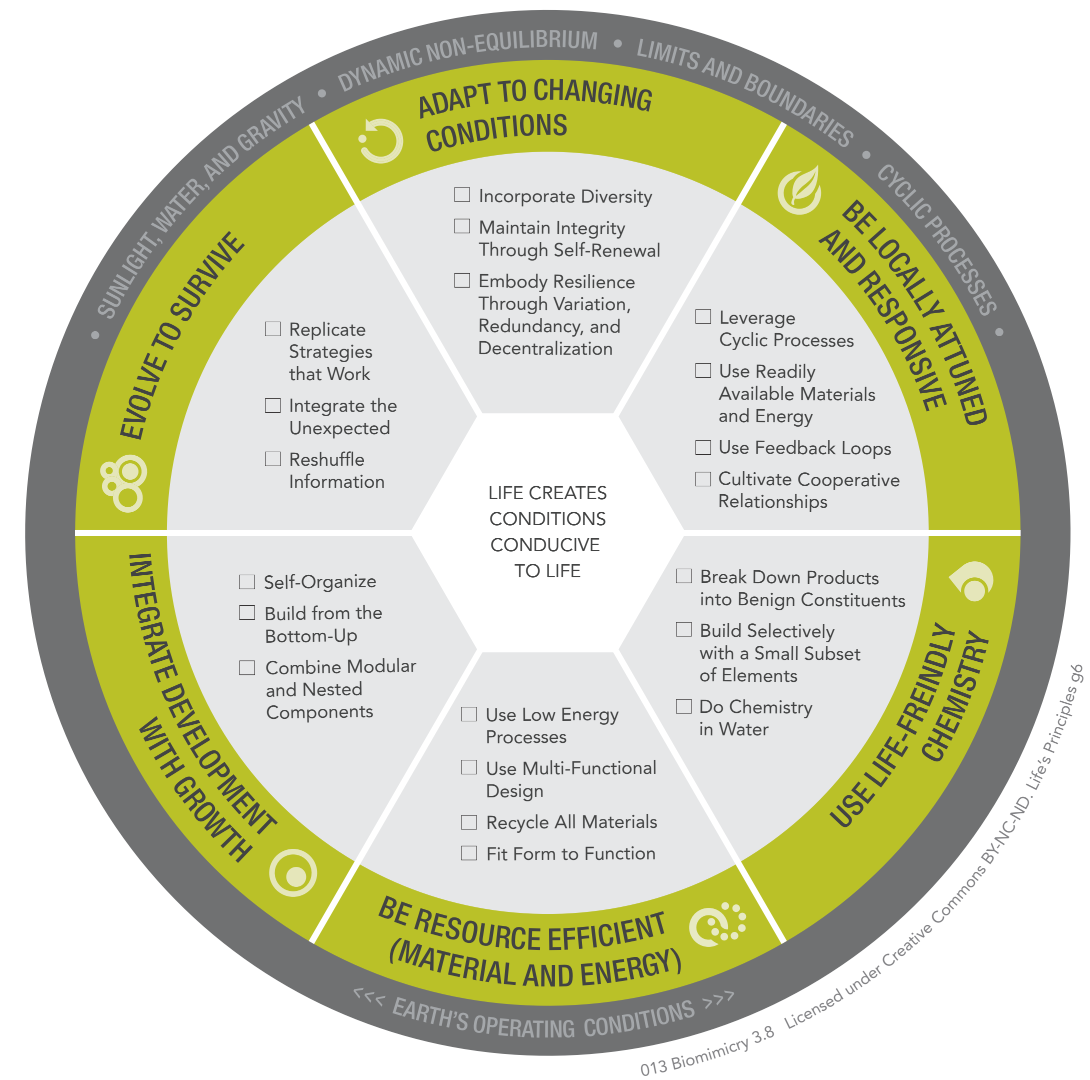
Organism / Ecosystem Attribute	Design Principle
Canopy Structure	Overlapping, redundant surfaces at multiple layers above the ground intercept and store water, reducing erosive force and increasing the potential for evaporation.
Downed Wood	Bundles of hollow cylinders transport water. Holes in the walls 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.

Identify the Most Relevant Life's Principles for Each Strategy

Life's Principles are overarching deep patterns found uniformly across most organisms surviving and thriving 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.

Due to the foundational importance of Life's Principles to biomimicry thinking, Biomimicry Oregon identified the top three to five Life's Principles illustrated by each organism or ecosystem strategy to include on the Local Genius Summaries.

Visit [Biomimicry 3.8's website] to learn more about the Life's Principles.



Brainstorm Application Ideas

The objective of this step is to brainstorm some simple application ideas that can be shared with others to give them a glimpse of how one might apply nature's principles to human designs.

Concept rendering by Sarah Steinberg, *strikeforcedesign.net*

Develop Graphics

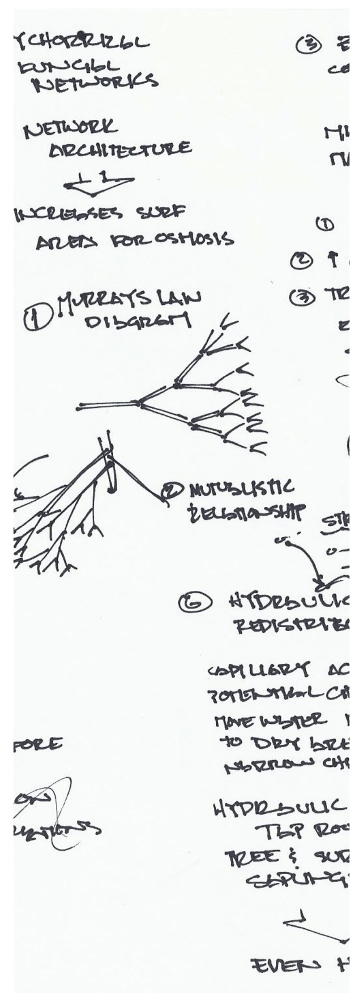
"*A picture is worth a thousand words*," so it is helpful to develop graphical representations of the design principles and application ideas. The Biomimicry Oregon team developed graphics for use in the Local Genius Summaries and the ideation workshop presentation.

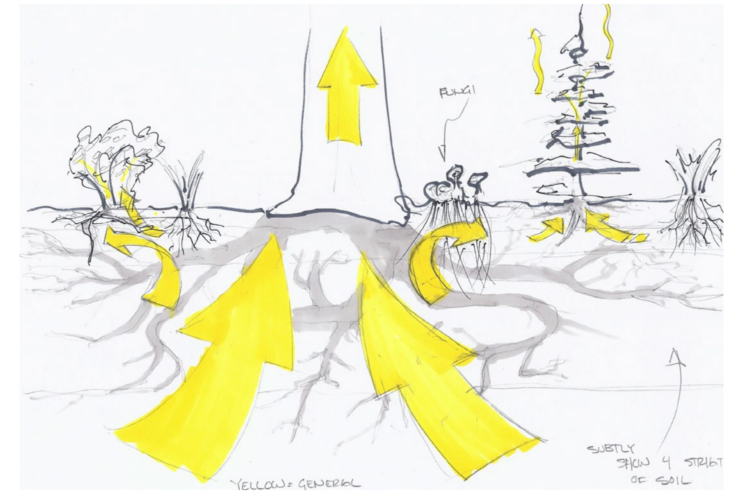
Communicating research and design principles to an illustrator forced the biologists to refine the clarity and core intent of the message(s) they hoped to communicate to their eventual audience. Visual thinking helped the entire team approach the biological stories and design principles from a variety of new perspectives and gain a better top-level view of the many ideas being presented.

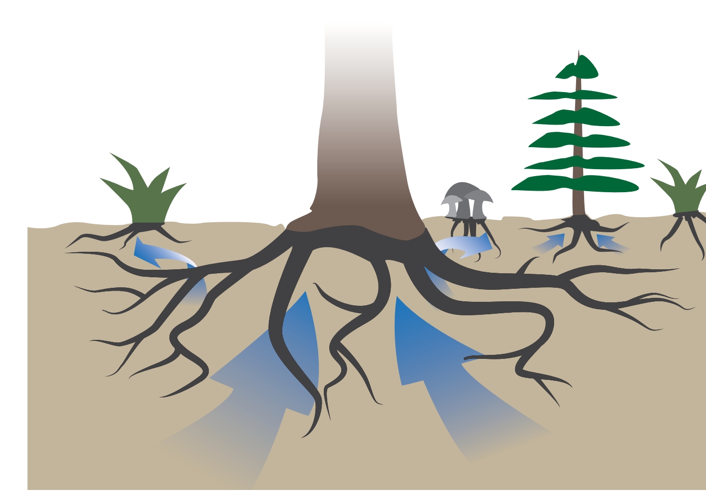
To initiate this process, the illustrator set up a shared spreadsheet that provided instructions for researchers to break down their findings into short blocks of information that would eventually be used in Local Genius Summaries and presentations (Appendix G). The categories included:

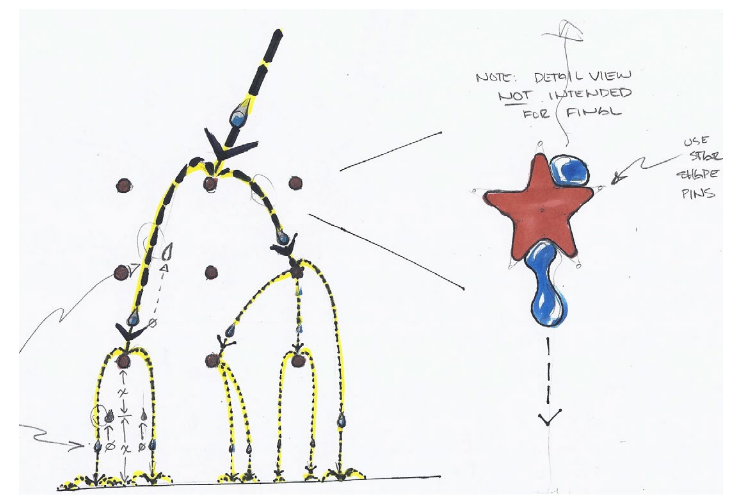
- Biological Strategy Focus (e.g., Diversity of Rooting Depths).
- Champion's Common Name (e.g., Black Cottonwood).
- Champion's Scientific Name (e.g., *Populus balsamifera*).
- Core Function (e.g., Absorb water).
- Biological Story (250 words or less).
- Mechanism (One sentence).
- Design Principle/s (One sentence each).
- Top Three Life's Principles.
- Possible Design Applications (One-two sentences each).
- Links to explanatory photos and illustrations.
- Notes.
- Researcher.

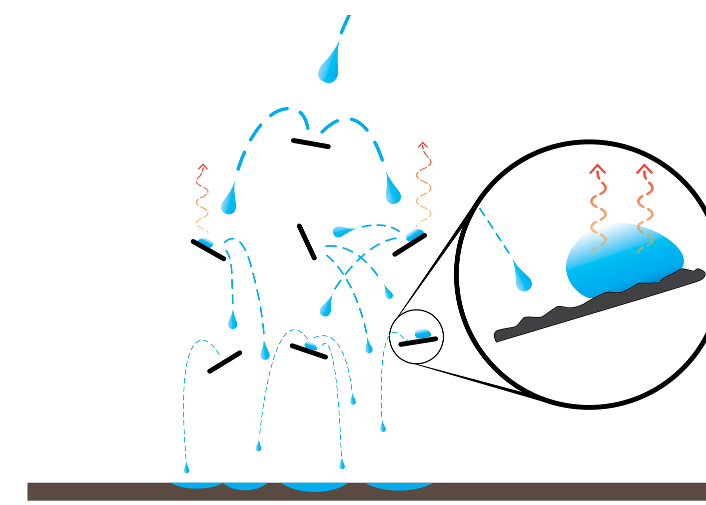
The illustrator worked with each biologist to help translate their research into appropriate morsels of information that aligned well in format and language with the information provided by the rest of the team. This initial exercise gave the illustrator the opportunity to gain an in-depth understanding of the research that had been performed and the design strategies that the researchers were attempting to communicate. Armed with this understanding, the illustrator produced napkin sketches to help describe each design principle and worked with each biologist to refine and tweak these sketches until they aligned with their intent. Once the sketches were all signed off, the illustrator produced a final rendered set of Local Genius Summaries that shared a common visual language (Appendix C).

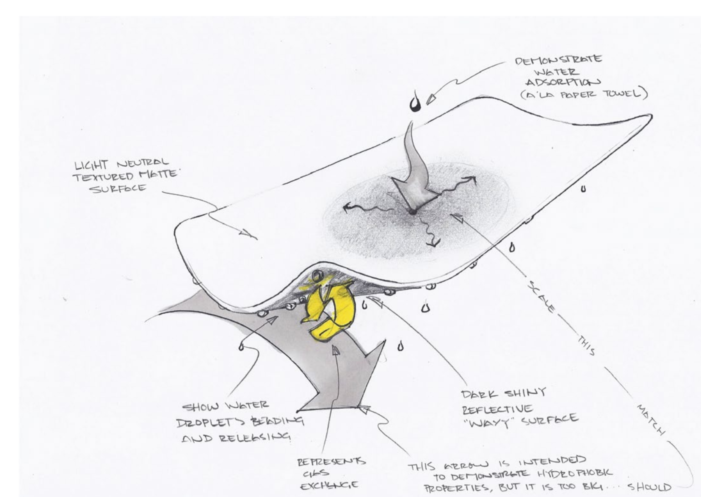


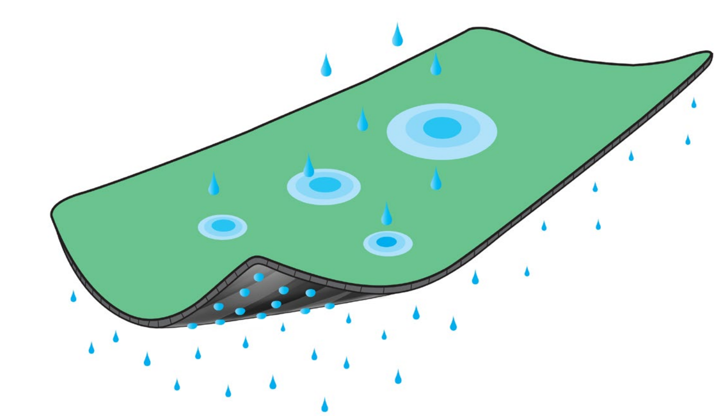












Ideate Locally Attuned Design Strategies

Ideation is about imagining possible design avenues. While the Biomimicry Oregon research team brainstormed some simple application ideas to share as examples, the real value in the Genius of Place process is to introduce the design principles to experts in the challenge's field and solicit their ideas. One way to do this is through an "ideation workshop." Workshop planning and outreach are described below.

Plan a Workshop

Steps for planning a workshop:

1. Develop workshop objectives and goals.
2. Plan logistics.
3. Develop the agenda & roles.
4. Develop workshop materials.

The Biomimicry Oregon team used two Google doc spreadsheets to plan the workshop. The first tracked logistics, workshop objectives, invitees/attendees, and sponsors. The second was the Workshop Agenda (Appendix H).

1. Develop workshop objectives and goals

The first step in planning a workshop is to identify the workshop objectives and desired outcomes. Then you can determine the length of the workshop in order to determine the date and reserve a venue. You also will need to be able to articulate the objectives to invitees.

The Biomimicry Oregon Team developed the following objectives and desired outcomes.

Workshop Objectives:

- Offer an interactive educational session focused on learning about biomimicry thinking, the Genius of Place process, and the stormwater flow management strategies of local organisms/systems.
- Inspire tangible design concepts that could be developed and applied to stormwater solutions (could be in realms of product, building, infrastructure, and/or policy design, for example).
- Increase understanding of what biomimicry is and its value as an innovation approach to solve sustainability challenges.

Desired Workshop Outcomes:

- Introduce ~50 design and research professionals to biomimicry as an innovation approach/framework for sustainable stormwater management.
- Introduce proven strategies used by local organisms/ecosystems to manage stormwater flows.
- Tangible design concepts that could be developed and applied to stormwater solutions.
- Participants feel inspired, curious, engaged, empowered (to look to nature and apply nature's inspiration), and interested in further exploring biomimicry as innovation approach.
- Seed future collaboration (participants with each other and/or with Biomimicry Oregon).

2. Plan Logistics

Logistics steps include:

1. Set date – Four months prior to anticipated workshop date:
   a. Poll the team to identify several available dates.
   b. Locate and reserve venue – getting the venue donated is a relatively easy form of sponsorship.
   c. Plan food & beverage – another relatively easy thing to get sponsored.
   d. Identify equipment and supplies needs.
   e. Secure volunteers to help with set-up, clean-up, check-in, video-taping, etc.

3. Develop the Agenda & Workshop Roles

Biomimicry Oregon's Workshop Facilitator obtained input from team members through a shared spreadsheet, created a draft agenda, and led a team meeting to refine the agenda and define roles (Appendix H).

4. Develop workshop materials

Each team member was responsible for developing presentation slides and talking points for their assigned portions of the workshop. Because there were four presenters, all talking points were compiled into one document to help develop a cohesive story line and avoid presenting redundant information.

Learning from other team members is one of the benefits of teamwork. Matt offered to develop the presentation in PREZI, an innovative presentation tool. Click here to view it.

Do Outreach to Attract Workshop Participants

Steps for outreach:

1. Identify target audience and number of people desired to participate.
2. Generate a list of people to invite.
3. Develop invitation & talking points.
4. Extend invitations.
5. Track responses and follow up as needed to fill the workshop to capacity.

The project challenge will largely influence who the target audience will be. A multi-disciplinary group will generate a diverse set of ideas and improve brainstorming outcomes.

Outreach materials, including e-mail text and a workshop flyer are in Appendix I. Biomimicry Oregon extended 87 invitations, with a 55% acceptance rate.

Virtually all those invited who declined expressed interest in either a future Genius of Place workshop or being kept informed about the project. All invitees were added to Biomimicry Oregon's contact database.


http://commons.wikimedia.org/wiki/File:Dandelion_seed.jpg

Results

Workshop Outcomes

Forty four stormwater professionals – engineers, architects and landscape architects, policy makers, entrepreneurs, and researchers – participated in a well-facilitated, energetic four-hour workshop. The interactive workshop focused on learning about biomimicry thinking, the Genius of Place process, the stormwater flow management strategies of local organisms and ecosystems, and ideating tangible sustainable design concepts at various scales. The attendee list is in Appendix J.

Approximately 30 design concepts were generated to “celebrate stormwater” (Appendix K). From “spongewood” to “living signs”, stormwater “trees”, awnings that “walk away” from a building, green roof promenades, and of course, “compcrete” (compost as additive to concrete mix)! 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 - as well as the COMOLEVI shade structure being used in Tokyo that was presented as a case study.

Although not part of the original project, the team held a “filtering” meeting on April 21, 2013 to review breakout group design concepts from the workshop. The group developed a list of the concepts deemed most practical (Appendix K).

The workshop presentation (Appendix L) was done in PREZI.

Two volunteers helped capture the workshop activities. The graphic recorder’s notes (see page 39) were available the day after the workshop. The workshop was also video-taped.

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!”

A summary of the written feedback is below. The evaluation form can be found in Appendix M.

- 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 (1 = not useful; 5 = useful & user friendly).
- 88% of respondents (22/25) would like to learn more about biomimicry.
- 72% of respondents (18/25) would like to engage further with Biomimicry Oregon, including nine who said they are interested in volunteering.
- Two people indicated they would like workshops for their organizations, and another said their company would help financially sponsor another workshop.

Network Building

This project allowed the team to develop assets – seven Local Genius Summaries and design concepts, this guidebook on how to do this type of project, and 100 new Biomimicry Oregon Network members that can be leveraged to catalyze future projects.

Focusing on this project brought three new volunteers to Biomimicry Oregon. They donated a significant number of hours to the project, and 19 other new volunteers helped with smaller contributions. Seven Biomimicry Oregon Advisory Group members also participated by attending meetings, connecting the core team with key interviews, and donating space to hold the workshop. Four new sponsors helped with the project by providing funds, food for the workshop, graphics, and printing.

Nine workshop participants indicated interest in volunteering with Biomimicry Oregon and 10 others indicated interest in engaging further through other projects or networking meetings.

Through invitations to participate in either the Bio-brainstorm or the Ideation Workshop, the team introduced 100 people to Biomimicry Oregon (possibly introducing them to the concept of biomimicry for the first time) - 28 local biologists and 72 local stormwater professionals. The project was also covered in Sustainable Business Oregon and the Oregon Public Broadcasting Ecotrope blog, presenting biomimicry and the Genius of Place Study to an even larger audience.

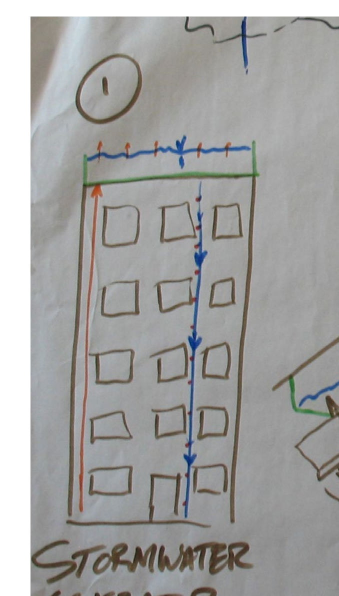
The Biomimicry Oregon Genius of Place team delivered a high quality project and proved its continuing ability to convene multi-disciplinary groups. Everyone involved in the project learned a lot about doing a Genius of Place study, collaboration, and about the place we call home.

Budget

The project budget was $17,800, compared with actual receipts of $13,340, or 74% of budget. Receipts consisted of cash receipts of $11,740 plus in kind donations of $1,600 (Appendix N).

Securing funds for an unproven organization is difficult! Fundraising efforts included talking with and submitting a sponsorship request letter to select architecture and engineering firms, talking with and submitting a grant application to a local soil and water conservation district, and asking for a $25-$50 donation from workshop participants. Biomimicry Oregon received $1,000 from Glumac, a top engineering firm dedicated to sustainable design, and $740 from workshop participants. At the end of the workshop, one participant indicated willingness to financially sponsor a future similar event.

In addition to falling short of revenue goals, the team spent many more hours on the project than anticipated. Budgeted hours were 406, compared with estimated 950 actual hours, or over 200% of budget. The original budget assumed 300 hours reimbursed at non-profit rate of $50/hour and 100 donated hours. The team cheerfully volunteered the hours to deliver high quality products.



Key Learnings

This project was a big learning experience for everyone on the team. No one on the team had ever done a Genius of Place study before. One of the team members, Karen Allen, had co-facilitated a Genius of Place workshop for HOK on a project in Lavasa, India, while two others had prior exposure to the concept through professional training from Biomimicry 3.8. One of the team members lives in a different corner of Oregon, so team meetings were largely conducted via Skype; distributed collaboration, where team members work from different locations, was new to some of the team members. While the team is satisfied with the project outcomes, the following key learnings - some of which we did and others that we wished we had - will hopefully help future projects run more smoothly.

Project Management Tips

- Take time at the beginning of the project to get to know each other. Convene an in-person meeting to discuss each member's strengths, skills, and levels of expertise in various aspects of the project. Share what you hope to learn and to contribute. Discuss the opportunities and challenges in working with a distributed team.
- Leverage each person's skills, strengths, and depth of biomimicry experience / training by matching project roles to strengths. Let the various disciplines on the team do what they do best (i.e., have biologists do biological research and designers develop application ideas, etc.). Be discerning about roles and tasks taken on by those with little or no training in biomimicry, and ensure they fully understand what they are being asked to do.
- Include adequate review time in the schedule and ensure the team sticks to the agreed upon schedule.
- Condense the project schedule. Our team did the project in 9 months, but it could be done in 4-5 months. A slow start to our project - due in large part to not having a client, lack of clarity about what we would work on, and unexpected death in the project manager's family - stalled team enthusiasm early on. It took the team about 4 months to identify the challenge; condense that to one month. See Appendix B for our schedule.
- Communicate! Encourage all team members to communicate about their availability, ask questions about roles / tasks, if needed, etc.
- Developing a GofP "fact sheet" summarizing key project information to give to the press, and for the team to use as a quick reference, proved useful.
- Select a project management tool and stick with it… too much for the team to learn different tools. The team tried a couple of free, web-based project management tools to share documents, calendars, etc., and ended up using Skype and Google docs extensively for communications, project management, and document sharing. Even these tools were challenging for some team members to master.

Communications and Fundraising Tips

- Develop a communications plan and engage a volunteer or team to handle communications. Although a new volunteer developed a great communications plan for this project (Appendix O), Biomimicry Oregon has still not engaged people to handle communications and the core team did not have the bandwidth to carry out the plan, other than getting articles placed in Sustainable Business Oregon and the Ecotrope blog.
- Find a dedicated volunteer/team to do fundraising, and begin as soon as the value proposition for the project is identified in order to maximize sponsorship opportunities.

Selecting a Challenge Tips

- If the project intent includes building a network, identify a challenge relevant to those you want to engage.
- Our team found individual interviews the most effective way to surface potential challenges.
- Start the project by identifying a challenge; this will facilitate engaging with professionals by developing design principles that apply to a challenge with a "constituency" you can reach out to.

Biological Research Tips

- Ensure the whole team engages in the selecting organism / ecosystem strategies for in-depth research. This is a critical step that shapes the rest of the project that everyone will spend energy and time on.
- Design-oriented team members may want to jump to the solution space too soon; this showed up during our research phase and actually drove some of the strategy selection. Attention to ensuring application ideas are derived FROM the design principles (which are derived from the biological strategies) rather than from human cleverness and ingenuity…ensures you're doing biomimicry.
- Develop selection criteria for choosing organism / ecosystem strategies for in-depth research to ensure selecting champion adapters for the challenge, and to reduce the risk of selecting biological strategies to support pre-conceived application ideas.
- Although the team did not actually identify selection criteria and map the favored organisms against the criteria in order to select the strategies to proceed with, we recommend doing this. The project manager identified some sample selection criteria for this step in the work plan, but failed to circle back to it during this step to engage the whole team in developing and agreeing on criteria and then using it in the selection process. The sample criteria that were *not* used were:

  1. champion adapter (for challenge)
  2. well-known to general public
  3. keystone species

- Have the Biology Research Lead review the team's biology strategies, mechanisms, and design principles before the information is sent to the Graphics Lead. The Biology Research Lead could also be the sole point of contact with the Graphics Lead during the development of Local Genius Summaries to streamline the process and help ensure the integrity of the biology.

Genius of Place Process Report > Results > Key Learnings

Workshop Tips

- Consider looking into registering future workshops to be able to claim CEU/PDH for continuing education hours.
- Begin outreach to attract participants for the ideation workshop early. For example, you might ask people being interviewed to learn about the challenge who they recommend inviting to attend the workshop. It's also helpful to obtain support from leaders in the field early, and then use their names to attract participants.
- Ensure the team understands that the purpose of the ideation workshop is to bring design principles to participants for them to play with… not to bring fully formed solutions already developed by the team.
- Include a plan for workshop follow-up. This project has generated a lot of enthusiasm for biomimicry and the Genius of Place process, which the small, all volunteer working group is ill equipped to handle.
- Plan for how to help catalyze application of design concepts generated in the workshop. The team did convene a few of the more pragmatic workshop attendees to "filter" design concepts generated in the workshop to 3-5 of the most practical and brainstorm next steps to move them forward. This work was neither anticipated nor funded.

Early on, since the team did not have a specific client and desired to reach out to a variety of sectors, we discussed the idea of a project approach beginning with selecting a couple of local iconic organisms like salmon and Douglas Fir to research, followed by identifying challenges and abstracting design principles based on interesting biological strategies discovered, and convening a wide range of designers from various sectors to ideate possible applications. The team agreed that identifying a challenge up front was crucial to focusing the biological research and abstracting design principles that were relevant to the challenge.

Although our team followed a "challenge to biology" approach, we can envision a school doing a Genius of Place study by following a "biology to design" approach, where they would begin in their own 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.

Visual notes provided by Doug Neill, *The Graphic Recorder*

Next Steps

Workshop Follow-up

The team followed up on information in the workshop evaluation forms, and convened a small group of stormwater practitioners to identify the most promising ideas generated in the workshop to explore potential for implementation. The team also plans to publicize project results.

Genius of Place Central Component of 2013-2015 Strategic Plan

The team documented a process and developed seven Local Genius Summaries that Biomimicry Oregon will leverage as the centerpiece of its 2013-2015 strategic plan, focused 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 Education Collaborative

Biomimicry Oregon wrote a grant application and is actively looking for funding to leverage the Genius of Place study by convening a Biomimicry Education Collaborative for k-12, designed to empower students as stormwater designers, problem solvers, and community conveners.

Resources

Exploring the Willamette River near West Linn, Oregon

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Appendices

Thank you

Project Sponsors

The Bullitt Foundation
Glumac
City of Portland Bureau of Planning and Sustainability
Environmental Science Associates
Piazza Italia

Volunteers

Doug Neill, The Graphic Recorder
Kate Schuyler, Freelance
Brandon Sprague, Brightworks
Sarah Steinberg, Strikeforce Design
Many others who helped with interviews, brainstorming, and wise counsel

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Nicole Isle, Glumac
Matt Piccone, SERA Architects
Ethan Smith, Certified Biomimicry Specialist, ÆVI

Mentors

Nature
The gang at Biomimicry 3.8:
Janine Benyus
Dayna Baumeister
Bryony Schwan
Timothy McGee
Holly Harlan
Jamie Dwyer
Faye Yoshihara, Forest Fractal

BIOMIMICRY OREGON

Genius of Place Stormwater Project
Appendix A
Project Sponsors and Volunteers

The Biomimicry Oregon Genius of Place project team sincerely thanks all of our sponsors, volunteers, and workshop participants, without whom this project could not have been successful!

Name	Organization	Contribution
MENTORS		
Nature	Earth	Inspiration, instruction
Dayna Baumeister & Janine Benyus	Biomimicry 3.8	Vision, inspiration, instruction, Genius of Place process
SPONSORS		
Amy Solomon	The Bullitt Foundation	Funding
Craig Briscoe	Glumac	Funding
Vinh Mason	City of Portland Bureau of Planning and Sustainability	Workshop facility
Lauren Bruschi	piazza italia	Workshop food
Marjorie Wolfe	ESA	Printing
PROJECT TEAM		
Ethan Smith	Aevi llc	Graphics Lead
Karen Allen	Aequinox	Biology Research Lead, Workshop Facilitator
Lauren Bruschi	Student	Outreach, logistics, all around support
Mary Hansel	Freelance	Project Manager, Fundraising, Outreach Lead, Report Lead
Matt Piccone	SERA Architects	Research: all project phases, Workshop presentation development
Nicole Isle	Glumac	Research: all project phases, Fundraising, Workshop Presenter
OUTREACH		
Brandon Sprague	Brightworks	Communications plan
Faye Yoshihara	Forest Fractal	Interviews with media
KICKOFF MEETING ATTENDEES		
Bob Wise	Cogan Owens Owens, LLC	
Corie Harlan	Metro	
Darcy Winslow	Academy for Systemic Change	
Debra Taevs	Pacific NW Pollution Prevention Center	
Faye Yoshihara	Forest Fractal, LLC	
Howard Silverman	Solving for Pattern	
Johanna Brickman	Oregon BEST	
Mark Perepelitza	SERA Architects	
Mike Houck	Urban Greenpaces Institute	
Vinh Mason	City of Portland	
INTERVIEWEES		
Candace Stoughton	East Multnomah Soil & Water Conservation District	
Jennifer Belknap-Williamson	City of Gresham Watershed Division	
Linda Dobson	City of Portland Bureau of Environmentalt Services	
Michelle Brenes	PECI	
Mike Houck	Director, Urban Greenspaces Institute	
Pam Neal	Portland Development Commission	
Rod Lundberg	Freelance	

Genius of Place Stormwater Project
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Name	Organization	Contribution
BIO-BRAINSTORM PARTICIPANTS		
Bonnie Schoffner	Metro	
Deb Scrivens	Metro	
Emilie Bess	USDA entomologist	
Kate Holleran	Metro	
Mandy Stanford	Oregon Zoo	
Nan Woodman	BProfessional	
GRAPHICS		
Daniel Cole	Freelance	Design principles, Local geniuses summaries
Sarah Steinberg	Strikeforce Designs	Application idea renderings
WORKSHOP RECORDING		
Doug Neill	The Graphic Recorder	Visual recording notes
Kate Schuyler	Freelance	Videotape
WORKSHOP PARTICIPANTS		
Angela Wieland	Brown and Caldwell	
Bill Hart	Carleton Hart Architecture	
Brandon Wilson	City of Portland	
Brian Wethington	City of Portland Environmental Services	
Bruce Roll	Clean Water Services	
Candace Stoughton	EMSWCD	
Carol Mayor-Reed	Mayer/Reed	
Casey Cunningham	City of Portland Environmental Services	
Chris Larson	Larson Ventures	
Craig Briscoe	Glumac	
Dave Whitaker	DK Whitaker Engineering	
Deb Scrivens	Metro	
Elle Allan	City of Gresham, Watershed Division	
Emily DeWolfe	International Living Future Institute	
Faye Yoshihara	Forest Fractal, LLC	
Geoff Winslow	Glumac	
Ginny Stern	Sunnyside Environmental School	
Heather DeGrella	GreenCE, Inc	
Ivy Dunlap	City of Portland Environmental Services	
Jason King	TERRA.fluxus LLC	
Jay Kosa	International Living Future Institute	
Jennifer Belknap-Williamson	City of Gresham	
Joann Herrigel	City of Milwaukie	
John Houle	City of Portland Environmental Services	
Jon Dykhuizen	Mayer/Reed	
Jon Gray	Interface Engineering	

The Biomimicry Oregon Genius of Place project team sincerely thanks all of our sponsors, volunteers, and workshop participants, without whom this project could not have been successful!

Name	Organization	Contribution
WORKSHOP PARTICIPANTS		
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Linda Dobson	City of Portland Environmental Services	
Marjorie Wolfe	ESA	
Mark Anderson	CH2M HILL	
Matt Burlin	City of Portland Environmental Services	
Paul Dedyo	KPFF Consulting Engineers	
Roberta Jortner	City of Portland Planning & Sustainability	
Rod Lundberg	Unaffiliated	
Ryan Carlson	Mayer/Reed	
Scott South	Stevens Water Monitoring Systems, Inc.	
Ted Hart	Portland State University	
Tim Richard	Metro Regional Government	
Tom Liptan	Idea-er	
Vinh Mason	City of Portland Planning & Sustainability	
Vivek Shandas	Portland State University	

Biomimicry Oregon Genius of Place Stormwater Project

Appendix B

Work Plan & Schedule

xx = projected

/ xx = actual

			month	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
				2012								**2013**		
	Task	**Team**	**Outcomes/ Deliverables**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
1	Project Management	Mary												
1.a.	Develop project plan / team kickoff meeting	Mary	1. Schedule, list of deliverables, & budget 2. Contracts with scopes of work 3. Communications, document sharing, action & decision log protocols 4. Project team contact list	xx / xx	xx / xx									
1.b.	Outreach plan: when to do press releases, ID where press releases go, how to build network	Nicole	Outreach plan, including roles											
1.b. 1.	meet with brandon sprague	Nicole / Mary				xx								
1.c.	Manage budget / schedule	Mary	Keep budget and schedule on track											
1.d.	Weekly meetings	Mary / all	Accomplish project goals											
A	Train/align core GoP team on GoP process & outcomes	Karen / all	Team alignment on GoP process and outcomes											
A.a.	Interview B3.8 staff for latest best practices (Dayna, Jamie, Taryn, Tim)	Karen	List of GoP best practices			xx								
A.b.	Review & discuss B3.8 examples	Karen / all	discussion in 7.17.12 weekly mtg, update schedule to reflect consensus on approach; solicit TM feedback			xx								
A.c.	Meet with Tim McGee to discuss essentials of GoP and our approach a) Invite entire core group	Tim / all	GoP training with Tim McGee, in-person											
2	Outreach to identify challenges in various	Matt / all												
2.a.	Develop criteria to identify sectors a. included in Bullitt Grant application? b. enthusiastic participants? c. priority for City and/or State? d. newsworthy / attractive to media? e. likely for break-thru innovation? f. place-based (value of GoP)	Mary / Ethan	List of sector evaluation criteria			xx								

Biomimicry Oregon Genius of Place Stormwater Project

Appendix B

Work Plan & Schedule

xx = projected
/ xx = actual

			month	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
							2012						2013	
	Task	**Team**	**Outcomes/ Deliverables**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
2.b.	Draft list of potential sectors & selection a. evaluate against criteria b. bring the Advisory Group for discussion / confirmation	Mary /	1. Matrix of sectors and selection criteria 2. List of sectors and contacts for each 3. Table of selected sectors and rationale for selection			xx								
2.c.	Identify ecoregion (wwf), and main selection pressures in Portland area (to drive overarching theme)	Karen	Ecoregion & SPs to all in core group			xx								
2.d.	Develop GofP for 1 organism: organism, strategies, design principles for Advisory Group Mtg.	Nicole & Ethan	GoP graphics & infographic template			xx								
2.e.	Plan Advisory Group meeting a. who, when, where b. what - id sectors, align on project approach, id contacts, list of needs they can help with c. develop agenda	Nicole, Ethan, Mary	1. Agenda 2. Logistics 3. Meeting materials - sample GoP principle, sector evaluation, list of project needs			xx								
2.f.	Meet with Advisory Group a. Share 1 GofP example and walk through project & workshop ideas. b. Solicit contacts & challenges. c. Solicit help with project tasks - who wants to play? (include others from id'd sectors in this meeting as well? i.e., Green Sports guy, woman who works with pollution prevention in advanced mfg... sectors we haven't yet worked with?)	Ethan / all	1. Alignment on project approach & sectors 2. Shared understanding of Genius of Place 3. List of contacts in each selected sector 4. Draft list of challenges in each sector 5. List of who wants to be more heavily involved in the project (i.e., facilitate focus groups to id challenges, fundraise, do outreach for workshop, help find workshop venue, etc.)			xx								
2.g.	Identify 1 top local challenge in selected sectors a. develop outreach strategies (ask Advisory Group? survey monkey? focus groups? individual interviews?) b. execute outreach strategies	Matt / all	1. List of local challenges, keyed to sector and people 2. Press release			xx	xx	9/11						
B	Fundraising													

Biomimicry Oregon Genius of Place Stormwater Project

Appendix B

Work Plan & Schedule

xx = projected
/ xx = actual

			month	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
				2012								**2013**		
Task		**Team**	**Outcomes/ Deliverables**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
B.a.	Develop & execute fundraising strategy (once sectors/challenges identified) a. Develop funding strategy & outreach materials (consult with Doug & Holly) b. Develop list of potential sponsors/funders c. Meet with potential funders		1. Funding outreach materials 2. List (google doc) of potential funders, contact info, strategy for contact, person responsible to contact 3. $8,200 in funds / in-kind for facility, food			xx	xx	xx	xx		xx			
3	Develop genius of place for 3-5 organisms/5 strategies	Karen/ Nicole, Ethan												
3.a.	Identify 3-5 organisms for GoP a. define selection criteria * champion adapter (for challenge) * well-known to general public * keystone species b. meeting with local naturalists - bio-brainstorm functional challenges	Nicole / Corie, Karen	1. 3-5 organisms for GoP research 2. Press release				xx			xx				
	3.a. b. bio-brainstorm to engage local biologists in project/introduce them to biomimicry								xx					
3.b.	Biological research a. establish data collection framework b. define content & format for research findings & deliverables c. research!	Karen, Matt, Nicole	Table of research findings						xx	by 11/23				
3.b.	pattern recognition in research	Karen & Nicole								by 11/26				
	Core Team chooses top 5 strategies through voting (involve those who have challenges in choosing which strategies to narrow down to?)	Karen/ Nicole/ Matt								by 11/27				
3.c.	Abstract GoP organism mechanisms & develop design principles	Karen / Nicole, Tim M., Ethan	1. Description & graphics of strategies/mechanisms 2. Description (& graphics?) of design principles							xx	by 12/8: asset submission to Ethan			

Biomimicry Oregon Genius of Place Stormwater Project

Appendix B

Work Plan & Schedule

xx = projected
/ xx = actual

			month	1	2	3	4	5	6	7	8	9	10	11
				2012								2013		
	Task	**Team**	**Outcomes/ Deliverables**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
3.d.	Graphics: Develop GoP sheets (1-2 pg worksheet per strategy)	Ethan / Karen, PNCA, AI students	1. GoP infographics 2. Press release								xx	xx		
4	Outreach to attract workshop attendees													
4.a.	Develop & execute workshop outreach strategy a. Identify potential workshop attendees b. Develop outreach strategy & materials c. Do outreach to potential workshop attendees	Mary / All	1. (google doc) of potential workshop participants, contact info, strategy for contact, person responsible to contact 2. Outreach strategy and materials 3. List of workshop attendees					xx	xx	xx	xx			
5	GoP Ideation Workshop(s) (1 day)	Karen / Nicole	Design ideation workshop(s)									1/17/13, 1-5pm		
5.a.	Plan workshop(s) a. review list of targeted attendees (4.a.) b. Identify # of workshops c. Develop agenda d. Identify facilitators (and invite?)	Karen / Nicole, Mary, Ethan	1. Workshop(s) details - size(s), date(s) 2. Agenda 3. List of facilitators				1. xx							
5.b.	Workshop logistics a. Reserve date(s) & place(s) b. Invite attendees c. Arrange food d. Facilitator agreements	Mary / Lauren	1. Workshop location reserved 2. Facilitators' agreements				xx			xx				
5.c.	Develop presentation (in PREZI)	Matt/All										final draft by 1/10		
5.d.	Hold workshop(s) (budget includes $1,400 for facility and food, and $200 for printing/materials)	Karen & Nicole / all										1/17, 1-5pm		
5.e.	Workshop followup (e-mails, documentation, follow-up on pragmatic ideas)	Mary / Nicole												
6	Summary Report	Mary / Ethan												
6.a.	Draft outline	Mary					xx				xx			

Biomimicry Oregon Genius of Place Stormwater Project

Appendix B

Work Plan & Schedule

xx = projected
/ xx = actual

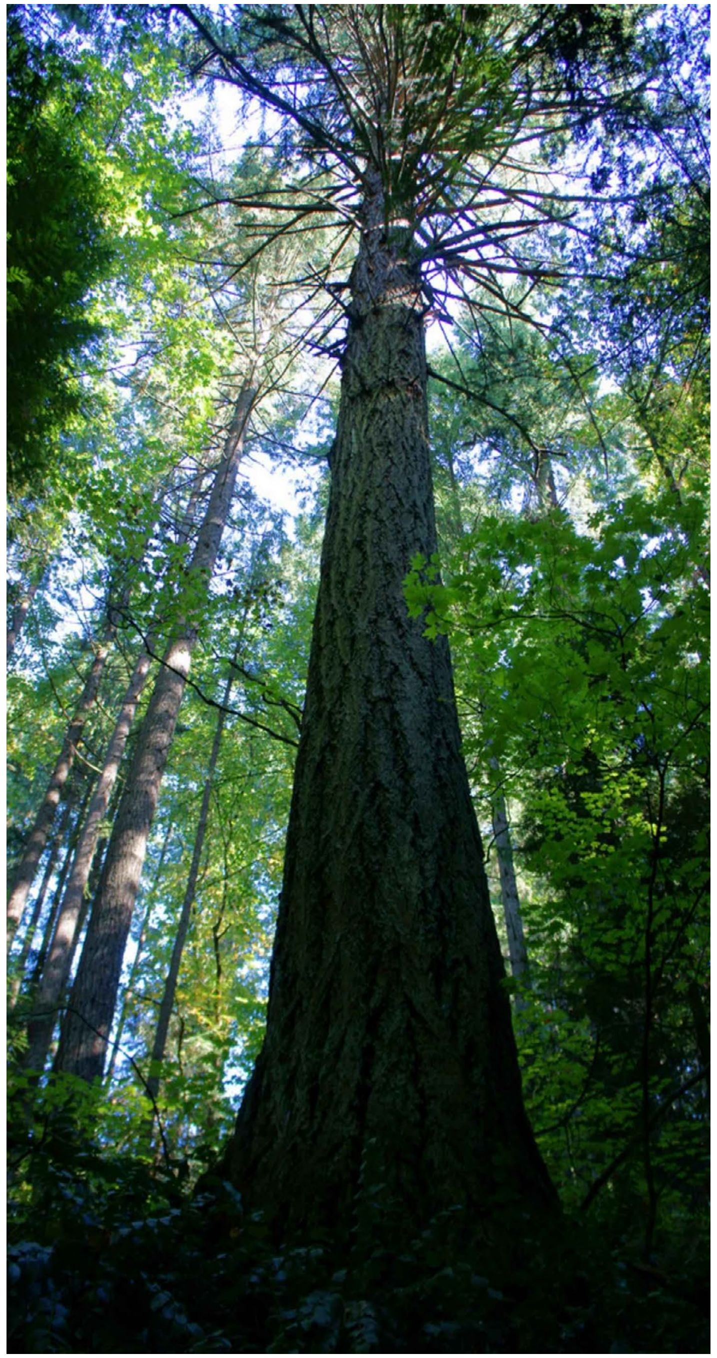
	Task	Team	Outcomes/ Deliverables	2012 May (1)	June (2)	July (3)	Aug (4)	Sept (5)	Oct (6)	Nov (7)	Dec (8)	2013 Jan (9)	Feb (10)	Mar (11)
6.a.	Draft report a. GoP process/methods b. info graphics c. application ideas/outcomes of workshop d. brainstorm & summarize next steps/how to leverage use of GofP	Mary / Ethan	Draft report										xx	xx
6.b.	Brainstorm next steps for region's GoP	Mary / all	Paragraph for Summary Report										xx	
6.c.	Develop outreach & communications plan (of GofP process)	??	Outreach & communications plan										xx	
6.d.	Final Report (budget includes $200 for printing)	Mary / Ethan	1. Report to Bullitt and ?? 2. Press release											Mar 1

Notes

1. Number on each task (i.e., "1. Prepare project plan") corresponds to task number on budget. If there is a capital letter in front of the task (i.e., "A. Identify potential funders"), it was not included in the budget submitted to Bullitt.

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

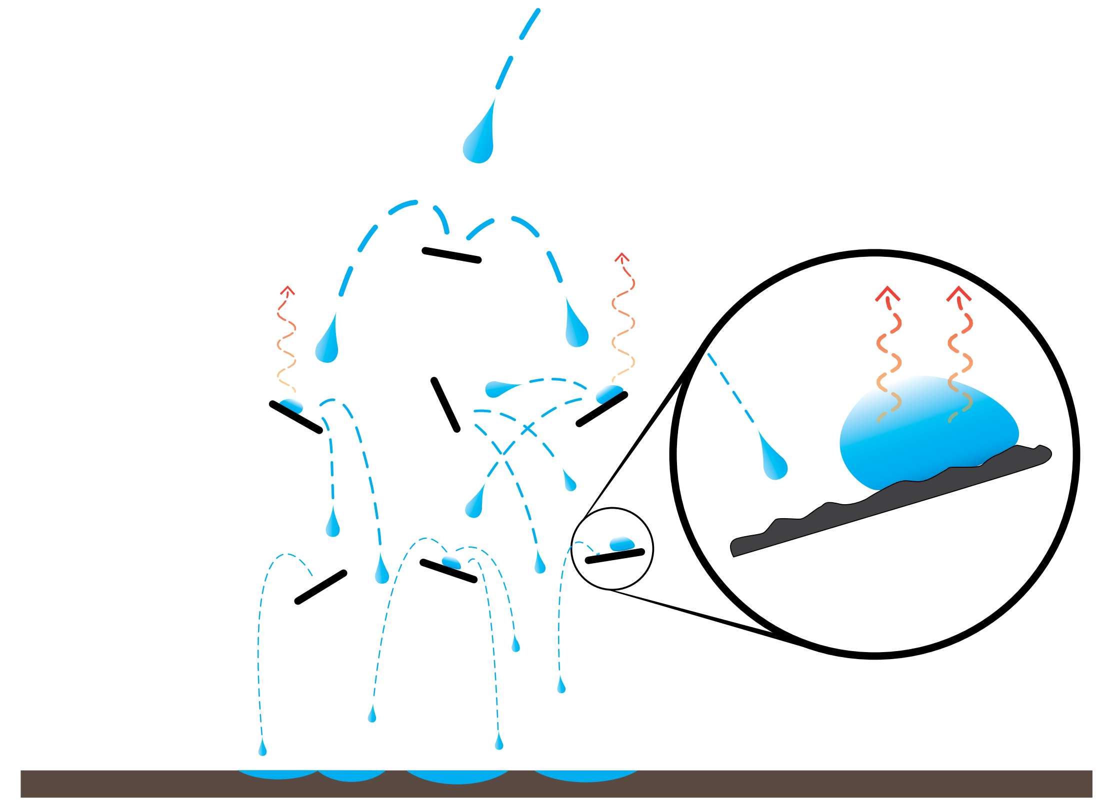
Allen, Scott T. 2012. Trickle-down ecohydrology : complexity of rainfall interception and net precipitation under forest canopies. OSU thesis.

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.

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



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

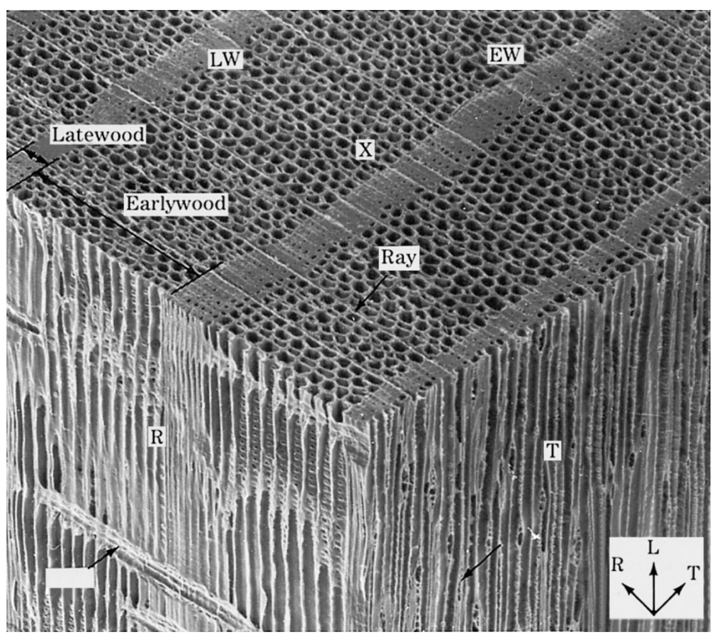
Application Ideas

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).

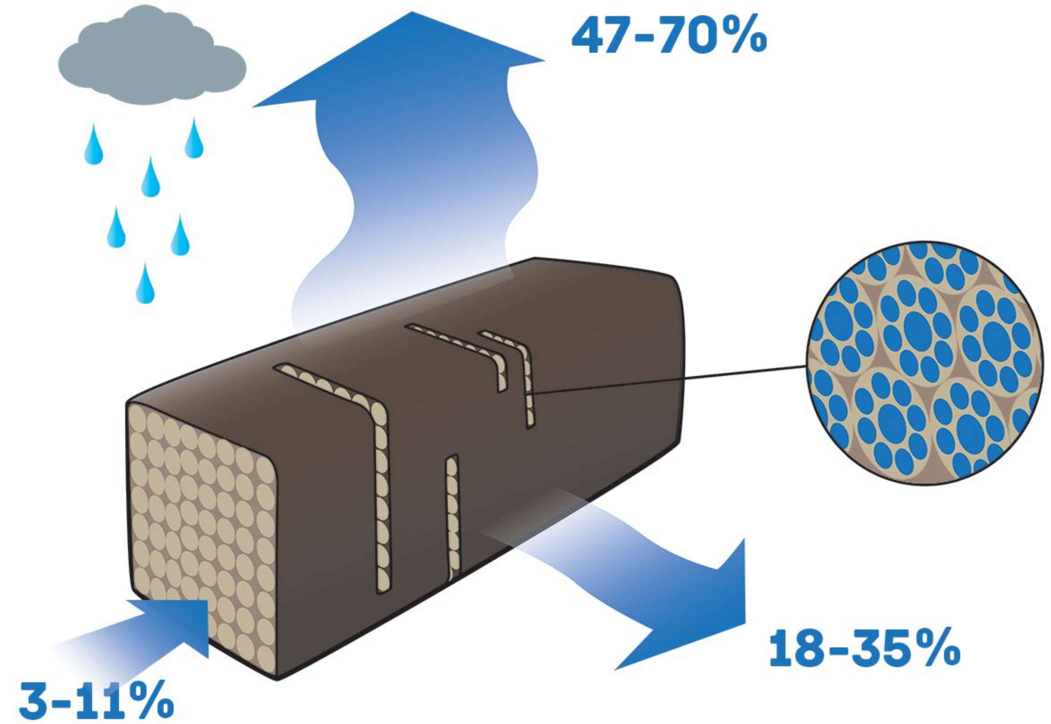
Ephraim Segerman. 2001. Some Aspects of Wood Structure and Function. For publication in the Journal of the Catgut Acoustical Society. URL: http://www.nrinstruments.demon.co.uk/wood.html. Accessed Fall 2012.

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.



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.

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.

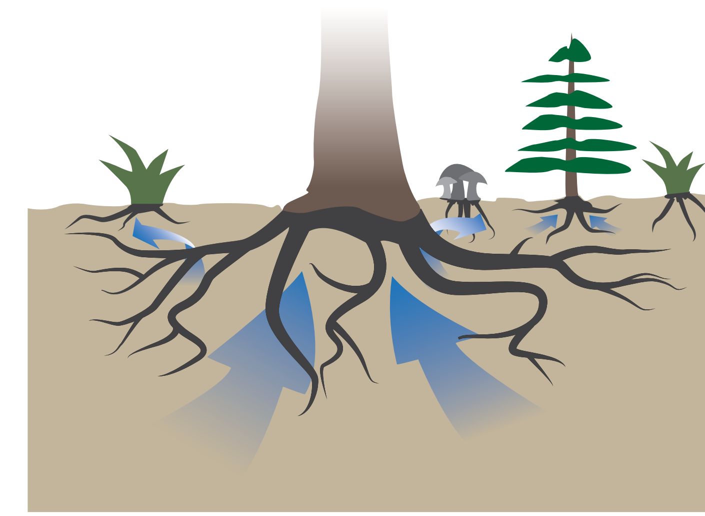
Key Life's Principles

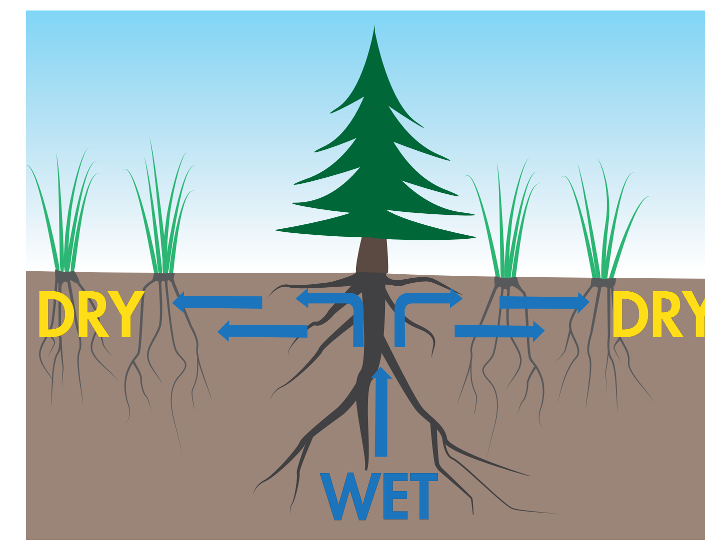
- Use feedback loops
- Use readily available materials and energy
- Leverage cyclic processes

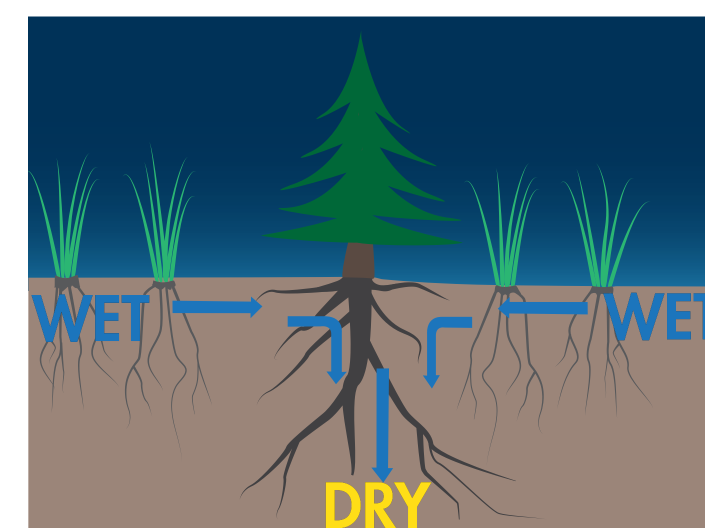
Application Ideas

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

Design piping that can transfer water using capillary action.

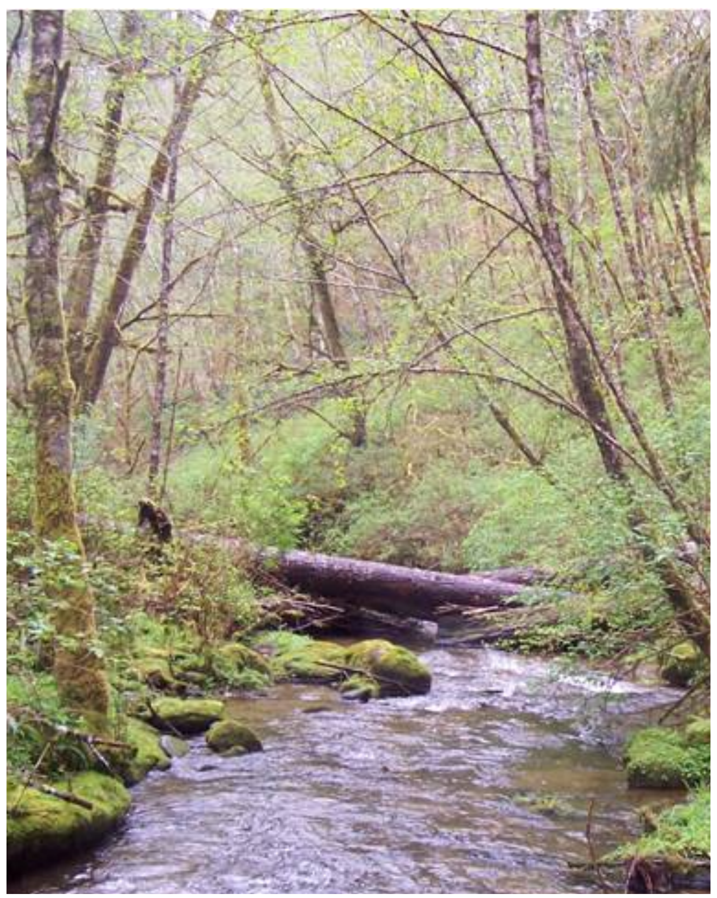






Beaver Dams

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.

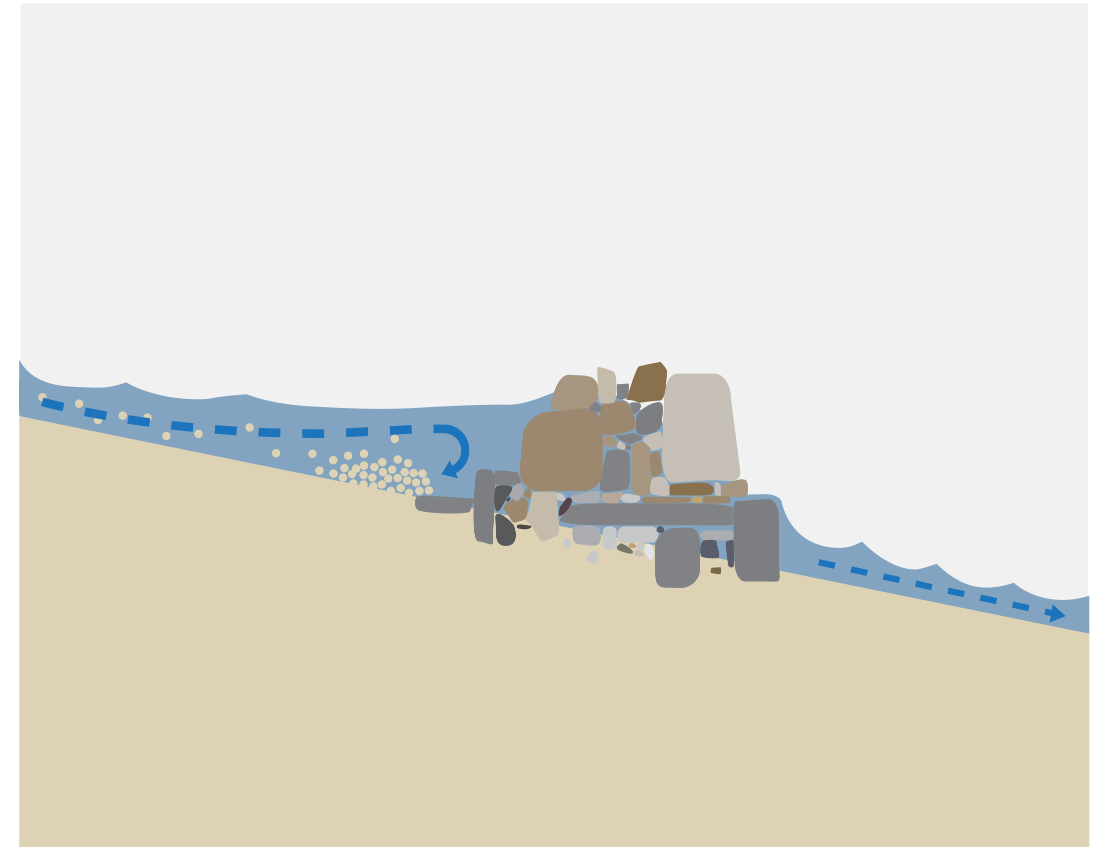
Champion

American beaver (*Castor canadensis*)

AskNature. Stream remodeling alters ecosystems: American beaver . Provided by the Biomimicry 3.8 Institute. URL: http://www.asknature.org/strategy/fe336fe9a62943d43701a6ed 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

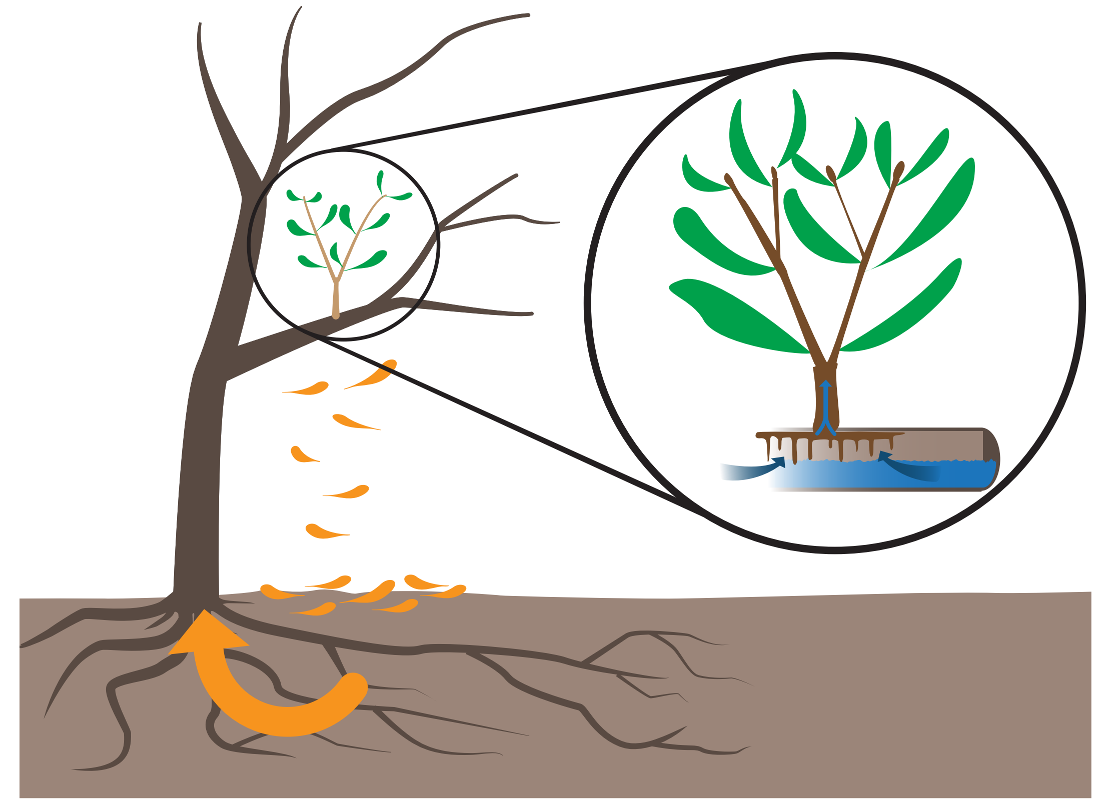
Pacific mistletoe (*Phoradendron villosum*) &
Oregon white oak (*Quercus garryana*)

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.

Genius of Place Project Report > Nature's Strategies > Parasitic Resource Sharing



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

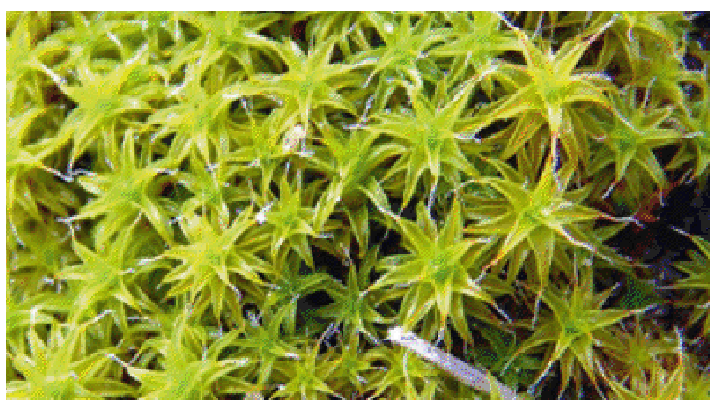
Application Ideas

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


© Michael Lüth



Biology

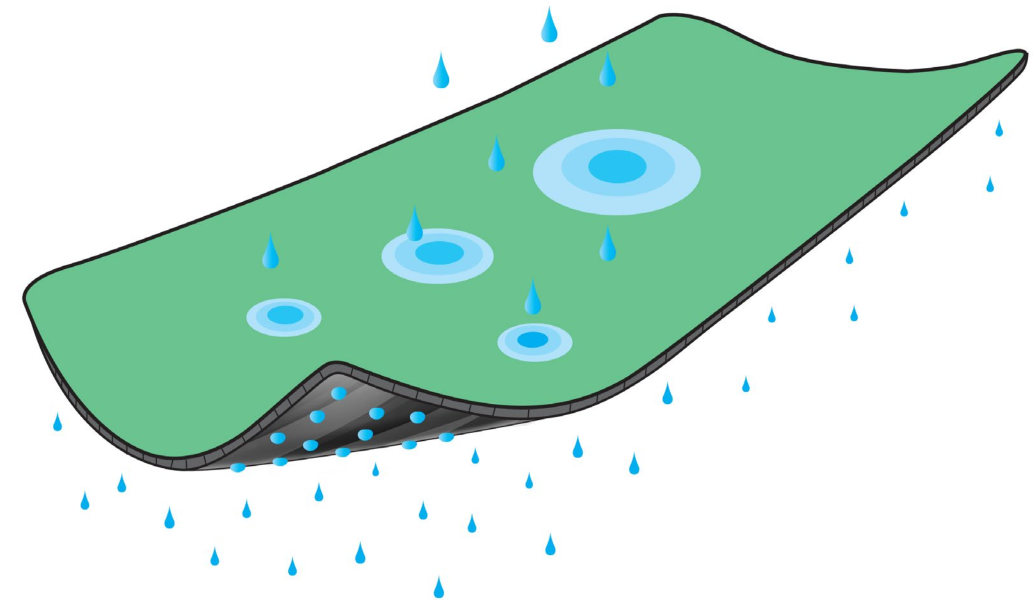
Mosses are an abundant part of temperate coniferous and broadleaf forests. Since mosses lack vascular tissues, they must absorb all water and nutrients at the surface and pass them from cell to cell. Their water content tends toward equilibrium with the water status of the environment: under wet conditions 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

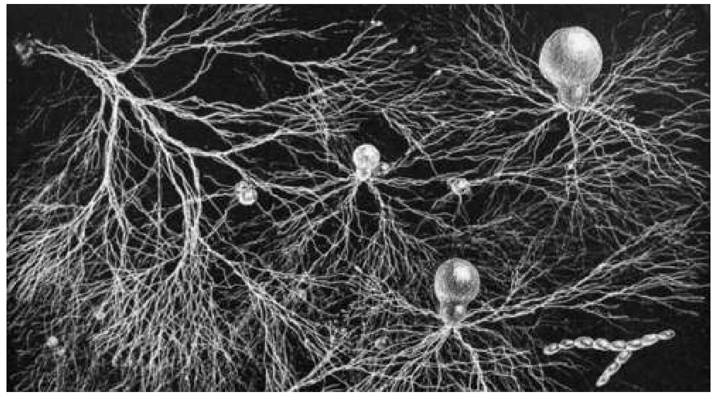
- Combine modular & nested components
- Use multi-functional design
- Leverage cyclic processes

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.

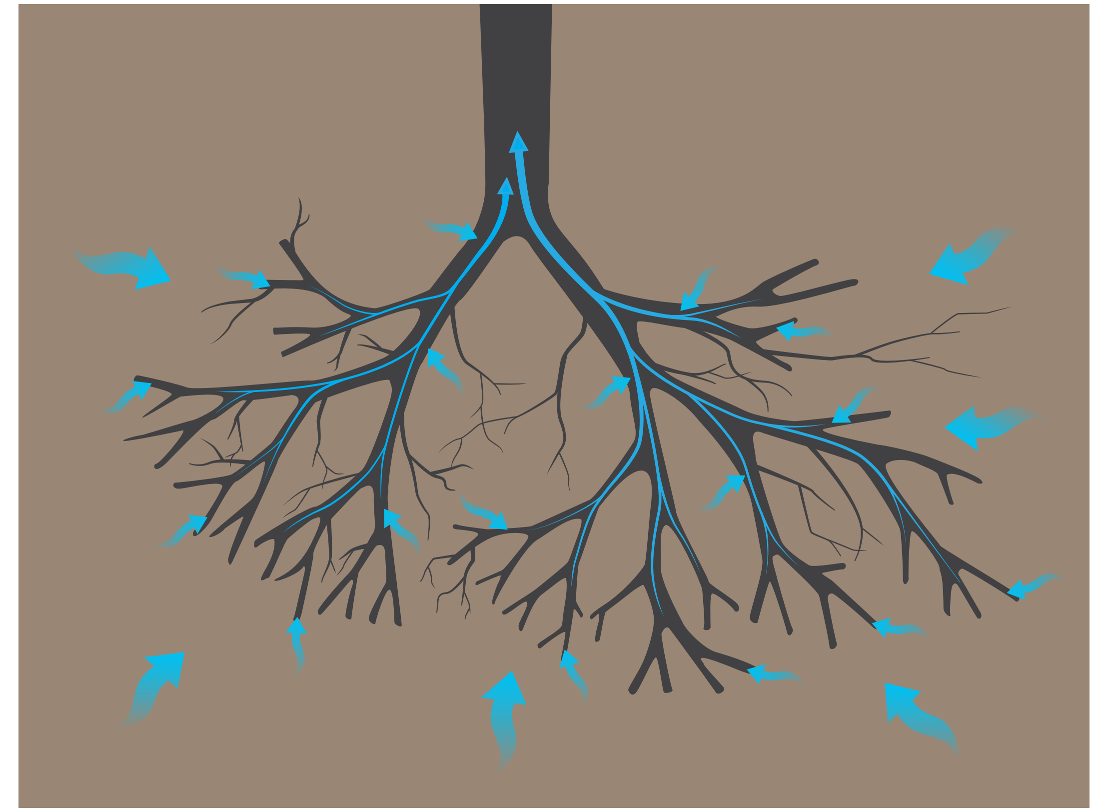
As an evolutionary strategy, mycelial architecture is amazing: one cell wall thick and so pervasive that a single cubic inch of topsoil contains enough fungal cells to stretch more than 8 miles, when placed end-to-end. A forest's vitality is directly related to the presence, abundance, & variety of mycelial 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.

Appendix D - Online Survey

Biomimicry Genius of Place - Challenges

1. What are the top 1-3 sustainability challenges the Portland Metro Region is facing today and in the near future? Please describe.

	Response Count
	3
answered question	3
skipped question	0

2. What basic functions are at the root of your challenges?

	Response Count
	3
answered question	3
skipped question	0

3. What type of (or specific) industr(ies), organizations, or sectors are trying to solve this challenge?

	Response Percent	Response Count
Built environment	**100.0%**	**3**
Urban Planning	**100.0%**	**3**
Government Policy	**100.0%**	**3**
Software	33.3%	1
Apparel	0.0%	0
Clean Technology	66.7%	2
Renewable Energy	**100.0%**	**3**
Food/Agriculture	**100.0%**	**3**
Advanced Manufacturing	0.0%	0
Education	66.7%	2
Other (please specify)		2
answered question		**3**
skipped question		**0**

4. Do you have any contacts there who might be interested in helping or being helped?

	Response Count
	2
answered question	**2**
skipped question	**1**

5. Please rate our current list of potential challenges from most (5) to least important (1)

	5	4	3	2	1
Regulation of Thermal Comfort	0.0% (0)	**100.0% (2)**	0.0% (0)	0.0% (0)	0.0%
Stormwater Management	0.0% (0)	**100.0% (2)**	0.0% (0)	0.0% (0)	0.0%
Waste water management	0.0% (0)	**66.7% (2)**	0.0% (0)	0.0% (0)	33.3%
Potable Water Quality	**33.3% (1)**	**33.3% (1)**	0.0% (0)	0.0% (0)	**33.3%**
Resource and waste distribution at a district scale	0.0% (0)	**66.7% (2)**	33.3% (1)	0.0% (0)	0.0%
Communication and adoption of existing solutions	0.0% (0)	**33.3% (1)**	**33.3% (1)**	**33.3% (1)**	0.0%
Bioodiversity and the Natural Environment in the Urban Landscape	0.0% (0)	**66.7% (2)**	0.0% (0)	33.3% (1)	0.0%
					answered qu
					skipped qu

6. In what ways can we best engage people in your sector?

	Response Percent	Response Count
(e)newsletter	**100.0%**	**3**
calendar	0.0%	0
website/blog	66.7%	2
workshop	0.0%	0
lecture/presentation/webinar	66.7%	2
	Other (please specify)	1
	answered question	**3**
	skipped question	**0**

7. We would like to continue to identify and solve local problems with local solutions. How do you see this type of problem solving integrating with Oregon business practices?

	Response Count
	3
answered question	**3**
skipped question	**0**

8. Do you know of any organizations or people who might like to help fund this project or others like it? Would you be willing to reach out to them or provide us an introduction?

	Response Count
	2
answered question	**2**
skipped question	**1**

9. What is the most you would pay to attend a workshop that explores applications for the results of these studies?

	Response Percent	Response Count
Free	0.0%	0
$25	**66.7%**	**2**
$50	33.3%	1
$100+	0.0%	0
	Comments	2
	answered question	**3**
	skipped question	**0**

10. Would you or anyone you know be interested in a report of our results? (skip this question if "no") How much would you pay?

	Response Percent	Response Count
Free	**66.7%**	**2**
$5	33.3%	1
$10	0.0%	0
$15	0.0%	0
$20	0.0%	0
	Comments	1
	answered question	**3**
	skipped question	**0**

11. How else could we fund this project?

	Response Count
	2
answered question	2
skipped question	1

12. Do you have any media contacts that would be interested in reporting on this project? Would you provide an introductions (preferred) or contact info?

	Response Count
	3
answered question	3
skipped question	0

13. Which publication's readers would be interested in this project or its results?

	Response Count
	2
answered question	2
skipped question	1

14. Please pass on this survey and newsletter to anyone you think may have an interest. If you would like to be contacted further about this project, please provide your info here and a brief description of how you would like to help.

	Response Percent	Response Count
Name	**100.0%**	**1**
Email	**100.0%**	**1**
Phone	**100.0%**	**1**
Skype Username	0.0%	0
How you can help	**100.0%**	**1**
	answered question	**1**
	skipped question	**2**

15. Final Comments:

	Response Count
	0
answered question	**0**
skipped question	**3**

Q1. What are the top 1-3 sustainability challenges the Portland Metro Region is facing today and in the near future? Please describe.		
1	The need to convert existing suburban neighborhoods and shopping districts to local, walkable, resilient, closed-loop systems that address the environmental, social, economic realms. This could mimic the closed loops of natural systems, eliminating waste and causing all parts to thrive.	Aug 13, 2012 9:19 AM
2	energy use / stormwater management / transportation (energy use + air quality)	Aug 12, 2012 12:25 PM
3	Resilience in the face of changing climatic conditions Wide swings in water availability - overabundance in winter, followed by dearth in summer - solving for storage Stormwater management for volume and water quality	Aug 9, 2012 11:41 AM

Q2. What basic functions are at the root of your challenges?		
1	Economic loss for communities due to globalism and waste. Environmental degradation. Dependence on outside economics, food supply, energy supply, etc. Prevalence of individualism that isolates people and reinforces the culture of consumption.	Aug 13, 2012 9:19 AM
2	- inefficient use of resources (to varying degrees) - use of non-renewable resources	Aug 12, 2012 12:25 PM
3	resilience/adaptability long term storage short term storage and purification	Aug 9, 2012 11:41 AM

Q3. What type of (or specific) industr(ies), organizations, or sectors are trying to solve this challenge?		
1	Economic planning (civic ecology or eco-district thinking) Systems thinking in education and outcome modeling Communitiy Organizations and neighborhood groups	Aug 13, 2012 9:19 AM
2	The other categories may also be trying to solve the challenge, but it appears to be a lower priority	Aug 12, 2012 12:25 PM

Q4. Do you have any contacts there who might be interested in helping or being helped?		
1	Yes, this might involve any number of people I'm connected with or getting connected with.	Aug 13, 2012 9:19 AM
2	possibly	Aug 12, 2012 12:25 PM

Q6. In what ways can we best engage people in your sector?

1	social media	Aug 9, 2012 11:41 AM

Q7. We would like to continue to identify and solve local problems with local solutions. How do you see this type of problem solving integrating with Oregon business practices?

1	Local problems can be solved by identifying opportunities for existing local business to expand their thinking, efforts and reach; or by the formation of new businesses to fill in gaps, capture lost resources and waste, etc.	Aug 13, 2012 9:19 AM
2	I think it would be good to actively seek opportunities to collaborate with businesses and organizations that already understand, or can be shown the potential benefits of biomimicry.	Aug 12, 2012 12:25 PM
3	If local businesses see this process successfully modeled in a replicable way, and they are given available resources to replicate it (names of interested experts capable of providing insights into nature's solutions), I believe that it will be easy to get others to try to use this approach and add to the knowledge bank available to other biomimics.	Aug 9, 2012 11:41 AM

Q8. Do you know of any organizations or people who might like to help fund this project or others like it? Would you be willing to reach out to them or provide us an introduction?

1	I wish I did, but I suspect they are out there. This is the area I understand the least.	Aug 13, 2012 9:19 AM
2	Oregon BEST is good for collaboration, but I'm not sure whether than can help fund it. OEC would also be a good collaborator.	Aug 12, 2012 12:25 PM

Q9. What is the most you would pay to attend a workshop that explores applications for the results of these studies?

1	It seems that initially the workshops should be structured as collaborative sessions. As such, they should initially have minimal or no cost. As priorities are established it should be possible to identify specific resources and processes that have value which brings greater financial engagement.	Aug 12, 2012 12:25 PM
2	I would be willing to pay to attend if any resulting report acknowledged attendees' role in contributing to the definition of those applications.	Aug 9, 2012 11:41 AM

Q10. Would you or anyone you know be interested in a report of our results? (skip this question if "no")
How much would you pay?

1	Initially free, perhaps over time there could be a fee. See response to question 9.	Aug 12, 2012 12:25 PM

Q10. Would you or anyone you know be interested in a report of our results? (skip this question if "no")
How much would you pay?

Q11. How else could we fund this project?

1	See response to question 9.	Aug 12, 2012 12:25 PM
2	You could take on problems specific to a particular project underway, but relevant to a broader audience, with a client willing to pay for the degree of insightful engagement on addressing those problems.	Aug 9, 2012 11:41 AM

Q12. Do you have any media contacts that would be interested in reporting on this project? Would you provide an introductions (preferred) or contact info?

1	At least our local blog and Facebook page, possibly community newspaper, trade publications (architecture & design) etc.	Aug 13, 2012 9:19 AM
2	No contacts at this time, but will keep in mind.	Aug 12, 2012 12:25 PM
3	Sustainable Business Oregon - Christina Williams - you probably know her but I can make an introduction if helpful. TrimTab, Cascadia and ILFI's quarterly journal - I can make an introduction to the editors Metropolis Magazine - I have an open invitation to submit blog postings to their website.	Aug 9, 2012 11:41 AM

Q13. Which publication's readers would be interested in this project or its results?

1	I think it's good to include the mainstream Oregon publications - the Oregonian, the Portland Tribune, Willamette Week - as well as regional environmental and sustainability publications.	Aug 12, 2012 12:25 PM
2	the ones I listed in question 12, plus Grist, FastCompany, Treehugger, NY Times.	Aug 9, 2012 11:41 AM

Q14. Please pass on this survey and newsletter to anyone you think may have an interest. If you would like to be contacted further about this project, please provide your info here and a brief description of how you would like to help.

	Name	
1	Mark Perepelitza	Aug 12, 2012 12:25 PM
	Email	
1	markp@serapdx.com	Aug 12, 2012 12:25 PM
	Phone	
1	503.445.7305	Aug 12, 2012 12:25 PM
	Skype Username	
	How you can help	
1	Please keep me posted. This is relevant to SERA work, we should be able to share resources and opportunities.	Aug 12, 2012 12:25 PM

Biomimicry Oregon Genius of Place Stormwater Project

Appendix E

context for stormwater challenge - includes interview notes

		Source	Notes / Possible Function
challenge: How do we reduce the volume of peak water in the city combined sewer system?			
challenge: 1. How do we manage storm water at a building/district/city scale? (Considering population growth and an increase in winter volumes due to climate change)		7.25.12 GofP KickOff meeting	FLOW How does nature absorb water (inspired by walk in woods and moss)? How does nature evaporate water? How does nature collect water? How does nature move water? QUALITY How does nature clean water? How does nature filter particulates? How does nature cool water?
Context: what are the big stormwater challenges in Portland	Older Portland neighborhoods have a sewer system that mixes untreated sewage and stormwater runoff in a single pipe. During very heavy rain storms, runoff from buildings, streets, and other hard surfaces can fill these combined sewers to capacity and cause them to overflow.	http://www.portlandonline.com/bes/index.cfm?a=316721&c=31030	
	1993 - Work begins on projects to divert stormwater runoff from the combined sewer system. The sump installation, sewer separation, stream diversion and residential downspout disconnection projects are known collectively as the Cornerstone Projects.	http://www.portlandonline.com/bes/index.cfm?a=316721&c=31030	
	Main challenge during peak flows. Possible solutions: reuse grey water/collect at source. ....to reduce ww burden or reduce stormwater in. collect (grey) water at source (building, city scale)		manage (excess) flows: collect/store, infiltrate/absorb, manage runoff.
	** Although green infrastructure may not be innovative, it is significant -- socially, environmentally, and financially. ** The issue could not be more timely, as water policies have become politicized and the good work of BES needs support. ** Portland is a leader on green infrastructure, and over 700 towns and cities around the country with combined sewer systems will face similar challenges. In my thinking, you might consider the stormwater topic an easy win. It's a biomimicry story that goes beyond industrial ecology to involve larger-scale ecosystem process and function. It need not take much of your budget. I researched this topic earlier this year for an Ecotrust report, called Partners with Nature (http://www.ecotrust.org/forests/Partners_with_Nature_3-23-12.pdf), and i'd be happy to help out as i am available and able. You would still have funds to seek other, more innovative examples of GoP.	7.25.12 GofP KickOff meeting	Howard Silverman follow-up e-mail;
	I would argue that while we know a whole lot..... but our knowledge is certainly NOT perfect. But I do feel that the bigger challenge at this point is policy and politics and education. It's one thing to have pretty good information on how we can better design cities to mimic natural systems, it's quite another thing to adopt and implement policies on the ground and adequately fund those efforts. Portland's grey to green initiative is about to be defunded and the city is under pressure politically to crawl back into their silos and simply go the pipes and concrete route again. As I said yesterday, I think the biomicicry work you are proposing might add to the knowledge base, but just [or more] importantly provide a new perspective on the ecosystem services/green infrastructure conversation... and be VALUE ADDED to other work Bullitt Foundation is already funding in the region e. g. PSU ISS program; The Intertwine Alliance ES/GI work, which is collaboration among BES, Clean Water Services and PSU ISS [fletcher beaudoin} and the work Howard has been involved in as well.	7.25.12 GofP KickOff meeting	Mike Houck: Houck reply e-mail
	Managing stormwater – big issue in Portland, lot of people engaged with; included in Portland Plan; would be educational/value-add to green infrastructure activity – biomimicry could frame a different way. This project could provide the public with needed education and outreach on green infrastructure. (Mike)	7.25.12 GofP KickOff meeting notes	
	I see stormwater management listed as a possible challenge but I want to call out water quality explicitly. Similar issue but slightly different frame. How can we look to nature for ways to cool, clean and filter our water (and runoff) to ensure high water quality in urban areas?	Corie Harlan, 8.2.12 e-mail	how does nature cool, clean and filter our water (and runoff)?

Appendix E

context for stormwater challenge - includes interview notes

challenge: How do we reduce the volume of peak water in the city combined sewer system?		Source	Notes / Possible Function
	I see Stormwater mgmt and water quality as linked. Quality is not sufficient, in that quantity is at least as important---particularly with regard to Climate Adaptation. In other words, no matter how "clean" the water is, if massive amounts are discharged into streams and wetlands due to more intense winter storms (as predicted) aquatic systems will be highly degraded. We have, unfortunately, too many examples of that fact already. It's impossible to disconnect water quality and quantity within the context of mimicking natural systems. I'd be amazed if Portland BES or CWS would debate that point. If the objective is to imitate/duplicate natural hydrologic function in the built environment and capitalize on green infrastructure Stormwater mgmt means controlling quality and quantity Idid not see anyone from BES on this exchange so added Linda Dobson, their innovative Stormwater expert to solicit her input. I also added Rich Hunter from Clean Water Services for the same reason. If we're going to talk stormwater let's be sure to include those who are practicing it in local Stormwater agencies.	Mike Houck, 8.2.12 e-mail	
"Healthy Connected City"	"A healthy connected city requires quality basic services — to protect human and watershed health and safety — sewer, water stormwater, transportation, transit, environmental services, parks, recreation, public safety and education. These form the foundation of healthy neighborhoods with their centers, greenways and other connections." Sample Policy or Early Action: Manage and maintain publicinfrastructure to provide essential public services for all residents.	Portland Plan, pg 13	
	"The city continues to expand its green stormwater managementinfrastructure as an efficient, cost-effective way to control stormwater at its source. Portland's combined sewer overflow control program,completed in 2011, significantly reduced sewage overflows to theWillamette and virtually eliminated overflows to the Columbia Slough."	Portland Plan, pg 14	
	Runoff from yards, streets and buildings is a significant source ofpollution and contaminants in local waterways, compromising thehabitat and water quality of Portland's streams, rivers and othernatural areas. More than 80 special status species that are rare, indecline, or of concern either reside or pass through our city.	Portland Plan, pg 15	
	how to read Portland Plan Strategy **Healthy Connected City - starts on pg 73. Link to combined system**:	Portland Plan, pg 28	
	Portland Today: Watershed health: Neighborhoods with generous tree canopy and less pavement have cleaner, cooler air. Trees andother vegetation also help reduce risks of flooding and landslides. Rivers, streams and upland habitats support diverse,native resident and migratory fish and wildlife. About 33 percent of the city is covered with pavement or buildings. Mostwaterways do not meet quality standards. Tree canopy, on average, covers 26 percent of the city, but some neighborhoodshave fewer trees. Many beneficial wildlife species are declining or at risk. Quality public infrastructure: Quality public infrastructure provides residents with necessities like clean drinking water,quality sewer and safe streets. Today, services in some parts of Portland do not meet city standards. For example, there arestreets without sidewalks and 12,000 properties are at risk of basement sewer backups during heavy storms. Revenue tomaintain infrastructure, including green infrastructure components (e.g., median trees, natural areas) is increasingly limited.	Portland Plan, pg 75	
	2035 OBJECTIVES: 28. Watershed health: Watershed health is improved, and the Willamette River and local streams meetwater quality standards. Tree canopy covers at least one-third of the city and is more equitably distributed.Fewer homes and businesses are at risk from flooding. A diversity of critical habitats (including floodplains,riparian areas, wetlands, oak groves, native forests and remnant native meadows) are protected, connectedand enhanced to support a rich diversity of native and migratory wildlife. High quality trees are routinelypreserved and planted on development sites.	Portland Plan, pg 77	
	2035 OBJECTIVES: 30. Quality public infrastructure: By 2035, all Portlanders have safe and reliable transportation choices andwater, stormwater and sewer services at levels that 1) benefit human and watershed health and safety, 2)meet or exceed customer and regulatory standards, and 3) are resilient to hazards or other disruptions.Sufficient resources are dedicated to maintain these assets, including green infrastructure.	Portland Plan, pg 77	

Biomimicry Oregon Genius of Place Stormwater Project

Appendix E

context for stormwater challenge - includes interview notes

		Source	Notes / Possible Function
challenge: How do we reduce the volume of peak water in the city combined sewer system?			
	Healthy Connected City, Element 3: COnnections for People, Places, Water Wildlife. Guiding Policy H - 28: Design neighborhood greenwaysand civic corridors to integratesafe and accessible facilities forpedestrians and cyclists, sustainablestormwater facilities, tree plantingand community amenities.	starts on pg. 88 - strategies already established.	
	MEASURES OF SUCCESS: 12 measures. #12. Healthy Watersheds. Success in 2035 based on score on Portland Water Quality Index. Also measures impervious surfaces and tree canopy. Shows effective impervious area by watershed. SEE THIS SECTION for current stats and targets.(" Each tree intercepts 572 gallons of rainfall!").	pg. 105; healthy watersheds: pg 137	
	value statements: 3 or 4 apply - see Plan	Portland Plan, pg142	
	Combined Sewer Overflows. Water Quality: Controlling CSOs is an important part of Portland’s efforts to improve Willamette River water quality. CSO solutions included projects to divert runoff from sewers and building new facilities to carry sewage and stormwater to the Columbia Boulevard Wastewater Treatment Plant.	**good history of issue: http://www.portlandonline.com/bes/index.cfm?a=316721&c=31030**	is this a pretty good comprehensive look at existing strategies to deal with Portland's combined sewer/stormwater system? i.e anything we suggest would be in relation to these strategies?
Cornerstone Projects:	Portland started the CSO control program in 1991 with a set of Cornerstone Projects that remove stormwater from combined sewers. Projects included installing street sumps and sedimentation manholes, building separate sewers for stormwater in some neighborhoods, encouraging homeowners in targeted neighborhoods to disconnect downspouts from the sewer system, and removing underground streams from the combined sewers.	http://www.portlandonline.com/bes/index.cfm?a=316721&c=31030	
Big Pipe Projects:	combined sewage transport systems to wastewater tx plants wth expanded capacity.		
	Environmental Services promotes other innovative projects to manage stormwater onsite instead of piping it into sewers or streams. Projects include ecoroofs, green streets, rain gardens, swales and stormwater planters.	http://www.portlandonline.com/bes/index.cfm?a=316721&c=31030	
	keep stormwater out of combined sewers. City investing in green projects that 'mimic nature' (bio-utilization'): green street facilities: small rainwater collection gardens planted along streets to collect and slow runoff and allow more infiltration. Eco-roofs: reduce runoff. Tree plantings. Portland receives 37 inches of rainfall/yr. Searching for alternatives to putting clean water into Big Pipe system. Sustainable solutions to keep rainwater out of system.	CSO Program Video: http://www.portlandonline.com/bes/index.cfm?c=31030&a=402830	
	Need to research - see Howard Silverman e-mail notes above.	Partners with Nature (http://www.ecotrust.org/forests/Partners_with_Nature_3-23-12.pdf)	
Grey to Green Initiative	The City of Portland started the Grey to Green initiative in 2008 to expand stormwater management techniques that mimic natural systems, protect and restore natural areas, and improve watershed health. These investments in green infrastructure improve the quality of our neighborhoods, rivers and streams, and help us adapt to a changing climate. (11/9/12, Mike Houck: don't use this terminology anymore... new mayor!)	http://www.portlandonline.com/bes/index.cfm?c=47203	
Linda Dobson interview (Nicole, 9/7/12)	Nicole, it was good speaking with you today. It got me thinking…. more particularly about your international examples….. Clearly I am thinking of a large scale but if the above model (Hydrological cycle showing: 1% surface runoff, 64% infiltration, and 35% evapo-transpiration) was applied to a Cityscape I wonder what it would mean in terms of modification to our existing designs and development. …. How would it affect our building performance?..............etc Linda	Linda Dobson	
		http://www.thenatureofcities.com/2012/07/31/cyborgs-sewers-and-the-sensing-city/ biomimicry stormwater study done in NE Ohio in 2011	

Appendix E

context for stormwater challenge - includes interview notes

		Source	Notes / Possible Function
challenge: How do we reduce the volume of peak water in the city combined sewer system?			
Tim McGee	Tim – how does water go from a drop to a river? Multiple scales. Effects time. Trace that drop. How many interactions does drop have. Flow. Drop in Lavasa. Landscape – planting scale. Building scale – handle water on a roof panel. Create more evaporation. Forest in Japen – theory – trees – leaf drop water on spikes – splits water into drop lets. Exponential evaporation. Split drop lets increased evaporation. Thorten Thomas eddie – how water drops move on any surface. Technical within. Slow down water, increase uses, match flow systems - % evaporation, % of run off.	Tim McGee, 9.14.12 meeting	
Rod Lundberg Interview 9.14	the problem is two-fold:		
	<u>infiltration:</u>		
	keep water upstream and capture it at the source.		store or collect water
	biggest challenge is lack of space to provide proper pervious/collection surfaces.		
	during the rainy season there needs to be a fine balance between slowing the rate of the catch basins to avoid a surge and having the capacity for the next rain event.		
	relying on planters for street run-off limits the reuse of the water to irrigation of only those plants in the planter.		
	challenges of street planters include standing water (safety/health), depth needed for infiltration, trip hazards for emergency vehicles		
	possible strategies inlcude: ecoroofs, living machines, and collection for re-use	Tom Lipton (CoP contact)	
	<u>Storage:</u>		store water
	should be decentralized at neighborhood/residential scale		
	how do we store and treat street run-off?		
	<u>Maintenance Concerns:</u>		
	Some of the stormwater planter/rain garden maintenance is inherent such as trash removal, removal of accumulated sediment, vegetation maintenance (replacement of failed plantings, mowing/trimming, etc.), keeping curb openings clear of debris. There is also the potential need to replace the topsoil on some frequency due to the accumulation of toxins such as heavy metals. Not all of the stormwater facilities have piping infrastructure. It is preferable to avoid pipes if possible, with any overflow just draining down the street to the nearest existing catch basin. Those that do have pipes might need periodic maintenance such as clearing debris from the catch basin/grate, or pipe cleaning. Infiltration can be problematic if the facility is in close proximity to a structure with a basement (potential for leaking into the basement).		
Mike Houck Interview 9.24.12	Mike thinks our first challenge is 'to understand what's understood'. We already know a lot about How nature deals with water. Until recently, we've taken an engineering solution. Pipe and shut off before water into wetland. Portland has Progressive leadership = stormwt mgt agency and elected. Sewage agency transformed to watershed health…clean water services…Portland Bureau of Environmental Services.		
	***Biomimicry Oregon Opportunity or Value-Add: to bring different set of constituents (than who is already at the table), eg. bring a different perspective and shine a different light on innovative stormwater practices…to encourage what's already being done and hopefully offer a few new ideas. Value add would be that a new constituent would be advocating for emulating nature (more than the same old voices).		
	When Mike got my e-mail, he called Linda Dobson. Apparently yesterday, Linda provided Nicole with info. Mike thinks the most efficient way to proceed is to have 2 people from B. Oregon in Portland sit down with him and Linda (first see what Nicole got). Main Point: Mike is open to meeting. (Mary met with them 11/9/12)		
Candace Stoughton interview, 10/2/12 (Mary)	LID focus on residential audience. Tehre are jurisdictions that regulate development, and there are better opportunities to do more... regs don't go far enought.	Candace Stoughton interview, 10/2/12 (Mary)	
	The built environment is an opportunity... teaching the average homeowner... did you know your could build a rain garden and help solve a big problem? Since we're not regulatory, this is an opportunity.	Candace Stoughton interview, 10/2/12 (Mary)	
	People who take our class	Candace Stoughton interview, 10/2/12 (Mary)	
	WE may provide raingarden incentives... we might build a raingarden.	Candace Stoughton interview, 10/2/12 (Mary)	
	FLOW: Problems with strategies: part is politics (EPA's main focus is on human health, and they are just starting to talk about how much water is being sent to streams instead of just dirty water... so this is hydrology... they are just getting it that too much water is a pollutant	Candace Stoughton interview, 10/2/12 (Mary)	

Biomimicry Oregon Genius of Place Stormwater Project

Appendix E

context for stormwater challenge - includes interview notes

challenge: How do we reduce the volume of peak water in the city combined sewer system?		Source	Notes / Possible Function
	We ask developers to manage flow at pre-development levels. What they're not saying is that the forest is no longer there. Need to base on prior to human clearing of land.	Candace Stoughton interview, 10/2/12 (Mary)	
	In GA Nature Conservancy, looked a whole watershed... need to function as pre-development. Serious science was done.	Candace Stoughton interview, 10/2/12 (Mary)	
	We have infrastructure that could be damaged if more water was infiltrated... Seattle	Candace Stoughton interview, 10/2/12 (Mary)	
	Sus Stormwater Symposium presentations will be put online	Candace Stoughton interview, 10/2/12 (Mary)	
	Eric Strecker, GeoSyntech - advanced thinker. 40% of rain in PNW would never get infiltrated. 50% into shallow or deep groundwater... find this thru massive forest canopy. Now we say, we'll put it all in the ground. He has concerns that we are over-taxing the groundwater aquifers.	Candace Stoughton interview, 10/2/12 (Mary)	
	Blue roof instead of a green roof where you design to capture water... like building a swimming pool and let it evaporate.	Candace Stoughton interview, 10/2/12 (Mary)	
	University of Oregon looked at the whole Willamette Valley and changes over time. Graphics flying over at 3 periods in history. Candace will look for it.	Candace Stoughton interview, 10/2/12 (Mary)	
	Predevelopment hydrograph of Western Pacific NW... will send me the slide	Candace Stoughton interview, 10/2/12 (Mary)	
	Pollutants are a problem too... Washington researchers believe pollutants are causing female salmon to die before they can spawn... we could see extinction of some species within 10 years ago... and that was 3 years ago. The Wild Fisheries... NOAA had a great video related to copper (all brakepads spew copper). When a salmon is predated upon, it exudes a chemical that warns other salmon. When "normally" polluted water, salmon don't perceive the predator chemical... NOAA funded the Wild Fisheries Institute to do a lot of that work.	Candace Stoughton interview, 10/2/12 (Mary)	
	Biologists say... each generation is seeing fewer numbers of species... "good" is less good than the previous.	Candace Stoughton interview, 10/2/12 (Mary)	
Alexis Morgan e-mail, 10/9/12	re: biomimicry and stormwater...there's nothing directly that comes to mind, but I would point towards the extensive literature on the importance of riparian areas to managing overland flow. This is basically nature's way of managing excessive flooding...that combined with vegetation and aerated soils with good nutrients and microbial activity. Erosion processes also help to slow water and manage stormwater, and then there are things like wetlands that not only manage flow but nutrients as well. Nature releases water slowly...humans like to reduce permeability, channelize and speed up water. The slower the water, the more life happens...though at certain point (stagnancy) you do get eutrophic conditions (too much life!). re: green infrastructure - I'd recommend looking at some of the PES efforts out there - e.g., Water Funds http://www.nature.org/ourinitiatives/habitats/riverslakes/water-funds-investing-in-nature-and-clean-water-1.xml Anyhow - happy to chat with you about this over the phone if you want to bounce certain things around. Regards, Alexis	Alexis Morgan e-mail, 10/9/12 (mary)	nature releases water slowly... riparian areas, erosion processes, wetlands
Doug Paige, 10/9/12	key lesson from Ohio work was to slow the water down and manage it onsite. he will send the file from their project.	mary	
Jennifer Belknap-Williamson interview, 10/12/12	Maximize volume reduction is new focus for the industry; previous work in stormwater primarily focussed on pollutant removal and 100 year flood flows. 2-10 year events are problematic in that they tear up stream channels... so our focus on flow reduction is great. Look up hydromodification...	mary	
Jennifer Belknap-Williamson interview, 10/12/12	In high infiltration soils, green infrastructure can generally handle 2-year storms, but not 25-year storms	mary	

Appendix E

context for stormwater challenge - includes interview notes

challenge: How do we reduce the volume of peak water in the city combined sewer system?		Source	Notes / Possible Function
Jennifer Belknap-Williamson interview, 10/12/12	Gresham's strategy is two-fold: 1) green infrastructure for residential and streets; 2) regional infrastructure wetlands for larger areas and overflow. They have 3 regional SW facilities; one treats for 900 acres. She'd be happy to give us a tour if we'd like to make that part of our project!	mary	
Jennifer Belknap-Williamson interview, 10/12/12	Effectiveness of green infr. measures on evapo-transpiration range widely depending on soil composition, the evaporation capacity of the air, vegetative activity (in Portland when we get all the rain, transpiration is down due to deciduous trees and humidity in air), whether the rain garden/bioswale is lined, etc.	mary	
Jennifer Belknap-Williamson interview, 10/12/12	Rain gardens are often lined to protect water/other underground infrastructure and to prevent underground contamination from spreading.	mary	
Jennifer Belknap-Williamson interview, 10/12/12	RESOURCES: WA State Univ at Puyallup: raingarden studies... how do different plant mixtures affect evapo-transpiration (ET) rates? HIgher rates of ET in spring and fall; not as high in winter when we get all the rain. They've found 30-40% ET thru some plant mixes. If you used non-native plants, could you get higher ET rates? Maybe you'd use sterile varieties to avoid invasive species issues. SPROUT: Silverton, OR: phyto-remediation research NYC Dept of Environment: blue roofs (capture thin layer of water on roofs to slow it down) Clean Water Services & Brown & Caldwell: Modeling of North Bethany Area found huge range of values depending on whether green infr. facilities were lined or not, soils, etc. Portland Sustainable SW research is online... raingarden models.	mary	
Jennifer Belknap-Williamson interview, 10/12/12	Willamette Valley ecosystems: Prairie; Oak savannah; Forest on the slopes	mary	
Jennifer Belknap-Williamson interview, 10/12/12	Prairie grass roots break up soils, thereby increasing infiltration capacity	mary	
Jennifer Belknap-Williamson interview, 10/12/12	CHALLENGES: 1) Retrofits of existing development. How do we find the space for green infrastructure? Sidewalks need to be used for sidewalks; streets not wide enough. Green roofs are expensive. 2) New development - need to make implementation of green infr. practical. Need streets made wide enough for bioswales, and planter boxes, etc. Often a developer's plan is not carried out when lots are built on by individual homeowners. And in cases where the developer is developing the whole area, there is a gap in engineering expertise to do green infrastructure. Large engineering firms don't generally work with developers, they work with municipalities. Small engineering firms that work with developers generally only do grading and streets; they don't have stormwater expertise. Developers focus on fast-pace and want "solutions in a box". One example of this is Filterra, who sells trees in box made to collect street water. 3) Ongoing lifecycle maintenance of green infrastructure.	mary	
Steve Behrndt, Manager, Wastewater Group, Portland Bureau of Env. Services	Combined Sewer System in Portland covers 35% of the City (42 sq miles) & 60% of the population. 2,500 miles of pipe in the sewer system.	mary	11/9/11 Water Issues: User Perspectives forum put on by League of Women Voters of Portland
"	Eco-roofs: goal is 40 acres; current is ~11 acres.	mary	"
"	Over 50,000 downspouts have been disconnected.	mary	"
Lorna Stickel, Water Resources Planning Mgr, Portland Water Bureau	Portland water use is 60% residential and 40% Commercial, Industry, Institutional (CII)	mary	"
Linda M. Dobson, Division Manager, Sustainable Stormwater Management, City of Portland Bureau of Environmental Services	focus of BER: Our overall mission is to improve water quality and watershed health, and to protect and restore natural resources. While we do this we also look for ways to be multi-objective in our approach to address other issues. Here are some specific bullets: Improve watershed health through integrated, high –quality stormwater management, resource protection and restoration Increase high quality and increased quantity of green space in developing and existing dense urban areas	nicole	

Appendix E

context for stormwater challenge - includes interview notes

challenge: How do we reduce the volume of peak water in the city combined sewer system?		Source	Notes / Possible Function
	Provide high quality, visible, diverse landscape with aim of increasing human health and habitat in urban areas		
	Impervious area reductions with intent of reducing heat-island effects in urban areas Increase overall urban canopy Preservation of existing high quality resource areas		
Linda Dobson, 10/29/12	My background is planning and heat island with stormwater can be addressed together and could take us down roads we haven't been down before, so could be some could synergies there	mary, 10/29/12	
Vinh Mason, 10/29/12	East Lents Floodplain Restoration… Johnson Creek – Fulton Road and 120th… creek had been channelized… creek backing up. city bought 30 lots and constructed a wetland… it mimics nature and is working... see Resources tab for link to project website.	mary, 10/29/12	
Linda Dobson, 11/9/12	Frame the challenge in positive terms… not "how does nature manage excess flows"… not excess in nature… abundance. We talk about stormwater being a "valuable resource", not a problem… of course it is problematic… Frame challenge around human health… we know that people are less healthy in cities… Highlight how green infrastructure also cools the air, reduces energy use.	mary, 11/11/12	
Mike Houck, 11/9/12	- Portland re-doing Comprehensive Plan right now... "designing with nature" is one of overarching principles. Linda: Not anymore… I think that's been taken out… Mike: Well, it's still in process. - This project… not concrete policy outcomes, but creating ideas… The best value add for this project for policy is on built structures (bldgs, etc.), plus other voices advocating green infrastructure. - Come up with ideas on this project we can take to City Council… they need to hear from different people. - The thing I like about B-OR and why I've given a little of my time to it is that it pulls in different people.	mary, 11/11/12	
Linda Dobson/Mike Houck meeting, 11/9/12	Mary: why need to reduce stormwater flows if already installed the Big Pipe? Linda: We need to maintain capacity in the pipe (there are 3 big pipes) or we lose our investment… it's like freeways… keep bldg them and traffic increases… don't want to build more big pipes. The combined sewer system & "Big Pipe" only covers 1/3 of city, so don't focus on it. Stormwater in other parts of city is either piped directly to streams/rivers or, on the east side, injected into wells… also a flood plain. Flooding occurs. Streams get "engorged and incised". Mike: The big gap is at building and site scale. Net zero is the biggest challenge… what if we could provide habitat for invertebrates and birds?	mary, 11/11/12	

Biomimicry Oregon Genius of Place Stormwater Project

Appendix E

Initial Research Questions

		source/ references	who added / revised	date added / revised
1. What are pre-development ecosystem types in Portland area? Forest (w. red cedar, w. hemlock, doug fir)? Prairie? Oak Woodland?	per Jennifer Belknap-Williamson, forest on slopes, Willamette Valley is prairie and oak savannah		mary	
	One map, developed by the Nature Conservancy and the Oregon Natural Heritage Program, used surveys from the 1850s to define historic vegetation zones. It and other investigations indicate that as much as 1 million acres in the 3.3 million-acre valley were covered in Oregon white oak savanna and woodland prior to settlement in the mid-nineteenth century. Today, only 8 percent remain.	http://news.oregonmetro.gov/1/post.cfm/metro-preserves-valuable-oak-habitat-at-voter-protected-natural-areas-across-the-region?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+OregonMetroNews+%28Metro+news%29&utm_source=Metro+contacts&utm_campaign=b7a62f95cc-Naturalareas&utm_medium=email	mary/karen	10/15/2012
	Willamette Valley: "The vegetation mosaic today includes Quercus woodlands, coniferous forests, grasslands, sclerophyllous shrub ocmmunities (chaparral) and riparian forests.All must be considered seminatural incharacter because of human activities (since mid-19th century). valley mosaics known as 'interior valley' or 'Pinus-Quercus-Pseudotsuga' zone.	Franklin & Dyrness, 1973. Natural Vegetation of Oregon and Washington. pg 110	Karen	10/28/2012
	"At the time of first settlers, conifer stands clothed almost the entire area of western washington and northwestern oregon from ocean shore to timberline except for the willamette valley and some prairies in the puget sound tough."	Franklin & Dyrness, 1973. Natural Vegetation of Oregon and Washington. (see pdf uploaded to google docs). pg 55	Karen	10/28/2012
	"temperate coniferous forest" Psuedotsuga menziesii (douglas fir) dominance, Tsuga heterophylla (w. hemlock)-Thuja plicata (W. red cedar) climax. Uniqueness of forest: coniferous dominance, size and longevity, productivity: 'these forests have produced the greatest biomasss accumulation of any plant formations in the temperate zone and possibly the world." Soils in western hemlock zone: 'moderately deep"; surface horizons are well aggreggated and porous. moderate to high organic matter content. soils are medium texture: samdy loam to clay loam	Franklin & Dyrness, 1973. Natural Vegetation of Oregon and Washington. pg 53-4	Karen	10/28/2012

Appendix E

Initial Research Questions

		source/ references	who added / revised	date added / revised
2. What are the infiltration, evapo-transpiration, and runoff percentage rates in an intact PNW forest, prairie, oak woodland, etc. ecosystems?		http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs143_024824.jpg	mary	10/13/2012
	1% surface runoff, ??-??% infiltration, 40-50% evap/tranps (don't know how to read graphic)		mary	10/13/2012
3. What are the infiltration, evapo-transpiration, and runoff percentage rates in the City of Portland?	64% surface runoff, 25% infiltration, 11% evap/tranps	11/9/11 presentation by Steve Behrndt, Mgr, Wastewater Group, Portland Bureau of Environmental Services http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs143_024824.jpg		
	20-30% surface runoff, ??-??% infiltration, 20-30% evap/tranps (don't know how to read graphic)	Water cycle slides (Puget Sound Partnership), 10/3/12 e-mail from Candace Stoughton http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs143_024824.jpg	mary	10/13/2012
What is total volume of stormwater/yr going into Big Pipe? How many gallons per year are being diverted from Big Pipe through green infrastructure?	Per Linda, not really relevant. The combined system/Big (3) Pipe(s) only cover 1/3 of the City.	Linda Dobson	mary	11/11/2012
4. What was % infiltration, evap/tranps and runoff in City of Portland prior to green infrastructure going in (year)?		http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs143_024824.jpg		
5. To what extent does current green infrastructure affect % infiltration, evap/tranps and runoff (is data available?). Call out by specific green infrastructure feature.	nicole does not think this info is available. Impervious area tracked. Nicole's thought confirmed by Linda. Further, there are many different types of green infrastructure: bio-swales, green roofs, rain gardens, urban trees, floodplains, etc.	Linda Dobson	mary	11/11/2012
6. What local organisms have an effect on evapo-transpiration, infiltration, collection/storage/absorption, or reduce runoff? (include flood attenuation or slowing down flow)	use biological research tab			
7. What are the other benefits of stormwater management strategies?				

	source/ references	who added / revised	date added / revised
Linda: I just spent a couple hours with XXX from Climate Solutions. He wants to talk about carbon sequestration of our bio-swales and green roofs… there are multiple benefits that you need to talk about… could be real synergies there… also with reducing heat island effects. Mike: Yes, multiple benefits… that's what nature does… need to focus on those.		mary	11/11/2012

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Appendix E

CURRENT GREEN INFRASTRUCTURE IN PORTLAND: what's already here, working, and understood

Challenge: How do we manage storm water at a building/district/city scale? (Considering population growth and an increase in winter volumes due to climate change)

Green Infrastucture Strategies: what strategies are already in place & working in Portland?	*Application / Use in Portland (describe how it is used in Portland: are there incentives for people to do this? what scale installed at? Is there performance data? eg. 1500 bioswales in Portland treating x gallons/year; affect on infiltration, runoff, evap/trans? how many installed, etc.)*	*Evaluate it re: biomimicry? is it biomimicry, bio-utilization, bio-assisted? none of the above?*	
What	**Source**	**Notes**	**Who**
green roofs		Effectiveness of green infr. measures on evapo-transpiration range widely depending on soil composition, the evaporation capacity of the air, vegetative activity (in Portland when we get all the rain, transpiration is down due to deciduous trees and humidity in air), whether the rain garden/bioswale is lined, etc.	
green roofs and urban heat island effect	http://greenroofs.b2science.org/learn		karen
bioswales	**can we use Popplet for some of this? <-- I put some of this info into popplet (Matt)**		
infiltration basins			
storage: how do we store and treat street run-off?			
Federal Stream Corridor Restoration Handbook (NEH-653)	http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/water/manage/restoration/?&cid=stelprdb1043244	Accepted management techniques	Nicole
pre and post development % infiltration, evapotransporation, deep infiltration	http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs143_024824.jpg	graphic for workshop presentation	Nicole
Stream Ecology: Structure and Function of Running Waters, J. David Allan	Book with a good overview of how the water cycle works and stream functions	need to scan relevant pages	Nicole
City Sustainable Stormwater Management Solutions	http://www.portlandonline.com/bes/index.cfm?c=31870	includes documents for all types of passive stormwater management strategies Studies show that natural landscaping at a residential development can reduce annual stormwater runoff volume by as much as 65%. Natural drainage and native landscaping areas in residential developments can remove up to 80% of the suspended solids and heavy metals, and up to70% of nutrients like phosphorous and nitrogen from stormwater runoff. An ecoroof can capture and retain 60% of the annual precipitation that falls on it. Trees capture and hold rainfall in leaves and branches. They slow runoff flow and can decrease stormwater volume by 35% or more for small storms.	Nicole
City Stormwater management Manual	http://www.portlandonline.com/bes/index.cfm?c=47952		Nicole
Portland's Gray to Green Program	http://www.portlandonline.com/bes/index.cfm?c=47203	good information on city initiatives, ecosystem services defined, info on green street strategies and benefits, city progress reports	Nicole

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What	**Source**	**Notes**	**Who**
	http://www.portlandonline.com/bes/index.cfm?c=53559&	City Stormwater Management Guides and EPA Guides	Nicole
	http://www.portlandonline.com/bes/index.cfm?c=52055&a=177184	Ecosystem services - as defined by the city	Nicole
	http://econw.com/case-studies/calculating-the-economic-benefits-of-green-infrastructure/	Economic benefits of green infrastructure By EcoNorthwest - Published 2012	Nicole
Economic Value of The Intertwine - connected natural areas with parks and trails in the City of Portland	http://econw.com/case-studies/economic-value-of-the-portland-metro-intertwine/	ECONorthwest described the value of the Intertwine's ecosystem services, including its effects on stormwater and water quality; benefits to wildlife and habitat; carbon sequestration and air filtration; and increased and enhanced recreational opportunities. ECONorthwest's results show that, over the next 20 years, the Interwine will provide about $1.5 billion in benefits from ecosystem goods and services to the local community and an additional $0.3 billion in benefits to non-local communities.	Nicole
Economic value of ecosystem services provided by beavers	http://econw.com/case-studies/economic-value-of-ecosystem-services-provided-by-beavers/		Nicole
The Portland Plan - good city stats and graphics on canopy coverage and stormwater and goals. A few key stats are listed here. pages 137, 131, 138, 139	http://www.portlandonline.com/portlandplan/index.cfm?c=56527	About 33 percent of the city is covered with pavement or buildings. Most waterways do not meet quality standards. Tree canopy, on average, covers 26 percent of the city, but some neighborhoods have fewer trees. Many beneficial wildlife species are declining or at risk. One Goal: Preserve and restore habitat connections and tree canopy to link stream and river corridors, landslideprone areas, floodplains, wetlands and critical habitat sites into a system of habitat corridors. This provides connections for wildlife, supports biodiversity, improves water quality, reduces risks due to flooding and landslides, and supports Portland's adaptation to climate change. Page 94 BES study notes that each City tree intercepts 572 gallons of rainfall removes 0.2 lbs of air particulates and sequesters carbon. page 139	Nicole
Portland Watershed Management Plan	http://www.portlandonline.com/bes/index.cfm?c=38965	http://www.portlandonline.com/bes/index.cfm?c=38965&a=395956 - useful PPT of images and program progress	Nicole

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What	**Source**	**Notes**	**Who**
Portland Urban Forestry Action and Management Plans - great stats on current and future goals for canopy coverage across different land use types	http://www.portlandonline.com/parks/index.cfm?a=184641&c=38306 http://www.portlandonline.com/parks/index.cfm?c=38294&a=226238		Nicole
Maps and blog from Terra Fluxus on the "hidden streams of Portland."	http://www.terrafluxus.com/archives/1122/comment-page-1#comment-801		Nicole
peak stormwater flows from rain on snow events	http://andrewsforest.oregonstate.edu/pubs/pdf/pub1369.pdf	May be an interesting parallel with urban impervious landscapes	Nicole
email to Grey to Green Initiative - response from Sara Culp Watershed Services | Capital Projects Coordinator City of Portland Bureau of Environmental Services 503.823.3235		Well, I can give you an estimate of the land area covered by ecoroofs and land acquisition to protect/restore natural areas (or create natural areas where there used to be houses and roads, in the case of Johnson Creek Willing Seller). Since 1996, the Johnson Creek Willing Seller program has acquired approximately 262 acres of land for restoration of floodplain. Since 2008, the Grey to Green program has acquired approximately 320 acres of natural area for protection/restoration. Since approximately 2000 (I am not sure when the first one was built exactly), Portland has built approximately 34.7 acres of green roofs (that includes roofs that the City didn't provide incentives for, and includes both "ecoroofs" and roof gardens). So, between those, that's 616.7 acres. Portland Parks and Recreation and Metro have probably acquired/converted some other land that we weren't involved in, especially before 2008. For actual conversion of hard surfaces back to green space, the organization Depave would probably have some info about what they've done, which would mostly be in addition to the land acreage above (although there is one project I'm aware of where we purchased a property through Grey to Green and worked with Depave to rip up the parking lot there!). For green streets, it's a little trickier. This has probably grown slightly, but the number I have is that Portland has	Matt

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What	**Source**	**Notes**	**Who**
Costs and Benefits of Storm Water BMPs	http://water.epa.gov/scitech/wastetech/guide/stormwater/upload/2006_10_31_guide_stormwater_usw_d.pdf	Great guide showing construction and maintenance costs for various stormwater best practices.Shows the economics of real world applications of bio-utilization/biomimicry ideas	Nicole
Cost Benefit Analysis for Ecoroofs in Portland	PDF report from Tom Puttman. Uploaded to Google Docs	There is an immediate and long term benefit to the public. At year five, the benefit is $101,660, and at year 40 the benefit is $191,421. The ecoroof benefit is generated from reduced stormwater management system improvements and O & M costs, carbon reduction, improved air quality, and habitat creation.	Nicole
Urban Design and UrbanWater Ecosystems	PDF report uploaded to Google Docs	Interesting ideas for transforming the urban landscape to manage stormwater using pre-development, natural techniques	Nicole
Riparian Ecosystem Management Model	PDF report uploaded to Google Docs	Page 31 (Word pg #) has a good graphic showing where water goes when it hits the forest.	Nicole
Book - “Wild in the City, Exploring the Intertwine”	Need to scan and upload	“In 2004, PSU students estimated that South Park Block trees contribute $3.4 million in aesthetic and environmental value to the city. Other researchers have found that a mature tree, such as one of the large elms in the Park Blocks, can absorb up to 550 gallons of stormwater a year.” “Portland’s urban forest covers 26% of the city and removes 88,000 tons of carbon dioxide per year. Mature trees also increase property values up to 25% and a tree with a 30-foot crown “drinks” up to 700 gallons of rainfall annually.”	Nicole
great resource for tree species and canopy cover in oregon	http://www.oregon.gov/ODF/Pages/resource_planning/forestatlas.aspx		

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Appendix E

Sustainable Stormwater & Portland Resources

2012 Sustainable Stormwater Symposium	http://www.stormwatersymposium.org/?q=node/338
Achieving Water Independence in Bldgs	https://ilbi.org/education/Resources-Documents/Reports-Docs/WaterDocs/Achieving_Water_Independence_in_Buildings.pdf
Portland Sus Stormwater	http://www.portlandonline.com/bes/index.cfm?c=34598
East Lents Floodplain Restoration Project	http://www.portlandonline.com/bes/index.cfm?a=286175&c=33213
Portland Green Streets	http://www.sustainablecitynetwork.com/topic_channels/water/article_c26ddcfe-b313-11e0-a5fa-001a4bcf6878.html?mode=story
Business Case for Green Infr - 1/8/13	http://www.sustainablebusinessoregon.com/columns/2013/01/the-business-case-for-greening-our.html
Portland Plan	http://www.portlandonline.com/portlandplan/index.cfm?c=56527&
good history of issue	http://www.portlandonline.com/bes/index.cfm?a=316721&c=31030
OSU Stormwater Solutions	http://extension.oregonstate.edu/stormwater/
Flood reduction on Johnson Creek	http://www.americanrivers.org/newsroom/blog/sudvardy-20120315-portland-oregons-flood-protection-success-story.html
Partners with Nature	http://www.ecotrust.org/forests/Partners_with_Nature_3-23-12.pdf
Willamette Water 2100	http://water.oregonstate.edu/ww2100/
WaterCraft - designs for the ecological city (Cleveland)	http://www.gcbl.org/blog/marc-lefkowitz/watercraft-dives-designs-ecological-city
HOK Genius of Biome	http://www.hok.com/thought-leadership/tapping-the-genius-of-the-biome
Sustainable Stormwater Symposium	http://www.stormwatersymposium.org/
Coke & DEKA water supply	http://www.sustainablebusinessoregon.com/national/2012/09/coca-cola-deka-team-on-clean-water.html?ed=2012-09-27&s=article_du&ana=e_sbo
Impact of Green roofs on stormwater	http://oregonbest.org/commercialization/columbia-green
	http://sustainablebusinessoregon.com/articles/2012/09/oregon-best-awards-commercialization.html?page=all&utm_source=BEST+e-News+Update%3A+SEPT+2012&utm_campaign=Sept+2012+E-News&utm_medium=email
The parking space metric was quoted to me by Deb G at Mithun from her work on the Lloyd Crossing project which lives here (Alexandra)	http://issuu.com/mithun/docs/lloyd_crossing?mode=embed&layout=http%3A%2F%2Fskin.issuu.com%2Fv%2Flighticons%2Flayout.xml&autoFlip=true&autoFlipTime=6000
Debunking Misinformation	http://cleantechnica.com/2012/09/30/misinformation-has-big-psychological-advantages-unfortunately/
Inflatable dam	http://inhabitat.com/nyc/nyc-installs-inflatable-dams-in-williamsburg-and-red-hook-to-control-flooding/
biomimicry stormwater study done in NE Ohio in 2011	biomimicry stormwater study done in NE Ohio in 2011
http://www.thenatureofcities.com/2012/07/31/cyborgs-sewers-and-the-sensing-city/	http://www.thenatureofcities.com/2012/07/31/cyborgs-sewers-and-the-sensing-city/
[5:21:05 PM] Ethan Smith:	http://www.portlandonline.com/bes/index.cfm?c=34598

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Appendix E

Sustainable Stormwater & Portland Resources

[5:22:15 PM] Ethan Smith:	http://www.werf.org/liveablecommunities/index.htm
WA State Univ at Puyallup: raingarden studies.	
SPROUT: Silverton, OR: phyto-remediation research	
NYC Dept of Environment: blue roofs	
Clean Water Services & Brown & Caldwell: Modeling of North Bethany Area	
Puget Sound Partnership	http://www.psparchives.com/publications.htm#pie
Raingardens video	http://earthfix.kuow.org/water/article/new-stormwater-regs-promote-low-impact-development/?goback=.gde_3778895_member_141286507
white oak ecosystem	http://news.oregonmetro.gov/1/post.cfm/metro-preserves-valuable-oak-habitat-at-voter-protected-natural-areas-across-the-region?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+OregonMetroNews+%28Metro+news%29&utm_source=Metro+contacts&utm_campaign=b7a62f95cc-Naturalareas&utm_medium=email
NYC green infr	http://dirt.asla.org/2012/04/04/green-infrastructure-goes-large-in-new-york/
Banking on Green Infr	http://www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf
Oxbow/Sandy flooding	http://news.oregonmetro.gov/1/post.cfm/hidden-forest-emerges-at-oxbow-but-surging-sandy-river-leaves-questions?utm_source=Metro+contacts&utm_campaign=ede42e01bf-Naturalareas&utm_medium=email
Portland Climate Data	http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or6749
	http://www.nrcs.usda.gov/Internet/FSE_MEDIA/nrcs143_024824.jpg
Columbia Green - stormwater effects of green roofs	http://www.sustainablebusinessoregon.com/articles/2012/09/oregon-best-awards-commercialization.html
PNW stormater strategies	http://earthfix.opb.org/water/article/if-bioswales-and-rain-gardens-are-so-great-why-are/
Ecotrust book "The Rainforests of Home"	
Plants of the Pacific Northwest Coast - Pojar taxonomy guidebook	
Functional Surfaces in Biology, 2009, SN Gorb, ed.	http://www.springer.com/life+sciences/book/978-1-4020-6696-2
Rising Currents: Projects for NYC's Waterfront	http://www.moma.org/explore/inside_out/2009/12/01/rising-currents-two-weeks-deep/

Appendix F

Biology Research Data

Common Name (organism/process/ system)	function (what the organism does)	strategy (1-2 sentence description of the specific strategy used by the organism; how organism meets function)	abstracted design principle (one sentence description of the basic, underlying principle at work, without reference to the biology)	source / citation	photo link	who added / revised	date added / revised	application idea
riparian vegetation (alder, cottonwood, willow, sedges/rushes, etc.)	slow flows, enhance infiltration	riparian species are adapted to tolerate flood flows by having flexible stems and the ability to send out roots (rather than shoots) along stems where buried in sediment. Riparian vegetation slows flood flows, traps sediment, and consequently allows greater infiltration & less runoff.	multiple vertical structures spread across a surface slow water	Karen		Karen	10/15/2012	
riparian areas	manage overland flow	This is basically nature's way of managing excessive flooding...that combined with vegetation and aerated soils with good nutrients and microbial activity.		Alexis Morgan [alexis.j.morgan@gmail.com]		mary	10/9/2012	
wetlands	manage flow and nutrients; cleanse water			Alexis Morgan [alexis.j.morgan@gmail.com]		mary	10/9/2012	
skunk cabbage	collect water	leaf arrangement collects water (wetland plant)		Karen		Karen	10/15/2012	
perched wetlands	hold/store water; prevent infiltration	Cooper Mountain is derived from columnar basalts. Soil is formed from loess (wind-blown sediment) that over time forms a 'fragipan'. The 'pan' (impermeable layer) forms 3-4 ft down, holding water.		Geology Story of Cooper Mountain: Deb Scriven's notes from a walk with a geologist contracted for Metro work on Cooper Mountain, prior to opening of the Cooper Mountain Nature Park…mid-nineties?	uploaded to google docs	Deb Scrivens, Karen	11.19.12	
fragipans - perched wetlands	dense materials to hold/store water; prevent infiltration	fragipans--subsurface soil layers characterized by high density and high mechanical strength relative to overlying soil layers. The presence of a fragipan in a soil landscape controls water storage and discharge because it restricts downward water movement and promotes the development of perched water tables above the fragipan. In sloping landscapes, the fragipan encourages lateral subsurface water flow. Site index and annual volume growth were greater where the fragipan was underlain by soil material rather than parent material, thus suggesting the importance to tree growth of root penetration into this horizon. The ability to penetrate and utilize the soil underlying a fragipan may be a characteristic of oak species. DeByle and Place (1959) found the rooting depth of northern pin oak and bur oak was greater than pine in soils containing fragipans. The perched water does not necessarily flow perpendicular to surface elevation contours because the topography of the fragipan surface is not parallel to the topography of the soil surface. In western Idaho, McDaniel and Falen (1994) found that 30-60% of the seasonal precipitation was stored above the fragipan during the wet winter months. This water is redistributed across the landscape through lateral flow above the fragipan interface. McDaniel and Falen (1994) found that the depth to the fragipan surface and the thickness of the zone	decentralized storage locations with lateral connections	http://soilslab.cfr.washington.edu/ESRM311/OregonSoilJudgingManual.pdf http://water.usgs.gov/wrri/00grants/KYfragipan.pdf http://www.ncrs.fs.fed.us/pubs/ch/ch01%5CChvolume01page285.pdf http://naldc.nal.usda.gov/download/15335/PDF		Karen	11.19.12	creation of traffic circles at intersections with rainwater collection/distribution. side benefits of slowing traffic, creating more walkable areas, reducing impervious surface, adding area of tree canopy, & creating wildlife corridors
Algal mats	filter water	Algae is cultivated in water treatment facilities in order to reduce atmospheric CO_2 and water soluble compounds such as inorganic nitrate, inorganic phosphate, nitrite, ammonia, and ammonium.		Adey, Walter H., Kangas, Patrick C. and Mulbry, Walter 2011. Algal Turf Scrubbing: Cleaning Surface Waters with Solar Energy while Producing a Biofuel. Bioscience, 61(6): 434-441. doi:10.1525/bio.2011.61.6.5. PDF of Algal Turf Scrubber system brochure http://www.hydromentia.com/Products-Services/Algal-Turf-Scrubber/Product-Documentation/Assets/ATS-Technical-Brochure.pdf		Emilie Boss	11/18/12 Karen	
TREE ROOTS & STRUCTURES								
roots	uptake water & nutrients	Fine roots: Primary roots usually <2 mm diameter that have the function of water and nutrient uptake. They are often heavily branched and support mycorrhizas. These roots may be short lived, but are replaced by the plant in an ongoing process of root 'turnover'.	regeneration of small, biodegradable parts			matt		components made using 3D printing technology, with a biodegradable medium

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mistletoe - haustorial roots Stem Hemiparasite - Obligate	uptake water & nutrients	Haustorial roots: roots of parasitic plants that can absorb water and nutrients from another plant. Two main types of parasitic plants can be distinguished: stem parasites and root parasites. Parasitic plants may also be classified as holoparasites, hemiparasites, obligate parasites, or facultative parasites. Facultative parasites contain chlorophyll and can be grown to maturity without hosts. Obligate parasites, on the other hand, require a host for maturation. Hemiparasites contain chlorophyll when mature (hence are photosynthetic) and obtain water, with its dissolved nutrients, by connecting to the host xylem via the haustorium. Holoparasites lack chlorophyll (and are thus nonphotosynthetic) and must rely totally on the contents of the host xylem and phloem. All holoparasites are obligate parasites. The stem parasitic mistletoes also exceed their hosts' transpiration rates. Given this, it is not surprising that mistletoes are most abundant in areas where access to sunlight is not limited, such as savannahs and at the top of forest canopies where shading is avoided. Recent work has shown that diversification in Loranthaceae occurred during the Oligocene, a time when temperate deciduous woodlands and grasslands were displacing tropical biomes. The aerial portions of woody plants certainly represented an unexploited niche that offered opportunities for colonization by such early mistletoes. The haustorium of Viscaceae never forms epicortical roots, but	redistribute resources using interconnected infrastructure	http://www.apsnet.org/edcenter/intropp/pathogengroups/pages/parasiticplants.aspx http://www.anbg.gov.au/mistletoe/haustoria.html		matt		greywater systems connecting multiple structures, using a central host. secondary structures feed on larger ones when they cannot access a main source.
root hairs	absorb water	Most water absorption is carried out by the younger part of the roots. Just behind the growing tip of a young root is the piliferous region, made up of hundreds of projections of the epidermal tissue, the root hairs. Root hairs are constantly being replaced, are narrow walled, and greatly increase the surface area over which water absorption can take place. Water in the soil spaces is taken into the root hairs by the process of osmosis (higher water concentration outside than within the root hair cells).	to optimize water uptake, increase surface area over which osmosis occurs	http://www.microscopy-uk.org.uk/mag/indexmag.html?http://www.microscopy-uk.org.uk/mag/artmar00/watermvt.html	see source	Karen	11.21.12	
root systems of wetland plants - nebraska sedge and baltic rush	uptake/store water	Manning et al. (1989) found that baltic rush produced 72 feet/inch3 of roots and Nebraska sedge produced 212 feet/inch3 of roots in the top 16 inches of the soil profile (reported in Hoag 2000). Function: hold soil together/ reduce erosion, uptake water.	dense root network optimizes water absorption	Hoag, J.C. 2000. Riparian/Wetland Project Information Series No. 14.		Karen	10/28/2012	
prarie grass roots	increase infiltration and absorbtion	prairie grass roots break up soils, increase infiltration capacity		Jennifer Belknap-Williamson		mary	10/13/2012	
Big Leaf Maple	absorb water	Rooting Habit- Bigleaf maple has a shallow, widespreading root system well suited to the shallow or saturated soils on which it often grows. It probably has a competitive advantage over deeper-rooted species under such conditions.	cover wide area for water absorption			matt		
red alder	enriches soil. prepares/stablizes it for other species	Red alder trees invade clearings or burned-over areas and form temporary forests. Over time, red alders build up the soil with their copious litter, and enrich it with nitrogen compounds formed by symbiotic bacteria that live in little nodules on their roots. Red alder stands are eventually succeeded by Douglas fir, western hemlock, and sitka spruce.	consider phasing and incremental steps when working toward an endgoal	http://eol.org/pages/1145612/details		matt		

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	stability, stabilize soil, withstand wind	Windthrow is not common in alder because of the intermingling of roots and branches, the absence of leaves during winter storms when soils can be waterlogged, and the relatively deep-rooting habit of the species on well-drained soils. Uprooted trees are most commonly observed along cutting boundaries or where established root systems have been undercut by flooding or erosion.	interlocking pieces allow for more stability			matt		
black cottonwood	deep broad rooting system	Planted cuttings of black cottonwood root very well; they produce deep and widespread root systems if growth is not restricted by adverse soil conditions. Little information on rooting has been collected in natural or seedling stands.	diversity of rooting depths increases absorptive capacity	http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_2/populus/trichocarpa.htm		Matt	11/4/2012	
Willow	regenerative parts	In a study of willow, Rytter (1999) found that fine root turnover rates ranged from 4.9 - 5.8 yr-1. With these figures included, fine roots accounted for between 28 - 50% of the net primary production of the plant. Inclusion of fine root turnover rates increased estimates of belowground biomass of willow by 200 - 400% compared to single point in time biomass estimates.	Produce many small biodegradable parts to distribute nutrients	http://www.esf.edu/willow/PDF/reports/2001%20RootsReport.pdf		matt		
	linking distribution systems with similar organisms	Work on the horizontal distribution of willow roots is even more limited because planting densities are extremely high (10,000 - 20,000 trees ha-1). This means that very early in the life of the plantation there is extensive root overlap and in some cases grafting occurs. One study that did measure root lengths found that the longest roots on three-year-old S. dasyclados were 4.3 m long (Ericsson 1984).	connect with others to share resources	http://www.esf.edu/willow/PDF/reports/2001%20RootsReport.pdf		matt		
	related to above. linkage to other organisms produces greater biomass? could this also be true of nutirent levels?	Planting configuration for SRWC systems also affects root distribution. Ericsson's (1984) study of S. viminalis roots showed that root biomass in the top 20 cm of a peat soil decreased with increasing distance between the double rows used in commercial plantations. Roots from the three-year-old trees were found across the entire 1.5 m space between the double rows, but root biomass was 60 - 70% lower in the 1.5 m space than the areas directly under the canopy of the trees. (pg11)	redistribution of resources strengthens the weakest link	http://www.esf.edu/willow/PDF/reports/2001%20RootsReport.pdf		matt		
Willamette Valley Ponderosa Pine	distribution of roots determined by soil types and densities	Mature ponderosa pines put down a root to depths of more than 2 m (6 ft) in porous soils, but seldom more than 1 m (3 ft) in heavy clay soils. Exceptions occur in soils underlain by rock with deep fissures, where roots have been observed along cut banks at depths of 11 to 12 m (35 to 40 ft). In open stands, lateral roots may extend 46 m (150 ft). In dense stands, however, they are limited more to the crown width. The main mass of roots is concentrated within the top 60 cm (24 in) of the soil mantle	diversify your strategies, but focus your attention where the most resources are	http://eol.org/pages/1061751/details		matt		
Douglas Fir		The rooting habit of coast Douglas-fir is not particularly deep, with the roots tending to be shallower than those of same-aged Ponderosa pine, sugar pine, or California incense-cedar, though deeper than Sitka spruce. Some roots are commonly found in organic soil layers or near the mineral soil surface. However, Douglas-fir exhibits considerable morphological plasticity, and on drier sites coast Douglas-fir will generate deeper taproots.				matt		

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hydraulic redistribution	roots transfer water between soil layers of different water potential, affecting distribution and availability of water in the soil profile	Abstract: Plant roots transfer water between soil layers of different water potential, significantly affecting the distribution and availability of water in the soil profile. Study from Australia, on 2 species: Grevillea robusta and Eucalyptus camaldulensis. Demonstrated a redistribution of soil water from deeper in the profile to dry surface horizons by the root system. This phenomenon, termed “hydraulic lift” has been reported previously. However, we also demonstrated that after the surface soils were rewetted once rains began, water was transported by roots FROM the surface TO deeper soil horizons – the reverse of the “hydraulic lift” - termed “hydraulic redistribution” (HR). HR of water in tree roots is significant in maintaining root viability & facilitating root growth in dry soils. HR allows plants to maximize water uptake during periods of high water availability and to 'store' the water for later use when shallow soil layers are dry. HR partially bypasses the process of infiltration. Mechanism: redistribution of water occurs whenever there's a water potential gradient across soil layer.	water potential gradient cause water movement	Stephen S. O. Burgess, Mark A. Adams, Neil C. Turner and Chin K. Ong. 1998. The redistribution of soil water by tree root systems.Oecologia Vol 115, No 3. See pdf uploaded. (while not reserach from PNW, this is the first study to show that water can move down taproot when surface soil layers are wetter than the deeper soil layers).				supports diversity of species and rooting depths in rain gardens, etc. - redistribute liquids to multiple sources to allow for the highest storage capacity. the larger the network the larger the capacity
hydraulic redistribution		Hydraulic redistribution is the process where soil water is translocated by plant roots from wet to dry areas as it is drawn through xylem pathways by a water potential gradient. Hydraulic redistribution places soil water resources where they would otherwise not be. Although deep-rooted plants can transfer water up from depth into shallow soil layers, any localised ‘irrigation' of neighbouring plants tends to be obscured by recovery of the very same water by the donor plants during daytime transpiration. A new intercropping system was recently trialled which eliminates transpiration by the donor plant through complete shoot removal in order to maximise hydraulic redistribution. In the absence of any transpiring shoots, the donor plants are left to wick water up from depth 24 hours a day via their root systems, to the benefit of neighbouring shallow-rooted crops. This system allows deeper-rooted ‘nurse plants' to capture water that is out of reach of crops in a ‘water safety-net' role, which may be of considerable benefit in water-scarce environments.	water moves through xylem pathways (capillary action) along a water potential gradient	Burgess, Stephen S. O. Can hydraulic redistribution put bread on our table? Plant and soil, 2011 Apr., v. 341, no. 1-2, p. 25-29. 341 1-2				
hydraulic redistribution		Study looked at spatial & temporal variability in hydraulic redistribution (HR) across mulitiple years in 2 old-growth coniferous forest ecosystem. HR accounted for 3-9% of the total site water depletion seasonally, peaking at 0.16 mm per day in Ponderosa Pine or 0.30 mm per day in Douglas Fir. Variability was attributed to natural variablity in water potential gradients and seasonal courses of root conductivity.		Jeffrey M. Warren, et al. 2007. Hydraulic redistribution of soil water in two old-growth coniferous forests: quantifying patterns and controls. New Phytologist (2007) 173:753–765 (searched PSU database on 'hydraulic lift')				
tubers/root vegetables	store water	no significant research discovered				matt	10/21/2012	
mycorrhizal fungi	absorb water & nutrients	Mycorrhizal fungi form mutualistic relationship with roots of most plant species. The fungus colonizes the host plant's roots, either intracellularly (invade interior root cells) as in arbuscular mycorrhizal fungi (AMF or AM), or extracellularly as in ectomycorrhizal fungi (form exterior sheaths around roots). Fungi obtains carbohydrates from the plant while increasing absorbtive capacity for water and mineral nutrients. Mechanism: physical - comparatively large surface area of mycelium: root ratio; chemical: cell membrane chemistry		http://en.wikipedia.org/wiki/Mycorrhiza		Karen	10/15/2012	

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mycorrhizal mushrooms	absorb water	myco': mushrooms, 'rhizal': roots. Most plants have mycorrhizal partners. Because ectomycorrhizal mycelium grow beyond the plant's roots, it brings distant nutrients and moisture to the host plant, extending the absorbtive zone well beyond the root zone. David Perry (1994) postulates that the surface area - hence its absorption capacity - of mycorrhizal fungi may be 10-100 times greater than the surface area of leaves in a forest. Result: more rapid growth of plant,	increase surface area to increase capacity to absorb; create a win-win to thrive	Stamets, Paul. 2005. Mycelium Running: How mushrooms can help save the world		Karen	11/18/2012	
mycorrhizal mushrooms	increase nutrient absorbtion	The mycelium dramatically increases the plant's ingestion of nutrients as it decomposes surrounding debris.		Stamets, Paul. 2005. Mycelium Running: How mushrooms can help save the world		Karen	11/18/2012	
mycorrhizal mushrooms	transport nutrients	Mycorrhizae can transport nutrients to trees of different species. Experiments showed transfer of carbon - and nitrogen - based nutrients to trees artificially shaded (reducing photosynthesis). Also, plants with MF, show a fungal defense against invasive diseases. This symbiotic pairing is the norm in nature, not the exception. "...a forest's vitality is directly related to the presence, abundance, & variety of mycelial assoc." **1/5 - 1/10 of the total biomass in the topsoil of a healthy Douglas Fir forest in the PNW may be made up of mycelium.		Stamets, Paul. 2005. Mycelium Running: How mushrooms can help save the world	Cover of book - cool image - poor quality at this link: http://books.google.com/books/about/Mycorrhizal_Symbiosis.html?id=v9V8cH0mPS4C	Karen	11/18/2012	
mycorrhizal fungi	multi-functional, decentralized system	And Janine asked "Can a city be generous?" and then answered with the example of the "wood wide web" of fungal mycorrhizal networks that connect trees in a forest, allowing them to exchange nutrients, water, and chemical alarm signals. She believes we could design human technological infrastructure to mimic those ecosystem services provided by the fungi, essentially creating a decentralized yet interdependent network of multi-functional structures.		B3.8 Nov 2012 newsletter		Karen	11/16/2012	
AskNature Research	**taxonomy**							
The fungal skin of lichens	store liquids	prevents water loss to the algae below via its dense compacted thread structure.	dense thread structures prevent water loos	http://www.asknature.org/strategy/281e57b43f75969cf421b72deaeca600		Matt		Impermeable biological membranes for water storage tanks, impermeable tarps to retain soil moisture
cloud forests - douglas fir	capture, absorb liquids	Water condensing on the needles and dripping to the ground can increase precipitation enormously.		http://www.asknature.org/strategy/55f2f27aebc04a8f5e38c8451b00d341		Matt		
Fava beans (and other legumes)	distribute liquids. monitor and manage fluid flows		self healing systems prevent fluid loss	http://www.asknature.org/strategy/b6e589644f4f454ff1931e336fb3fc46		Matt		maintenance and self-healing pipes/distribution systems
Xylem conduits in plants		transport water from soil to leaves through a pulling force generated when water evaporates at the surface of leaves creating a negative pressure gradient.	capillary action (small tubes and negative pressure move water). (size of tubes critical for capillary action to work).	http://www.asknature.org/strategy/d7662735f5e44d5c879876f05652d091		Matt/Karen	11/17/2012	Storage pumping mechanisms
spider legs	regulate flows	are powered hydrolically and have a special mechanism to seal off a joint that prevented fatal depressurization when a leg was lost	self healing systems prevent fluid loss	http://www.asknature.org/strategy/7c45f8c9f552e8ba03e72dd2bc08fa6d		Matt		
	Provide ecosystem services - regulate water storage							
pines	slow water	evergreen trees provide a better year-round cover, slowing water reaching the soil. Transpiration and evaporative losses from pines are greater because this species retains most of its needles year-round. In contrast, the dormant hardwoods stand leafless through the fall and winter, and their bare trunks and branches allow more rain to reach the soil and seep to the streams…the conversion of just sixteen hectares of forest from oak-hickory to pines cost 23 million liters in lost water in a single year.	create durable strategies in all weather conditions	http://www.asknature.org/strategy/b101352e343607ce56105aa35d9cc042		Matt		
wetland (in PNW, palustrine emergent, scrub-shrub, and forested)	Provide ecosystem services - regulate hydrological flows	wetlands regulate flows by lacking topographic relief, lacking well-defined channels, and having extensive root systems. Attenuate flow in wet conditions and release it in dry conditions (peatland entry)	By mimicking the structures of peatlands, a community could absorb periodic floodwaters	http://www.asknature.org/strategy/0e0eb0b500f25b619536236eb16c9af3		Karen		

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vegetation	treat water, maintain water quality, reduce algae	Vegetation in water catchment basins strip nutrients from water by maintaining a diversity of organisms that act in different ways.	maintain water quality through the use of microorganisms (bioutilization)	http://www.asknature.org/strategy/4a40878949b8781e9e71f4f278d95a93		Matt		
Dufour's gland of plasterer bees	water proof	The Dufour's gland of plasterer bees protects their nests from water by secreting a natural polyester.	continual creation of organic fluid protects from excess moisture	http://www.asknature.org/strategy/43eee1ef18843706b39818dc0e851e6c		Matt		
		humidity-sensitive hilar valve		http://www.asknature.org/strategy/69be3c9e5526f1f98d08d8353336ac28				
common arrowhead (a wetland plant)	adapt (leaves) to changing environment	Leaves of Sagittaria latifolia allow survival in fluctuating water levels by changing leaf type. Since wetland plants encounter a variety of water depths seasonally and interannually, they show a great deal of phenotypic plasticity, allowing them to adjust their growth as water levels change. One type of phenotypic plasticity that is widespread among macrophytes is heterophylly, the ability to produce different leaf types. Two kinds of leaves are commonly produced by herbaceous wetland species, submerged and aerial. Submerged leaves are thin, lack or have a greatly reduced cuticle, and lack functional stomata. Aerial leaves are thicker, have a cuticle, and have stomata. Changes in leaf shape, size, and thickness and petiole or leaf/shoot length are common in facultatively heterophyllous species. The porosity of their roots can also change significantly as soils become anoxic after flooding in flood-responders (Fig. 4.7). These morphological responses primarily serve as a way to improve oxygen uptake by leaves, the volume of internal gas storage, and the efficiency of internal gas redistribution by diffusion." (van der Valk 2006:67)	adapt morphology to abundance or scarcity of water	http://www.asknature.org/strategy/2983ffad60cef3be906472af54c3395d		Karen	11.20.12	
plant cells, osmosis	move water	Tissues of plants generate hydrostatic pressure by injecting solutes into a confined space and allowing water to enter. Osmosis requires two components: a semipermeable membrane inside to concentrate the solutes and a restraining, but elastic and expandable wall outside to prevent the compartment from bursting when water is taken up during the hydration of these solutes. The hydration of the solutes generates hydrostatic pressure inside the osmotic compartments. All plants use osmosis to pump and concentrate water-binding electrolytes and nonelectrolytes into the inside of their cells and in particular into the vacuole, a membrane-surrounded compartment specifically designed for storing solutes and water. Osmotically operating plant cells allow the build-up of internal pressures far exceeding that of car tires.	encourage water movement into 'cells' to store for later release. Utilize hydrostatic pressure to do work.	http://www.asknature.org/strategy/3e55a8aa655e1a2be17a225e93662d17#changeTab		Karen	11.20.12	Develop systems that control moving parts based on osmosis rather than electricity. Actuators that work by osmosis.
American Beaver	intercept flows, detain nutrients	Beavers alter ecosystems by cutting trees and shrubs and creating mosaics of wetlands, moist meadows, and ponds. Beaver activities retain sediment and organic matter in the channel, create and maintain wetlands, modify nutrient cycling and decomposition dynamics, modify the structure and dynamics of the riparian zone, influence the character of water and materials transported downstream, and ultimately influence plant and animal community composition and diversity.	A complex mosaic of material captures and detains nutrients and water flow.	http://www.asknature.org/strategy/fe336fe9a62943d43701a6edc1f2be69		Nicole	10.28.12	

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Animal Ecosystem Engineers in Streams	alter or maintain ecosystem function	Animal behavior (e.g., digging, foraging, material consolidation) and its physical morphology can modify stream systems to better handle hydrological disturbances like peak stormwater events. It's not all about the vegetation!! The impact an ecosystem engineer has on its environment will be a function of three main aspects of the biology of the engineer: behavior, body size and population density. Animals can create their own or modify habitat. Nest digging, foraging, bioconsolidation and particulate matter processing all positively influence stream health and can help streams modulate flood impacts. For example, while salmon nest digging is a substantial disturbance to spawning areas, their bioturbation may actually decrease the susceptibility of streams to erosion from floods. Specifically, by sorting sediments into size classes, salmon nest digging may increase critical shear stress (minimum flow before bed scouring occurs) of stream bottoms.	Material rearrangement, consolidation, and sorting - all disturbances from external influences - can actually strengthen substrates by enabling it to better handle larger more catostrophic disturbances.	http://fish.washington.edu/research/alaska/publications/ASP_Papers/Moore%20BioScience.pdf		Nicole	11.26.12	
Ecological Engineering	aerating soil for faster, deeper stormwater penetration and infiltration.	voles, moles, worms and other soil dwelling creatures are known to increase infiltration rates by aerating the soil and tunneling channels.	network of underground channels of varying diameters work together to enable stormwater to penetrate faster and deeper into the ground.			nicole		
Debris dams	slow flows, retain carbon	Storage of organic matter plugs carbon "leaks": riparian habitat. Trees along rivers help retain carbon in an ecosystem by adding organic debris and slowing down water.	material creates temporary plugs to capture nutrients and slow water. decomposes slowly to contributes to overall water nutrient levels.	http://www.asknature.org/strategy/1ca6d9c980b6ae7cfcb82ba9a5f61d23		Nicole	10.28.12	
tree branches, leaf veins, our lungs...	distribute fluids	Murray's Law: an optimum arrangement that minimizes the amount of biological work required to operate and maintain the system. The relationship between the diameter of the parent vessel and the optimum diameters of the daughter vessels was first derived by Murray (1926) using the principle of minimum work. This relationship is now known as Murray's law and states that the cube of the diameter of a parent vessel equals the sum of the cubes of the diameters of the daughter vessels."		http://www.asknature.org/strategy/d1442a1db68ec652989048958684909c		mary	10/28/2012	
forest floor	store water	stores water through absorption in soils and plant matter		Harvesting, Propagating, and Planting Wetland Plants. July, 2002.		mary		
forest floor: organic soil (A-horizon) below decomposed organic matter below leaf litter	intercept, increase absorbtion					Karen		
The Influence of Canopy Structure and Epiphytes on the Hydrology of Douglas-fir Forests	store water	water storage by lichens and bryophytes, canopy coverage and tree limbs. Good comprehensive study. The forest floor in old-growth Douglas-fir forests generally contain between 4-8 mm of litter (Chapter 2; Shaw et al., 2004) and have 25% of its surface area covered by deadwood (Harmon and Sexton, 1995). Forest floor litter is estimated to store between 100 and 150% of its dry weight in water (Helvey and Patric, 1965) and the deadwood on the forest floor is estimated to intercept and store 2-5% of Pn (Harmon and Sexton, 1995).	a variety of materials located at varying heights above the ground level, create an overlapping multi-directional mosaic. This pattern and structure works to intercept and absorb an enormous amount of stormwater before it evens hits the ground.	http://andrewsforest.oregonstate.edu/pubs/pdf/pub3846.pdf		Nicole		create a series of stratified layers for collection. think about how to collect, slow, and store. surface potential include roofs and canopies, walls and window systems, furniture, public art, biomass, transit shelters, energy generation, etc
Old Growth Canopy	absorb water	As precipitation increases, daily maximum temperatures and the daily temperature range decrease. This buffering reflects the large water-holding capacity of the canopy- about 264,000 gallons per acre equivalent to1 ¼ inches (3 cm) of precipitation.	large surface area	Franklin, Jerry, et al. 1981. Forest Service General Technical Report PNW -118: Ecological Characteristics of Old Growth Douglas Fir Forests.		nicole	11.19.12	

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HJ Andrews Research - Trickle-down Ecohydrology: Complexity of Rainfall Interception and Net Precipitation under Forest Canopies	Intercept rainfall, catch, store	Plant canopies intercept and temporarily store a large amount of moisture, typically less than 2 mm, or 0.15 to 0.5 mm per unit leaf area index (Carlyle-Moses and Gash, 2011), but as much as 5 mm has been observed (Pypker et al., 2006). In the Pacific Northwest, interception loss is 10 – 20 % of the annual precipitation, at the lower end of the spectrum despite the high storage capacity of dense coniferous canopies (Rothacher, 1963; Link et al., 2004; Pypker et al., 2005). The interception loss is low because the bulk of annual precipitation occurs during large winter storms, where the canopy storage capacity is far exceeded and evaporation rates are very low (Rothacher, 1963). In general, greater leaf area corresponds with greater interception (Aston 1979), and greater transpiration until a maximum leaf area is reached (Bond et al., 2007). It has been observed that leaf area is positively correlated with a regions average annual precipitation (Grier and Running, 1977; Hinckley et al., 1978);	Multi-layered / tiered mosaic of structures work collectively to intercept rainfall and temporarily store it for later release. The amount that evapo-transpirates or falls to the ground is related to the duration of rainfall and periods between storms. Canopy catchment redistributes rainfall before it hits the ground lessoning erosion and enables more even distribution of rainfall to the ground level instead of merely through canopy gaps.	http://andrewsforest.oregonstate.edu/pubs/pdf/pub4764.pdf		nicole		
Douglas fir	water uptake, interception and photosynthetic capability	tree leaf area increases with increased annual average precipitation. Coniferous leaf area can increase quite a bit over a gradient of drier to cool moist locations. Leaf area is a determinining factor in site water balance and total precipitation. Leaf area of Douglas-fir is higher than broadleaf deciduous forests. Disruption in water balance replacing native fir forests with ornamentals in urbanized areas?	material structure mass or total volume of "production area" (i.e., leaves for photosynthesis) is directly proportional to the amount of nutrients (water) available.	Ecology (1977) 58: pp. 893-899		Nicole		
Douglas fir - Tree water storage and its diurnal dynamics related to sap flow and changes in stem volume in old-growth Douglas-fir trees	move water, absorb	Water movement rates are highest in sapwood/heartwood (xylem) and lowest in phloem. Highest in lower portions of the tree and lowest in the crown. Graphics on pages 3 and 14 show water volumes in portions of a Doug fir tree and on 14, water volumes in 20 different tree species. On selected fine days between late July and early October, when daily transpiration ranged from 150 to 300 liters, the quantity of stored water used daily ranged from 25 to 55 liters, i.e., about 20% of daily total sap flow.	Material aborption rates help manage stormwater volumes and certain materials absorb much more water than others. Water can be used for a variety of purposes including creating food, circulation for nutrients, regulation, and other living processes.	http://treephys.oxfordjournals.org/content/27/2/181.full.pdf+html		Nicole		
Douglas fir Oregon White Oak Ponderosa Pine	store water	Increased use of stored water in larger trees could be an adaptation to, or simply a consequence of, tree size. Study found higher volumes of stored water in older trees than younger trees across these three species. Tables show stored water amounts for all three. Due to several variables, leaf area, difficulty for older trees to move water through.	water volume and biomass volume go hand in hand. Sometimes more water is needed because the mechanisms to move water are inefficient or not optimized.	http://treephys.oxfordjournals.org/content/23/4/237.full.pdf+html		Nicole		
How Trees Infl uence the Hydrological Cycle in Forest Ecosystems	water transport through tree species.	Research goes into depth about water uptake from roots through capillaries, leaves and released as vapor via stomata.	capillary pressure moves water from a source to a desired location, defying gravity. The more water withdrawn from the source, the faster saturated water conditions can be managed.	http://andrewsforest.oregonstate.edu/pubs/pdf/pub4449.pdf		Nicole		
How does rainfall become runoff?			variation of ground surfaces enable water to infiltrate or run off the surface of the ground at varying speeds.	http://andrewsforest.oregonstate.edu/pubs/pdf/pub3919.pdf		Nicole		
depressional areas	stormwater catchment and infiltration	Big Idea: roadway intersections renamed as "intercepts." These areas are depaved and scoured to form a depressional area with pavers and seeded area or a few key wells. Basically a big drywell.	Depressional areas on the ground serve to catch water for shallow and deep infiltration. The greater the depression, the lower the "risk" for erosion and slumping especially on steeper hillslopes.			Nicole		

Common Name (organism/process/ system)	function (what the organism does)	strategy (1-2 sentence description of the specific strategy used by the organism; how organism meets function)	abstracted design principle (one sentence description of the basic, underlying principle at work, without reference to the biology)	source / citation	photo link	who added / revised	date added / revised	application idea
downed wood/logs	absorb/store water	Measurements were made of throughfall, leachate, runoff, and absorption for logs during their 6th through 8th year of decay. During this period 47–70% of the throughfall landing on the logs evaporated, 18–35% flowed through the log and leached out, 3–29% ran off the surface, and absorption accounted for 3–11%. Together absorption and evaporation intercepted 60% of the throughfall impacting the logs.	Material absorption rates vary and often materials not only absorb, but work to redistribute water, hold it until sunlight heats the surface vaporizing water, and slows water before infiltrating the ground.	"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]) " http://www.bioone.org/doi/abs/10.3955/046.083.0204		Nicole		inclusion of decaying matter in parking lot/street side swales, raingardens (bio-utilization)
downed wood/logs - in old growth forests	absorb/store water	Old Growth Douglas Fir - Western Hemlock forest conditions (175-250 yr old) considered. From the graph in Part 2, it seems a newly fallen tree (dead wood) quickly absorbs an enormous amount of water rising from 450 to 550 milligrams per cubic centimeter (graph A if you scroll down about half way).	newer material (i.e., recent fallen trees) absorb a enormous amount of water initially until a carrying capacity or saturation state is achieved. Materials with more acid tannins (e.g. Doug fir over alder) decomposes more slowly acting as a water storage mechanism for long periods of time (100's of years).	Franklin, Jerry, et al. 1981. Forest Service General Technical Report PNW -118: Ecological Characteristics of Old Growth Douglas Fir Forests. (uploaded Parts 1 & 2 to google docs)		nicole	11.19.12	
Epiphytic Lichen & Moss in old growth forest	absorb water	Almost every surface of an old-growth Douglas-fir is occupied by epiphytic plants; more than 100 species of mosses and lichens. In forests below 3,500-foot elevation, about half the total weight of epiphytes is usually due to a single leafy or "foliose" lichen, Lobaria oregana, which is an active N fixer. It occurs chiefly on the upper sides of branches and twigs. Lepraria membranacea, on the other hand, prefers the lower trunk and the underside of branches. Nearly all mosses occur on the bottom half of a tree.	Diversity & Distribution optimizes absorbtion	Franklin, Jerry, et al. 1981. Forest Service General Technical Report PNW -118: Ecological Characteristics of Old Growth Douglas Fir Forests.		Karen	11.19.12	
most common epiphytic foliose lichen in old-growth forest	absorb water	Lobaria, the dominant epiphytic lichen in old-growth stands on the west slope of the Cascade Range, is metabolically active when wet and dormant when dry. One-half to 1 inch (1 to 2 cm) of rainfall will wet the canopy sufficiently to raise the water content of the Lobaria above 70 percent. Below this moisture level, the lichen ceases to fix N and is presumably protected against temperature extremes by dormancy. Note: although lichen absorb water quickly, they also release quickly		Franklin, Jerry, et al. 1981. Forest Service General Technical Report PNW -118: Ecological Characteristics of Old Growth Douglas Fir Forests.		karen	11.19.12	
peat moss	absorb water	absorb water when available; persist when water unavailable; 40 species in PNW		Plants of the Pacific Northwest Coast, Pojar, Mackinnon		Karen	10/15/2012	
mosses	absorb water	Lichens and bryophytes are all poikilohydric which is defined as meaning that their water content (WC, thallus water content) will tend to equilibrium with the water status of the environment. Under wet conditions they become hydrated and active,u nder dry conditions they dry out and become dormant. Often epiphytic ('air plants'), able to tolerate drying and absorbing water when available. Mosses that grow in dense turfs or cushions are able to capture the most and hold onto their water for longest.		Chapter 6 Ecophysiology of Desiccation/Rehydration Cycles in Mosses and Lichens. T.G. Allan Green, Leopoldo G. Sancho, and Ana Pintado. Part 1 (uploaded)	photo - Fig 6.1g Sphagnum shoots showing typical leaves appressed to lateral branches which store water in large dead cells;	Karen	11.19.12	
mosses	absorb water	Thallus water content for bryophytes and lichens is normally related to dry weight: WC (g H2O g dw_1) = [(fresh weight _dry weight)/dry weight] It is often expressed as a percentage so that a value of 100% indicates equal amounts of water and dry matter (1 g H2O 1 g dw_1). Sphagnum can be ~2,000% (2,000 g h20 per gm dw) or 4.4 pounds water (0.53 gallon) per 0.0022 pounds sphagnum = (2000x its dry wt in water!). Water absorption in Bryophytes: Bryophytes lack vascular tissues so Bryophytes must absorb all water and nutrients at the surface and pass them from cell to cell. A few have modified water transport cells, call hydroids, and a few have solute conducting cells, called leptoids, but this is rare.		Chapter 6 Ecophysiology of Desiccation/Rehydration Cycles in Mosses and Lichens. T.G. Allan Green, Leopoldo G. Sancho, and Ana Pintado. Part 2. Section 6.2.2 Thallus Water Content: The limits	fig 6.1g	Karen	11.19.12	

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Star moss	structure to absorb water	Many bryophytes have simple leaves, often only one cell thick,and, by various means, separate water storage from gas exchange (Fig. 6.1b). One method is to simply have concave leaves with the outer i.e. lower surface of the leaf water repellent (often by wax deposits) and the water stored on the hydrophilic concave upper surface. This is a highly efficient structure with photosynthetic cells carrying out gas exchange on the convex side and accessing stored water on the other. This is taken further in many bryophyte species by arranging shoot systems with closely overlapping concave leaves, the inner surfaces functioning for storage and the outer for photosynthesis, with the added advantage that water movement along the stem is also possible by capillarity. Good examples of this are Weymouthia spp., Pleurozium schreberi and Scleropodium spp. (Proctor 2008).	overlapping concave units with water repellent lower/outer surface and water stored on hydrophilic concave upper surface creates structural complexity to optimize water absorption (see photo link)	T.G. AllanGreen, Leopoldo G. Sancho, and Ana Pintado, 2011. Chapter 6 Ecophysiology of Desiccation/Rehydration Cycles in Mosses and Lichens. Part 1 (uploaded) http://eol.org/data_objects/20811942 http://eol.org/pages/88078/overview	Fig 6.1b	Karen	11.19.12	utilize design principle on exterior vertical faces of buildings to help capture water.
mosses used in green roofs	absorb water, tolerate drought, lightweight	Mosses are sometimes used in green roofs. Advantages of mosses over higher plants in green roofs include reduced weight loads, increased water absorption, no fertilizer requirements, and high drought tolerance. Since mosses do not have true roots, they require less planting medium than higher plants with extensive root systems. With proper species selection for the local climate, mosses in green roofs require no irrigation once established and are low maintenance						
lichen	absorb water	absorb water when available, but not as good as moss at holding water. Easily dessicated. Not as structurally complex water storage mechanism as in moss. (mechanism: scales?). ***Any strategy that absorbs water, slows water input to the 'system'		Chapter 6 Ecophysiology of Desiccation/Rehydration Cycles in Mosses and Lichens. T.G. Allan Green, Leopoldo G. Sancho, and Ana Pintado, Part 3 (uploaded) Pojar. Plants of the Pacific Northwest Coast http://www.fastcoexist.com/1680661/want-water-solutions-nature-has-already-figured-them-out#8		Karen	10/15/2012	
sedums/succulants		used on greenroofs. prefer well drained locations. edible				matt		
birds	transport/move water	shed water from their wings to maintain light weight for flight				mary	1/16/2013	
ALTERNATIVE FUTURES FOR THE WILLAMETTE RIVER BASIN, OREGON	lesson on pre-development and current conditions for vegetation types in the Willamette Valley. Diversified vegetation as an important protection mechanism.	Historically, a diverse bottomland forest of black cottonwood, Oregon ash, alder, and other riparian species extended 2–10 km wide along the length of the Willamette River. Only 20% of that area is forested today (Gregory et al. 2002a). Elsewhere in the valley, fires set regularly by Native Americans maintained open grasslands and oak savanna (Boyd 1986). Extensive land conversion for human use, together with invasion of shrubs and trees following fire suppression, have lead to nearly 100% loss of some of the unique habitats that evolved under the presettlement fire regime. It is questionable whether any true oak savanna remains. An estimated 97% of the wet and dry prairie and 95% of wetlands have been lost. Upland portions of the WRB still are predominately forested, although forest age structure has shifted due principally to forest harvesting.	diversity of vegetation types and buffer areas along streams lead to diverse habitat and a variety of ways mechanisms for handling stormwater flows.	http://andrewsforest.oregonstate.edu/pubs/pdf/pub4066.pdf		Nicole		
search Oak Ck Station in MacDonald Forest				http://water.oregonstate.edu/oakcreek/research/hydrology/index.htm				
INSECTS								

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Appendix F

Biology Research Data

Common Name (organism/process/ system)	function (what the organism does)	strategy (1-2 sentence description of the specific strategy used by the organism; how organism meets function)	abstracted design principle (one sentence description of the basic, underlying principle at work, without reference to the biology)	source / citation	photo link	who added / revised	date added / revised	application idea
Leafhopper	waterproof	Waterproofing on wings, body, eggs. Brochosomes: intricately shaped proteinaceous secretory particles of 0.2-20 µm in size produced by the Malpighian tubules. Brochosomes produced by the insect form a powdery coating on body or eggs that repels water and honeydew/excrement.	http://www.inhs.uiuc.edu/~rakitov/brochosomes.html	Rakitov R. A. 1999. Secretory products of the Malpighian tubules of Cicadellidae (Hemiptera, Membracoidea): an ultrastructura study. International Journal of Insect Morphology and Embryology 28: 179-193. http://www.inhs.uiuc.edu/~rakitov/brochosomes.html		Emilie Boss	11/18/12 Karen	
Termite	waterproof	Waterproof wings. Sculptured hairs & micrasters (star-shaped structures 5-6µm in diameter) on the surface of the termite wing shed water by maintaining the spherical shape of water droplets, allowing droplets to roll off the wing surface. Termites are able to fly in rain, despite having large wings and being relatively weak fliers. Structures very similar to micrasters on the leaves of lotus and roses.		Watson G.S., Cribb B.W., Watson J.A. 2010. How micro/nanoarchitecture facilitates anti-wetting: an elegant hierarchical design on the termite wing. ACS Nano 4: 129-136. Lotus: https://plus.google.com/114601143134471609087/posts/HAsSkbb91RT#114601143134471609087/posts/HAsSkbb91RT		Emilie Boss	11/18/12 Karen	
Lacewing	waterproof	Waterproofing wings. Hairs with finely sculpted channels on wings. "Water drops with kinetic energy falling onto the surface of the wings of the lacewing can be repelled away with the aid of the hairs acting as a layer of microsprings that resist penetration and dispersal of drops."		Hu H-M., Watson J.A., Cribb B.W., Watson G.S. 2011. Multi-Functional Insect Cuticles: Informative Designs for Man-Made Surfaces. World Academy of Science, Engineering and Technology 59: 1370-1374. https://www.waset.org/journals/waset/v59/v59-260.pdf		Emilie Boss	11/18/12 Karen	
Isopods, flea larvae, rove beetle larvae, ticks.	Absorption of atmospheric water vapor	Colligative absorption: a special chamber (associated with mouthparts or rectum) into which hyperosmotic (e.g. salt- or sugar-rich) fluids are deposited by active transport. Hyperosmotic fluid attracts water vapor, which is absorbed by the arthropod.		Wright J.C., Machin J. 1993. Atmospheric Water Absorption and the Water Budget of Terrestrial Isopods (Crustacea, Isopoda, Oniscidea). Biological Bulletin 184: 243-253.		Emilie Boss	11/18/12 Karen	
Bark lice & parasitic lice	Absorption of atmospheric water vapor	The salivary glands produce a hygroscopic fluid film on a specialized smooth plate inside the mouth. Water vapor consenses on its surface as muscles of the head pump humid air through the mouth.		Rudolph D. 1983. The water-vapour uptake system of the Phthiraptera. Journal of Insect Physiology 29: 15-25.		Emilie Boss	11/18/12 Karen	
honeypot ant	store fluid	stores fluid in abdomen (I did not check to see if this is a local organism... likely not, but maybe there are other local ants that store fluid in abdomen?)		student work, ISSP (AskNature?)		mary	10/12/2012	
erosion processes	slow water, manage stormwater	Erosion processes also help to slow water and manage stormwater.		Alexis Morgan [alexis.j.morgan@gmail.com]	http://cooperhewitt.photoshelter.com/image/I0000T_t5v.pBNU4	mary	10/9/2012	

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Appendix G

GofP Assets

Challenge with context (covers all strategies) // ~30 words	Biological Strategy Focus	Champion (common name)	Champion (scientific name)	Core function	Biology story including strategy // 250-300 words	Mechanism	Design Principle/s // Bullet list of 5-10 words per principle
				What nature is doing.	Strategy: How the function is achieved.		The design principle is the idea that can be emulated in design. A mechanism can sometimes be directly copied, but usually the constraints on your particular natural example will not be exactly the same as those in the project, so direct imitation seldom represents the best emulation.
Water runoff from heavy rain events overload the city's existing sewer system.	Moss	Star moss	*Tortula ruralis*	Absorb water	Mosses are an abundant part of a temperate coniferous or broadleaf forest. They are often epiphytic, found growing on the lower half of trees, but can also be widespread across a forest floor. 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, 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! Many mosses have simple leaves that are one cell thick and can optimize water absorption and gas exchange. Mosses have concave leaves with a water repellent lower surface and a hydrophilic concave upper surface where water is absorbed and stored. The water repellency is often a result of wax deposits. This highly efficient structure allows photosynthetic cells on the lower convex side to carry out gas exchange, while the upper concave side absorbs water. In addition, shoot systems are arranged with closely overlapping concave leaves, the inner surfaces functioning for storage and the outer for photosynthesis. Reference: Green, T.G. Allan, Leopoldo G. Sancho, and Ana Pintado. 2011. Chapter 6 Ecophysiology of Desiccation/Rehydration Cycles in Mosses and Lichens. Parts 1 and 2.	Mosses have concave leaves with a water repellent lower surface and a hydrophilic concave upper surface where water is absorbed. The cells contain 'compatible solutes' (such as sucrose) that cause absorption via osmosis. The water repellency is often a result of wax deposits. This highly efficient structure allows photosynthetic cells on the lower convex side to carry out gas exchange, while the upper concave side absorbs water.	Overlapping concave units with water repellent lower surface and hydrophilic concave upper surface absorbs water and captures energy.
	Mycorrhizal fungal networks	Ectomycorrhizal fungi (many species). Chanterelle	Cantharellus sp.	Absorb water	Mycorrhizal fungal networks connect trees in a forest, allowing them to exchange nutrients, water, and chemical alarm signals, creating 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 comparatively large surface area of mycelium: 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. Reference: Stamets, Paul. 2005. Mycelium Running: How mushrooms can help save the world. Berkeley: Ten Speed Press.	Absorptive capacity is increased due to comparatively large surface area of mycelium: root ratio and to cell membrane chemistry.	- Optimize water uptake using network architecture that increases surface area over which osmosis occurs
	Diversity of rooting depths	Black Cottonwood	*Populus balsamifera*	Absorb water	Most intact native ecosystems in the PNW contain a diversity of species with a broad range in rooting depths. Some species, such as bigleaf maple or herbaceous wetland plants such as Baltic rush or Nebraska sedge have shallow, widespread root systems. Others have deep roots. Some trees, such as black cottonwood (Populus balsamifera) put down both deep tap roots and shallow, broad surface roots. The effect of this diversity of rooting depths is increased capacity to absorb water and hold soil together. Water absorption is carried out by root hairs that greatly increase the surface area over which absorption can occur via osmosis. However, in many some cases, mycorrhizal fungi associations provide the increase surface area to absorb water, preventing the plant from investing energy to produce root hairs.		Diversity of rooting depths increases water absorption in soil (not really a design principle)

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Appendix G

GofP Assets

Challenge with context (covers all strategies) // ~30 words	Biological Strategy Focus	Champion (common name)	Champion (scientific name)	Core function	Biology story including strategy // 250-300 words	Mechanism	Design Principle/s // Bullet list of 5-10 words per principle
				What nature is doing.	Strategy: How the function is achieved.		The design principle is the idea that can be emulated in design. A mechanism can sometimes be directly copied, but usually the constraints on your particular natural example will not be exactly the same as those in the project, so direct imitation seldom represents the best emulation.
	Beaver Activity	American Beaver	Castor canadensis	Intercept and slow water flow	For extensive water redistribution that controls flooding and erosion via the creation of wetlands, provides settling ponds for sediment, and habitat for fish and wildlife, nothing matches the work of beavers (Castor canadensis). The mere sound of moving water or even seeing or feeling the flow of water stimulates beavers to build. 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. Trees up to 3 ft. in diameter may be used, but the average diameter is 4 to 12 in. Sticks, bark (from deciduous trees), rocks, mud, grass, leaves, masses of plants, and anything else available, is then used to build the superstructure. The type of dam built and how it is built is dependent on the speed of water. In most cases, dams are built wider at the base. In slow-moving water, beavers may build a straight dam whereas in faster water dams tend to curve upstream. Spillways and passageways are built into the dam to allow excess water to drain off. The average height of a dam is 6 ft., while the average depth of water behind the dam is 4 to 6 ft. The thickness of the dam is often at least 5 ft. The length depends on the stream width, but averages about 15 ft. long. Video Link: http://animal.discovery.com/tv-shows/other/videos/fooled-by-nature-beaver-dams.htm Resources: AskNature. Stream remodeling alters ecosystems: American beaver . Provided by the Biomimicry 3.8 Institute. URL: http://www.asknature.org/strategy/fe336fe9a62943d43701a6ed c1f2be69. Accessed September and December 2012. Fall, Samuel W. 2007. Beaver Facts and Natural History / Dams. URL:	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.	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. Water slowed by the matrix backs-up, rising in height, wetting a larger surface area where it is detained until released or absorbed into the ground.
	Downed Wood	Mature Forest		Intercept water	Physically, wood is a collection of long thin pointed cells made up of cell walls on the outside and air in the inside. Think of it as a bundle of drinking straws, which is actually quite fitting since the cells' job is to transport water, nutrients and sugars up and down the trunk. Cell walls are made of two types of cellulose and lignin acts as a glue to hold together the layers of cells. Most cells have their long direction parallel in the direction of tree growth. The wall of each cell has a cross-sectional shape that is rectangular with slightly rounded corners. 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 a piece of wood. Wood is hygroscopic, which means it can absorb water vapor from the atmosphere. And when standing, a tree is constantly balancing its moisture content, but when a tree falls, it loses its ability to regulate water and cells become fully saturated. All of those drinking straws become full of 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 about 2-5% of the precipitation reaching the forest floor (not intercepted by the canopy or understory shrubs or younger trees). 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. Note that old growth forest typically allows for more water to reach the forest floor than new growth forests where trees are more closely packed together. 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	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.	Bundles of hollow cylinders transport water. Holes in the walls between hollow cylinders allow water storage, absorption, and evaporation.

Biomimicry Oregon Genius of Place Stormwater Project

Appendix G

GofP Assets

Challenge with context (covers all strategies) // ~30 words	Biological Strategy Focus	Champion (common name)	Champion (scientific name)	Core function	Biology story including strategy // 250-300 words	Mechanism	Design Principle/s // Bullet list of 5-10 words per principle
				What nature is doing.	Strategy: How the function is achieved.		The design principle is the idea that can be emulated in design. A mechanism can sometimes be directly copied, but usually the constraints on your particular natural example will not be exactly the same as those in the project, so direct imitation seldom represents the best emulation.
	Canopy Structure	Old growth forest		intercept rainfall	The canopy structure of an old growth forest provides a large amount of surface area for slowing, channeling, intercepting, and absorbing rainfall. This multi-layered architecture 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, equivalent to 1 ¼ inches of precipitation. This can account for about 10-20% of annual interception loss in a typical Pacific Northwest forest. Interception loss is the amount of water that does not reach the ground. Up to a threshold, the greater the total leaf area, the greater the interception. This is reflected in observations that show a positive correlation between total leaf area and annual precipitation. Coniferous forests have higher interception potential than deciduous forests since they maintain their leaf area throughout the year. Studies show that forests with older trees have a greater storage potential due to the overall greater biomass. 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. 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 and J. P. Sadler), John Wiley & Sons, Ltd, Chichester, UK. doi: 10.1002/9780470010198.ch2 Èermák, Jan, Jiøí Kuèera, William L. Bauerle, Nathan Phillips and Thomas M. Hinckley. 2007. Tree water storage and its diurnal dynamics related to sap flow and changes in stem volume in old-growth Douglas-fir trees. Tree Physiology 27, pg. 181-198. See final edits to worksheets KA 2.5.13 for the rest of references.	The multi-layered architecture of an old growth canopy intercepts and breaks up water droplets, slowing the rate at which they hit the ground.	Overlapping, redundant units/surfaces at multiple layers above the ground maximize surface area, intercepting water and reducing erosive force.
	Hydraulic Redistribution	Douglas Fir & Ponderosa Pine forests	Pseudotsuga menziesii & Pinus ponderosa	The canopy provides the forest floor with leaf and bark litter - absorbing up to 150% of its dry weight in water - as well as downed rotting wood, which can be responsible for collecting up to 5% of a total rainfall event.	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 are pulled up through the tap roots by capillary action, exiting through the 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. Water moves through the root xylems in a mostly passive manner, relying on the balancing of water potential gradients. See final edits to worksheets KA 2.4.13.doc for references - changes are not holding in this file. J. RENÉE BROOKS, FREDERICK C. MEINZER,ROB COULOMBE and JILLIAN GREGG. Hydraulic redistribution of soil water during summer drought in two contrasting Pacific Northwest coniferous forests. Tree Physiology 22, 1107–1117 © 2002 Heron Publishing—Victoria, Canada Burgess, Stephen O. Mark A. Adams, Neil C. Turner and Chin K. Ong. 1998. The redistribution of soil water by tree root systems.Oecologia Vol 115, No 3	Redistribution of water occurs whenever a water potential gradient exists across soil layers.	A subterranean network transports water along a water potential gradient.

Biomimicry Oregon Genius of Place Stormwater Project

Appendix G

GofP Assets

Challenge with context (covers all strategies) // ~30 words	Biological Strategy Focus	Champion (common name)	Champion (scientific name)	Core function	Biology story including strategy // 250-300 words	Mechanism	Design Principle/s // Bullet list of 5-10 words per principle
				What nature is doing.	Strategy: How the function is achieved.		The design principle is the idea that can be emulated in design. A mechanism can sometimes be directly copied, but usually the constraints on your particular natural example will not be exactly the same as those in the project, so direct imitation seldom represents the best emulation.
	Haustorial Roots	Mistletoe	Phoradendron villosum, flavescens	Collects and transforms water	Mistletoe (Phoradendron) is a stem hemiparasite native to Oregon White Oaks in the Pacific Northwest. This type of parasite is photosynthetic, producing its own chlorophyll, but it relies upon 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: 1. through several runners that grow like a vine and produce secondary haustorial roots that penetrate into the host plant's xylem; and 2) via a bulbous connection to the host that branches into 'cortical strands' once it has penetrated the host plant's xylem, resulting in multiple connection points within the host. While mistletoe acts as a parasite, it also contributes back to its host and local ecosystem in other ways. A genus of leafy mistletoe known as Phoradendron villosum transfers sugars back to their 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 their host's, supporting the proliferation of microbes in the soil. Mistletoes also act as a home and food supply for many woodland bird species. 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.	Multiple connection points optimize resource sharing.	Optimize resource sharing by using multiple connection points into a distribution network.
	Subterranean water barriers/diverters	Fragipan			Fragipans are subterranean striations of high-density soils that exist below pervious surfaces. These layers promote the distribution of water laterally on sloped surfaces through the restriction of downward infiltration. Fragipans also control water storage and discharge, while creating perched water tables. While the layers of soil are dense, they are not impenetrable, and when pervious materials exist below them, fragipans provide habitat for plant life with strong enough roots to break through the bottom layers, such as the north pin oak and bur oak. Depending on the porosity, continuity, thickness, and depth of the fragipans among a landscape, they can affect precipitation:evapotranspiration ratios, water quality, as well as infiltration rates of water, nutrients, and contaminates. Prolonged perched water tables are typically created seasonally, occurring in the heavy rain period, when decreased evapotranspiration rates, and lower air temperatures are present. More shorter-lived events can occur when the precipitation of a rain event exceeds the permeability of the fragipan. While short in duration, these small events may still be importants in transporting nurtients during drier seasons. J. A. Thompson. Fragipan influence on hillslope hydrology and solute transport. USGS WATER RESOURCES RESEARCH GRANT PROPOSAL. 2000 David H McNabb and Gene S.Cox. RELATIONSHIPS BETWEEN CHEMICAL AND PHYSICAL PROPERTIES OF A TYPIC FRAGIUDALF AND GROWTH OF SCARLET OAK. P.A. McDaniel, M.P. Regan, E. Brooks, J. Boll, S. Barndt, A. Falen, S.K. Young, J.E. Hammel. Linking fragipans, perched water tables, and catchment-scale		Subterranean impervious surfaces slow and redistribute water, making it available to local users.

Biomimicry Oregon Genius of Place Stormwater Project

Appendix G

GofP Assets

Challenge with context (covers all strategies) // ~30 words	Biological Strategy Focus	Top 3 Life's Principles	Possible Design Avenues // Bullet list of 1-2 sentences per application	Illustration Link/s	Illustration Thumbnail/s	Photo link/s	Photo Thumbnail	Photo Credit/s	Researcher
Water runoff from heavy rain events overload the city's existing sewer system.	Moss	• Combine modular & nested components • use multi-functional design • leverage cyclic processes	– Water and energy capture on sides of buildings – Add structural diversity to water capture in rain gardens – Embedded in sidewalks						Karen
	Mycorrhizal fungal networks		- Innoculate plantings with myc fungi (bio-utilization) - Incorporate high surface area in structures designed to reduce runoff/absorb peak flows			http://www.biology.ed.ac.uk/archive/jdeacon/microbes/ecto14.jpg Need a higher resolution photo			Karen
	Diversity of rooting depths		– Reduce urban runoff by integrating root design into pavement or building designs -						Karen

Biomimicry Oregon Genius of Place Stormwater Project

Appendix G

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	Beaver Activity	• Fit form to function • Integrate the unexpected • Use low energy processes • Embody resiliency through variation, redundancy and decentralization. • Build from the bottom up	- "Roughened Road" uses shallow physical blockades to divert water (but not traffic) into bioswales adjacent to roads (see illustration) - Off-channel detention (see illustration)						Nicole
	Downed Wood	• Combine modular and nested components • Use life friendly chemistry • Leverage cyclic processes • Use readily available materials and energy	Places to trap water: - Microhydro-powered streetlight - Bench absorption - Road intersection turned interceptor - Pervious absorptive speed bumps						Nicole

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Appendix G

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	Canopy Structure	- incorporate diversity - Embody Resilience through Variation, Redundancy, and Decentralization - Self-organize	Integrate a series of overlapping canopies and roof structures over existing impervious surfaces to delay runoff and maximize surface area potential. These structures can play host to elements that help absorb water, further reducing the amount of water the reaches the ground during storm events. Require a certain amount of canopy cover per area for new developments - Incorporate forms from canopy_profile.jpg in canopy structure folder						Matt
	Hydraulic Redistribution	- Use Feedback Loops - Recycle All Materials - Use Readily Available Materials and Energy -Leverage Cyclic Processes	Create distribution networks that can transfer water between them using passive mechanisms. Design piping that can transfer water using capillary action			http://3.bp.blogspot.com/-PNqHZFeGS6E/TmfZRfpUWFI/AAAAAAAAAXs/plhC_Mqq2qY/s1600/shannon-wright-network.jpg http://www.greenbeltconsulting.com/ctp/hydraulicredistribute.html			Matt

Biomimicry Oregon Genius of Place Stormwater Project

Appendix G

GofP Assets

Challenge with context (covers all strategies) // ~30 words	Biological Strategy Focus	Top 3 Life's Principles	Possible Design Avenues // Bullet list of 1-2 sentences per application	Illustration Link/s	Illustration Thumbnail/s	Photo link/s	Photo Thumbnail	Photo Credit/s	Researcher
	Haustorial Roots	- Use Readily Available Materials and Energy - Cultivate Cooperative Relationships - Integrate the Unexpected	Irrigate greenhouses, aquaponic systems, and vegetable gardens with water collected by surrounding buildings, using piping and filtration systems connected inside the host building. - see mistletoe.jpg for precedent structure	http://etc.usf.edu/clipart/61200/61274/61274_mistletoe_lg.gif					Matt
	Subterranean water barriers/diverters	- Use Readily Available Materials and Energy - Use Low Energy Processes - Use Multi-functional Design	creation of traffic circles at intersections with rainwater collection/distribution. side benefits of slowing traffic, creating more walkable areas, reducing impervious surface, adding area of tree canopy, & creating wildlife corridors						Matt

Genius of Place Workshop Agenda

Thursday, January 17, 2012. 1-5 pm

Venue: 1900 SW 4th, Portland, OR; Bureau of Planning & Sustainability Bldg

Time	Activity	Mins	Facilitator	Materials	Goal/Learning Objectives
1:00-1:20	Welcome: Review workshop objectives, schedule. Introductions, thank you's to sponsors	20	Karen	Prezi	Orientation
1:20-1:35	Genius of Place process	15	Mary	Prezi	understand GoP process
1:35-2:00	introduction to Biomimicry: 6 case studies related to water; form, process, system. Introduce LPs. Weave LPs into case study stories.	25	Karen	Prezi	Increase understanding of what biomimicry is & its value as an innovation approach to solve sustainability challenges. Learn about Biomimicry Thinking
2:00 2:10	Context on sustainable stormwater management; City of Portland's program	10	Nicole	Prezi	Understanding of green infrastructure in Portland; understand difference and value of each 'bio - ' approach.
2:10-2:20	interactive	10	Karen		interact; reflect on current system
2:20-2:30	break	10			
2:30-2:40	Our Place: setting the stage	10	Nicole	Prezi	understand what drives strategies in organisms/systems HERE
2:40-3:00	Our GofP strategies, Design Principles and Application Ideas	20	Karen, Matt, Nicole	Prezi	understand the flow management strategies of local organisms/systems. Biomimicry Thinking
3:00-3:55	Break out session: groups of 4. Ideate tangible sustainable design concepts	55	Karen introduce; All	flip-charts, markers; LP, Local Genius Summaries	work collaboratively across disciplines; Practice using design principles to develop concepts; ideate tangible sustainable design concepts.
3:55-4:35	Present design concepts	40	Karen	tape, flipchart	share collaboratively
4:35-4:45	What's Next? Further Biomimicry Education Opportunities	10	Karen		share ongoing learning about biomimicry
4:45-5:00	Closing, evaluations	15	Karen	closing slide, evaluations	reflective learning

Biomimicry Oregon Genius of Place Stormwater Project
Appendix I
Workshop Flyer & Invite

WORKSHOP INVITE (MODIFY TO SPECIFIC INTERESTS OF INVITEE)

On January 17, 1-5pm, Biomimicry Oregon will host an experiential biomimicry workshop focused on developing actionable, innovative stormwater management concepts inspired by local organisms, processes, and ecosystems. (more details at end of e-mail)

The workshop will bring together a multi-disciplinary group of local engineers, academic researchers, architects, planners, policymakers, product designers, and biologists who deal with stormwater or fluid flow.

We hope that you will attend, so please put January 17, 1-5pm on your calendar and rsvp to mary.hansel@pro.biomimicry.net.

This project is sponsored by the Bullitt Foundation and the City of Portland Bureau of Planning and Sustainability.

Suggested donation for the workshop is $25-$50. Noone turned away for lack of funds.

GofP Ideation Workshop

Thursday, January 17, 2013, 1-5pm
Hosted by City of Portland BPS: 1900 SW 4th Avenue, Room 7a
45-50 participants
Facilitator: Karen Allen
Suggested donation of $25-$50; no one turned away for lack of funds.

Workshop Objectives

- Provide an opportunity for working collaboration among diverse partners with an interest in sustainable stormwater solutions to ideate tangible sustainable design concepts.
- Increase understanding of what biomimicry is & its value as an innovation approach to solve sustainability challenges.
- Offer experiential educational session focused on learning about biomimicry thinking, the Genius of Place process, and the stormwater flow management strategies of local organisms/systems.

Desired Workshop Outcomes

- Introduce ~50 design and research professionals to biomimicry.
- Develop tangible sustainable design concepts (could be in realms of product, building, infrastructure, policy design).
- Participants feel inspired, curious, engaged, empowered (to look to nature and apply nature's inspiration), and interested in further exploring biomimicry as innovation approach.
- Seed future collaboration (participants with each other and/or with Biomimicry Oregon).

BIOMIMICRY OREGON

What Can Nature Teach Us About Managing Stormwater?

Biomimicry Oregon Seeds Life-Friendly Innovation By Inspiring People To Emulate Nature's Genius

Join Biomimicry Oregon for an interactive workshop to develop sustainable design concepts inspired by local organisms and ecosystems. Learn how they manage the abundant rainfall we receive, and imagine how we can apply these lessons in designing resilient, adaptive and sustainable buildings and infrastructure.

Genius of Place Workshop

JANUARY 17, 2013 1:00–5:00pm

Hosted by City of Portland BPS

1900 SW 4th Ave, Room 7A PORTLAND, OR

Contact: Mary Hansel mary.hansel@pro.biomimicry.net 510-325-6369

Biomimicry is the practice of learning from and emulating life's best ideas to create a sustainable world.

Genius of Place looks to the living organisms of a particular place to provide guidance and models for establishing locally attuned & sustainable strategies for design.

Project Sponsors

Bullitt Foundation GLUMAC

ESA Bureau of Planning and Sustainability Innovation. Collaboration. Practical Solutions. City of Portland, Oregon piazza italia

Biomimicry Oregon Genius of Place Stormwater Project
Appendix J
Stormwater Workshop Attendees
January 17, 2013

First Name	Last Name	Organization
Angela	Wieland	Brown and Caldwell
Bill	Hart	Carleton Hart Architecture
Brandon	Wilson	City of Portland
Brian	Wethington	City of Portland Environmental Services
Bruce	Roll	Clean Water Services
Candace	Stoughton	EMSWCD
Carol	Mayer-Reed	Mayer/Reed
Casey	Cunningham	City of Portland Environmental Services
Chris	Larson	Larson Ventures
Craig	Briscoe	Glumac
Dave	Whitaker	DK Whitaker Engineering
Deb	Scrivens	Metro
Doug	Neill	The Graphic Recorder
Elle	Allan	City of Gresham, Watershed Division
Emily	DeWolfe	International Living Future Institute
Faye	Yoshihara	Forest Fractal, LLC
Geoff	Winslow	Glumac
Ginny	Stern	Sunnyside Environmental School
Heather	DeGrella	GreenCE, Inc
Ivy	Dunlap	City of Portland Environmental Services
Jason	King	TERRA.fluxus LLC
Jay	Kosa	International Living Future Institute
Jennifer	Belknap Williamson	City of Gresham
Joann	Herrigel	City of Milwaukie
John	Houle	City of Portland Environmental Services
Jon	Dykhuizen	Mayer/Reed
Jon	Gray	Interface Engineering
Josh	Lighthipe	KPFF Consulting Engineers
Kate	Hibschman	City of Portland Environmental Services
Kate	Schuyler	Freelance
Kevin	Timmins	Otak, Inc.
Lauren	Bruschi	Portland State University
Leslie	Lum	City of Portland Planning & Sustainability
Linda	Dobson	City of Portland Environmental Services
Marjorie	Wolfe	ESA
Mark	Anderson	CH2M HILL
Matt	Burlin	City of Portland Environmental Services
Paul	Dedyo	KPFF Consulting Engineers
Roberta	Jortner	City of Portland Planning & Sustainability

Biomimicry Oregon Genius of Place Stormwater Project
Appendix J
Stormwater Workshop Attendees
January 17, 2013

First Name	Last Name	Organization
Rod	Lundberg	Unaffiliated
Ryan	Carlson	Mayer/Reed
Scott	South	Stevens Water Monitoring Systems, Inc.
Ted	Hart	Portland State University
Tim	Richard	Metro Regional Government
Tom	Liptan	Idea-er
Vinh	Mason	City of Portland Planning & Sustainability
Vivek	Shandas	Portland State University
Instructors		
Karen	Allen	Aequinox
Mary	Hansel	Freelance
Matt	Piccone	SERA Architects
Nicole	Isle	Glumac

Biomimicry Oregon Genius of Place Project

Appendix K

Stormwater Workshop Breakout Group Design Concepts

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
Three Trees	Living Street Signs	Moss	Gutters holding plants on the back of street signs.	street signage
	Moss inspired "cupwalls"	Moss	Long, skinny cups attached to walls.	building and other urban facades exposed to rain.
	Seasonal building evaporative feather coolers	Root structure (hydraulic redistribution), Mycorrhizal fungal networks	Collect winter stormwater into a cistern. In summer, wicks absorb water up into a feather type material that evapotranspirates to cool ambient air.	buildings, areas prone to the heat island effect.
	Wood chip mulch on roof	Downed Wood	Sandwiched mat of roof chip mulch on rooftops. 4 - 6 inches thick.	rooftops
Lichen	Living awnings	Moss	Living, vegetated awnings over sidewalks for people to avoid the rain in the winter and intense sun in the summer.	awnings, public plaza spaces (would allow for more absorptive material on the ground), ball fields, gazebos
	Dead wood strategic plan	Downed Wood	An underutilized resource in the city, downed wood would be better integrated into the urban forest management program. In Portland, there is no strategic program for the placement of these sponges to absorb water. There are lots of neighborhoods with trees at the end of their useful life. We prune, take care of trees and there is a lot of debris.	parks, nature areas, street medians, art work
	Beaver dam stormwater "checks"	Beaver Dam	Beaver dam like complexes and berms to slow water on concrete and cement surfaces.	streets, parking lots
	Vegetated sidewalks	Moss	Pervious, vegetated sidewalks, mulched paths provide a soft walking surface. Could be limited to a portion of a sidewalk to maintain ADA compliance.	sidewalks, parking strips

Biomimicry Oregon Genius of Place Project

Appendix K

Stormwater Workshop Breakout Group Design Concepts

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
Real World	Sidewalk moss	Moss	Moss or synthetic moss along paved areas.	impervious surfaces
	Interconnected curb and gutter system	Mistletoe	Integrated stormwater system mimics an "our property" approach to water management instead of an individual "property rights" focus. More collaborative, decentralized, cross-boundary approach.	Anywhere
	Capillary Tap	Root structure (hydraulic redistribution)	Distribution and capillary mechanism that could help get to deeper water during summer periods.	Rain gardens, water scarce areas
Mycorrizal	Paving complex	Downed wood, Mycorrhizal fungal networks	Layered pervious pavement system that uses capillary action between the layers to release water into the ground. A bark-like paving layer is on the top, followed by a capillary layer, infiltration layer and bedrock layer on the bottom. Analogous to layers within a tree (bark, cambium, heartwood).	Roadway systems, parking lots
	Stormwater nets	Canopy structure	Nets over the city to capture water (similar to the Japanese "fractal shade" cover inspired by tree canopies).	Building that are close to each other, stadium covers
	Water solid machine	Tardigrade - water bear	Stores water and "reactivates" it during the summer for use.	Any collection/storage location?
	Moss pavers	Moss	Moss paver that absorbs, stores water for later release. Not to be used in a frozen context.	Sidewalks, plazas, public spaces

Biomimicry Oregon Genius of Place Project

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Stormwater Workshop Breakout Group Design Concepts

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
	Stormwater tree	Downed wood, mistletoe, canopy structure	Analogous to the layers of a tree trunk to absorb, distribute & evapo-transpire water. Imagine a bark layer on the outside of a building that absorbs water and transpires it to the atmosphere. Imagine a mistletoe like system that "lives" on rooftop building equipment absorbing toxic emissions and fluid leaks, cleaning air or converting "waste" into energy.	Building cladding systems, rooftop equipment
	Living walls	Moss	Living wall ideas - cups, textured walls.	Wall facades
Absorption	Green roof promenades	Old Growth Canopy Structure	Create a series of multi-layered, linked "awnings" that "walk away" from buildings to redirect & slow water flow away from buildings & provide cover. Could be green roofs, or other material, depending on functions desired. elevations may vary depending on shading requirements and other water direction desired outcomes.	Sidewalks, alleys, adjacent to buildings. Could work well for retrofits. Could be useful where you don't have a right of way on the street level to work with… where on-street treatment is limited.
	Engineered eco-soils	Mycorrhizal Fungi	Add mixtures to soils to increase absorption capacity.	Eco-roofs, rain gardens.
	Sponge Pave	Moss	Put spongy material in voids beneath pavement.	
	Absorption Concrete	Downed Wood	Manufacture a pervious concrete material that has voids filled with absorbant material.	sidewalk pavement, building walls

Biomimicry Oregon Genius of Place Project

Appendix K

Stormwater Workshop Breakout Group Design Concepts

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
We Like Moss/Riparian	Sidewalk H20 Management System	Moss	Use sidewalk system to replace or augment current stormwater underground pipes. Intentionally widen spaces between sidewalks and add moss there to increase absorptive capacity. Create new sidewalk materials that mimics the hydrophilic/hydrophobic attributes of moss. Sidewalks become part of h20 management system: some water is absorbed, some infiltrates into ground below, and the remaining water is conveyed to current stormwater collection points via directed runoff.	Sidewalks
	Perforated Pipe Stormwater Collection	Mistletoe	Mistletoe-inspired perforated stormwater collection pipes allows for gradual water loss along the system, for more soil absorption, and less at end of pipe. Currently in Portland there are streambeds that are no longer active - goal of this design: to reactivate / rewater these via groundwater recharge.	Stormwater infrastructure
	Mossy Roof	Moss	moss-inspired: "embrace the moss on a roof!" ...explore other ways of holding water on a roof via a water-absorbent tile.	Buildings
	Plant Your Gutter		Add plant life to gutters to slow down run off.	Gutters
	Salmon Gutters		Salmon farming in the gutters.	
	Plant Below Sidewalks		Grated sidewalks with low light plants below to increase absorption capacity below sidewalk.	Sidewalks

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
Slow Flows	Stormwater Generator		Put microturbines in vertical pipes / gutters to generate energy from stormwater flows. Take advantage of all the vertical things in cities. Vivek has a group of students working on this idea right now; they submitted their idea to EPA's Rainworks Challenge.	Buildings
	Street Wood	Downed Wood Beaver Dam	Sections in the street can be cut out to intercept through a "street wood complex" spanning the street. The upper (upstream) portion mimics the "group of straws" idea from the deadwood concept, and channels stormwater to the downstream part of the matrix which consists of a permeable rock matrix. Some of the water is infiltrated, depending on soils, and the rest is channeled to a ditch alongside the street to infiltrate. Could place the street wood structures 20-30 feet abovecrosswalks to signal drivers that they are approaching a crosswalk and to watch for pedestrians.	Street infrastructure, City transportation / stormwater folks.
	Hydro Cradles	Moss Canopy Structure Mistletoe	Catch water in cups on side of buildings. Cups are larger at the base of the building and smaller as they go up to capture all of the water. Maybe have solar panels as well, and heat could help with evaporation. Water drains down the side of the building and feeds ground floor uses - perfect for mixed use building scenarios with ground floor commercial.	Buildings, architects.

Biomimicry Oregon Genius of Place Project

Appendix K

Stormwater Workshop Breakout Group Design Concepts

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
	Geo-Engineering Tulip	The British	Place a big funnel above Portland to capture water - inspired by a tulip and many other flower shapes. Brits are looking at placing a big shield above the city to block sunshine.	
Spongewoods	Tributary Stormwater Collection	Stream systems	Systems approach to stormwater collection, as tributary streams to main channels: collect in smaller arterioles, then move water to larger system.	Stormwater infrastructure
	Moss Strips	Moss	Increase absorbtive capacity between sidewalk and street.	Sidewalks
	SpongeWood	Downed wood	Use wood everywhere - in raingardens, parks, on ecoroofs, etc. - leave where it is vs. transporting - Joke about SPONGEWOOD: "now that Tom's in the private sector, he's going to call it 'spongewood' and try to market it!"	Parks
	Absorb with Trash		Reusing / repurposing materials for absorptive capabilities (plastic caps, bottles, etc.)	
	Compcrete		"Compcrete" - put compost in concrete.	
Wishful Thinkers	Moss Awnings	Moss	Hydrophobic layer on surface... make it more evaporative through miracle material to emanate the water more easily. Hydrophillic 'sponge' on bottom keeps surface cool & wet - then more evaporation on the surface. Result: reduced runoff.	Awnings, but perhaps could scale larger.
	Under-aggregate Absorption	Downed Wood	Add absorptive media under aggregate media under permeable pavements to holds more water and evaporate it later.	Roads, sidewalks
	Super Absorbent Carpet Pad		Super absorbent carpet pad that doesn't mildew to capture water, retain it, and wick it out.	Basements

Team	Concept Name	Inspiring Organism	Description	Where it would apply / scale / who would implement
Mossy Absorbers	Building Wrap / Living Wall on Steroids	Moss	Challenge: How to use what comes out of buildings... Create a moss wrap around a building that would absorb the excess heat generated inside the building and increase the biological activity... the evapotranspiration. It would expand and contract to store water. It would be a "living wall on steroids." Use the 3 dimensionality of the building to increase surface area substantially by covering all four sides of the building. Roof layer would also absorb water and expand and contract. Collection area on roof would channel water to walls for storage.	Commercial buildings
	Street Storage	Mycorrhizal Fungi	Streets as storage and conveyance to users. There is a ton of water to store and manage in winter and not as much biological activity. "Who can use that water?" Industrial users, non-potable uses in homes like toilet flushing. Design concept: Permeable streets with water storage layer underneath. Use capillary action to pull stored water up to those who need it (industry, homes). Street absorbs sound as well as water.	Streets

Biomimicry Oregon Genius of Place Stormwater Project
Appendix K
Breakout Group Design Concepts Filtering Meeting
April 21, 2013

A small group met at Glumac on April 21, 2013 to review concepts generated from the breakout groups in the January 2013 Genius of Place Stormwater workshop. The intent of the meeting was to identify the most practical and brainstorm next steps to move them toward implementation. The group reviewed the video presentations & drawings from the workshop, and a summary list of the concepts. Following are the concepts deemed most practical.
Filtering participants were: Craig Briscoe, Geoff Winslow & Nicole Isle (facilitator), Glumac; Johanna Brickman, Oregon BEST; Casey Cunningham, City of Portland Bureau of Environmental Services; Josh Lighthipe, KPFF Consulting Engineers; Mary Hansel, freelance.

Team Spongewoods: –Tributary Stormwater Collection - Murray's Law
The team investigated how the branching systems found in nature that distribute fluids could inspire a systems approach to stormwater collection. Conventional stormwater collection systems begin as “tributary streams” that feed into main channels. The team wondered if the efficiency of the system could be improved by mimicking the geometry described by Murray’s Law: the cube of the diameter of a parent vessel equals the sum of the cubes of the diameters of the daughter vessels. This is an optimum arrangement to move fluids using pressure differentials instead of energy inputs. We see it in tree branches, leaf veins, our lungs, and in fungal networks.
The review team liked the idea because it poses a potential method for moving water through pipes using minimal or no energy for pumping. However, the team questioned how adaptive such a system would be could new pipe branches be added over time?

Teams: Real World: Hydraulic Tap
The team investigated how root structures could inspire a design for tapping into deeper water during summer periods. The concept is based on hydraulic redistribution, where passive redistribution of water occurs whenever a water potential gradient exists across soil layers.

Multiple Teams: Absorptive Overhang and Roof Products
Several teams investigated the idea of integrating a series of overlapping canopies, awnings, and roof structures over existing impervious surfaces to delay runoff and maximize surface area potential for evaporation or channeling water to a storage location. These structures can play host to elements that help absorb water, further reducing the amount of water the reaches the ground during storm events. Inspired by moss and the multi-tiered design of tree canopies, five teams used bio-utilization (incorporating nature) and biomimicry (emulating nature) approaches in their designs. Materials included vegetation and moss, water-absorbent tile, synthetics, and a "miracle material" with hydrophobic and hydrophobic layers to absorb water and promote evaporation. The review team found this general idea to be highly practical although the added weight may require more structural support. Canopies that are not attached to buildings would pose a low risk to buildings or design investment, should early pilot test models fail. The review team believes the idea may be innovative enough to capture the interest of building roof and envelope manufacturers.

A related policy idea is to require a certain amount of canopy cover per area for new developments.

Teams Mycorrizhal & Mossy Absorbers: Stormwater Tree / Building Wrap

From canopy structure to the bark and inner layers of wood, two teams re-imagined a breathable building wrap inspired by trees, moss and downed wood. The material would have an outer layer that functioned like bark by absorbing water and transpiring it to the atmosphere. Some teams looked at the idea of adding "mossy cups" to the exterior of buildings and the review team thought it would add an extra absorptive quality to the nature-inspired building wrap. Team Mossy Absorbers addressed the challenge of how to use what comes from inside a building, and imagined a building wrap material that draws excess heat from the building interior and uses it to increase evaporation of stormwater collected on the outside of the material. The review team thought both concepts deserved further investigation and recommended creating a material mimicking wood and/or moss forms at the micro or nano scale.

Multiple Teams: Under-Aggregate Absorption

Inspired by downed wood and moss, six teams developed a concept that includes an absorptive media beneath the aggregate layer underlying permeable pavement. The material would capture water and either distribute it to where it's needed and accelerate infiltration and/or evaporation through capillary action. Team We Like Moss/Riparian imagined a "sidewalk H2O management system" using this concept and other ideas. Magic Carpet Pad: Also inspired by downed wood, this newly imagined super absorbent carpet pad would capture, retain and wick out water without forming mildew. The review team thought that the pad would indeed be a "miracle" material if designed to avoid potential health issues.

Teams Lichen & Spongewoods: Dead Wood Strategic Plan

An underutilized resource in the city, downed wood would be better integrated into the urban forest management program. In Portland, there is no strategic program for the placement of these sponges to absorb water; they could be placed in rain gardens, parks, medians, etc. There are many neighborhoods with trees at the end of their useful life, and a lot of debris is generated through pruning.

Team Absorption: Engineered Eco-Soils

Inspired by the absorptive capacity of mycorrizhal fungi, Team Absorption imagined developing add mixtures to the absorption capacity of soils. Absorptive capacity in mycorrizhal fungal networks is increased due to the comparatively large surface area of the mycelium to root ratio, and to cell membrane chemistry. Soils engineered for increased absorption could be used near sidewalks, alleys, adjacent to buildings, or on eco-roofs.

Biomimicry Oregon Genius of Place Stormwater Project
Appendix L
Workshop Presentation


BIOMIMICRY OREGON

What Can Nature Teach Us About Managing Stormwater?

Biomimicry Oregon Seeds Life-Friendly Innovation By Inspiring People To Emulate Nature's Genius

Join Biomimicry Oregon for an interactive workshop to develop sustainable design concepts inspired by local organisms and ecosystems. Learn how they manage the abundant rainfall we receive, and imagine how we can apply these lessons in designing resilient, adaptive and sustainable buildings and infrastructure.

Genius of Place Workshop
JANUARY 17, 2013 1:00–5:00pm
Hosted by City of Portland BPS
1900 SW 4th Ave, Room 7A PORTLAND, OR
Contact: Mary Hansel mary.hansel@pro.biomimicry.net 510-325-6369

Biomimicry is the practice of learning from and emulating life's best ideas to create a sustainable world.

Genius of Place looks to the living organisms of a particular place to provide guidance and models for establishing locally attuned & sustainable strategies for design.

Project Sponsors

Bullitt Foundation GLUMAC

Thank You!

Bullitt Foundation

GLUMAC

Bureau of Planning and Sustainability
Innovation. Collaboration. Practical Solutions.
City of Portland, Oregon

ESA

piazza italia


Karen Allen


Mary Hansel


Nicole Isle


Matt Piccone


Ethan Smith


Lauren Bruschi

BIOMIMICRY OREGON
Genius of Place project team

Workshop Objectives

- Introduce Biomimicry & the Practice of Biomimicry as an innovative approach to solve sustainability challenges
- Share our Genius of Place Process
- Learn about the Water Flow Management strategies of local organisms and ecosystems
- Practice using Design Principles from local geniuses to ideate innovative stormwater management concepts
- Provide opportunity for working collaboration among diverse partners with an interest in sustainable stormwater solutions
- Share on-going learning opportunities in Biomimicry
- Inspire curiosity and interest in further exploring biomimicry as innovation approach

Schedule

- 1 hour:
  - Genius of Place Process
  - Introduction to Biomimicry
  - Context on Portland's sustainable stormwater program
- Break - 10 minutes
- 30 minutes
  - Genius of Place research results
- 1 hour
  - Break out session (small groups)(: ideate design concepts
- 30 minutes – report out
- 15 minutes – Closing

1:20 – 1:35
G of P process - Mary

Local Genius

BIOMIMICRY DISCUSSION

---

a world empowered by nature's genius

BIOMIMICRY 3.8

www.biomimicry.net

BIOMIMICRY OREGON

oregonbiomimics.net

BIOMIMICRY OREGON

VISION: Inspiring innovation in Oregon by emulating nature's genius

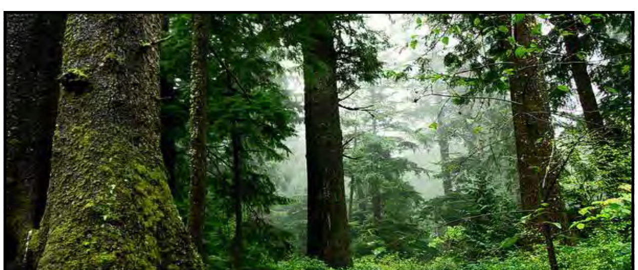
MISSION: Biomimicry Oregon seeds life-friendly innovation by inspiring people to emulate nature's genius through:

- **connecting** people from all sectors with biomimicry resources and each other,
- increasing **awareness** of the value and practice of biomimicry, and,
- **catalyzing** projects and **celebrating** successes.

oregonbiomimics.net

Genius of Place Project Goals

- Catalyze the application of biomimicry in Portland, Oregon
- Develop 3-5 Genius of Place stories for our region
- Introduce 50-100 design and research professionals to biomimicry
- Develop template that can be used in other regions
- Foster collaboration and build Biomimicry Oregon network



GENIUS OF PLACE

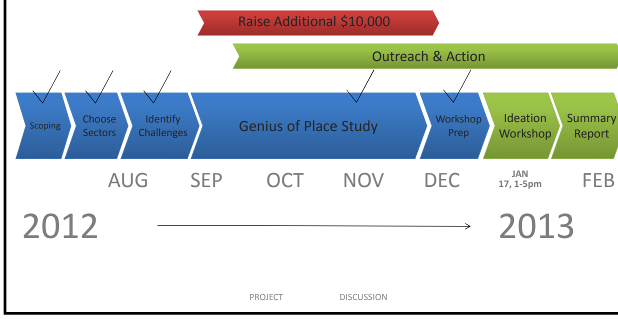
GENIUS OF PLACE

Looking to the living organisms and systems of a particular place to provide guidance and models for establishing locally attuned strategies for design.

Genius of Place in a Nutshell

1. Identify local challenge(s).
2. Biological research - look and listen for ways local organisms/ecosystems (the geniuses) address the challenge.
3. Translate the biological research into design principles.
4. Ideate locally attuned design strategies based on the design principles.

Schedule



Challenge:

How do 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?

Biological Research

"How does nature manage water flows?"

Functions to manage water:

- collect
- store
- absorb
- attenuate
- transport

How does nature manage water…
… in a moist deciduous forest ?

THE LAVASA LANDSCAPE MASTERPLAN FOR DASVE AND MUGAON VALLEY

MOIST DECIDUOUS FOREST FUNCTION

Canopy Layers:
1. Canopy captures and evaporates 10 - 30 % of rainfall
2. Evapotranspiration rate of 60 mm per month in wet season
3. Evapotranspiration rate of 40 mm per month in dry season
4. About 10% of incoming light reaches the ground in the wet season
5. Up to 54% of incoming light reaches the ground in the dry season
6. Biodiversity of 30 to 100 different native tree species per hectare

Litter Layer:
1. Can retain 51% of rainfall during the monsoon (75% during dry season)
2. Soil available water capacity 35 - 65%
3. Holds 70% of all nutrients deposited in the forest
4. Decomposes in 7-8 months

Ground:
1. Ground water recharge is 10% of total rain

Genius of Place - Lavasa

Genius of Place - Lavasa

Harvester Ants (genus Pheidole)

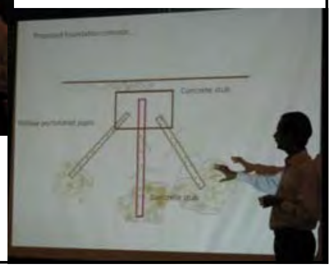
CHALLENGE
Protect from monsoon rains and erosion

DESIGN PRINCIPLE
Divert water with multi-path, low gradient, curvy channels

Sacred Fig (Ficus religiosa)

CHALLENGE
Protect from monsoon rains

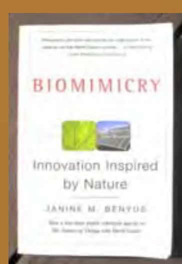
DESIGN PRINCIPLE
Elongated shapes and channels foster quick shedding of water from surfaces

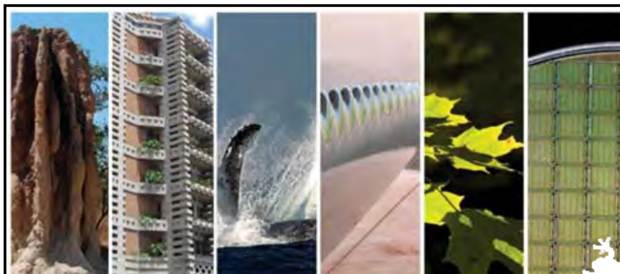


Genius of Place - Lavasa

1:35 – 2:00
Introduction to Biomimicry - Karen

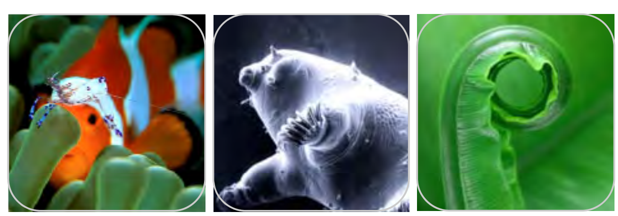
What can we learn from nature's designs to help sustain ourselves on Earth while protecting and restoring what's still here?





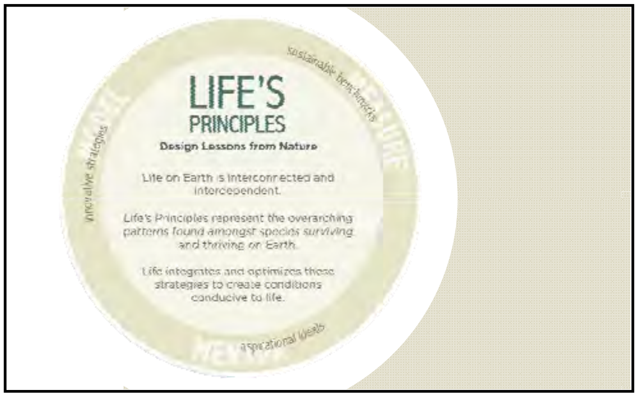
the conscious emulation of nature's genius

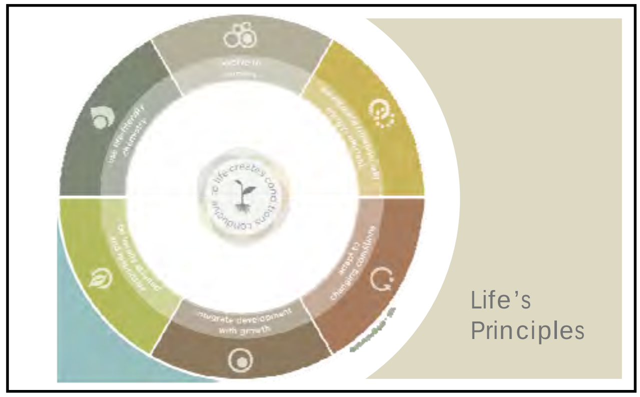
We are just one of the 30 -100 million



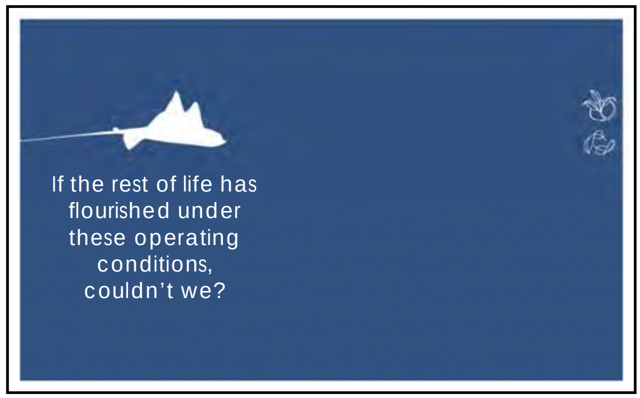
cooperating | storing water when available | capturing energy

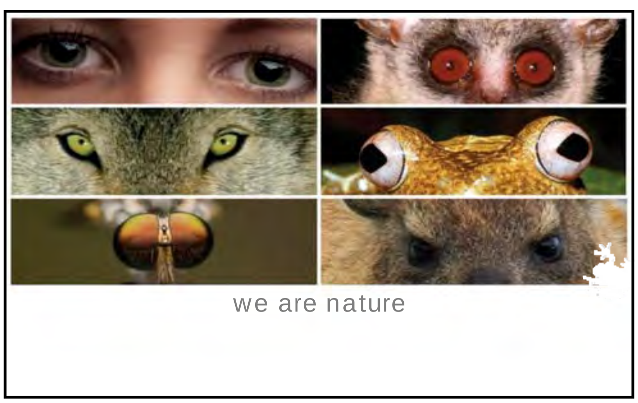
Biomimicry: learning life's strategies to solve the same challenges we have


LIFE'S
PRINCIPLES
Design Lessons from Nature
Life on Earth is interconnected and interdependent.
Life's Principles represent the overarching patterns found amongst species surviving and thriving on Earth.
Life integrates and optimizes these strategies to create conditions conducive to life.
sustainable benchmarks
innovative strategies
aspirational ideals


Life's Principles

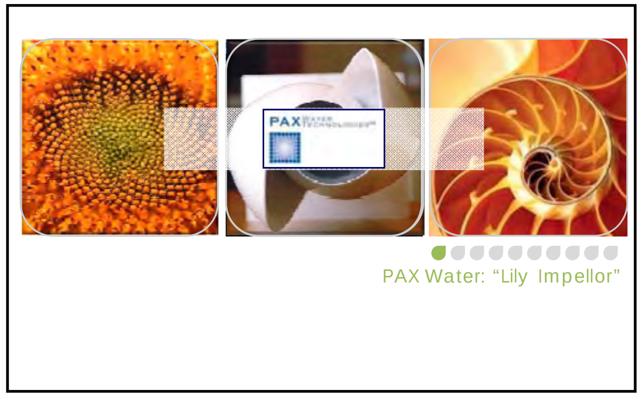

life creates conditions conducive to life


If the rest of life has flourished under these operating conditions, couldn't we?


we are nature


biomimicry and design
the practice of learning to fit in, again.

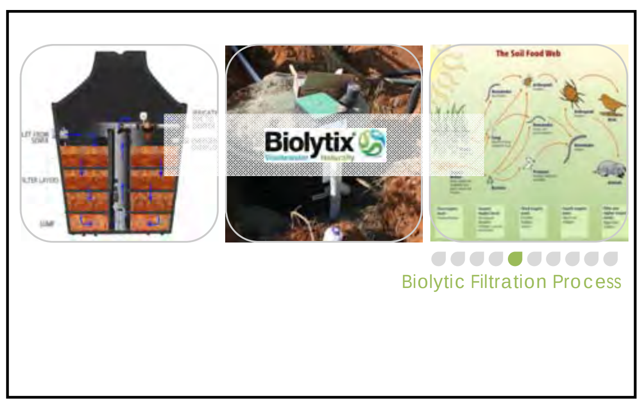

form
process
ecosystem


PAX
PAX Water: “Lily Impellor”

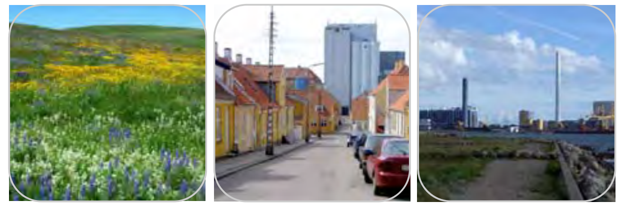

BioPower
Systems
bioWAVE™, bioSTREAM™, bioBASE™


LOSFEE
COMOLEVI
Forest Canopy

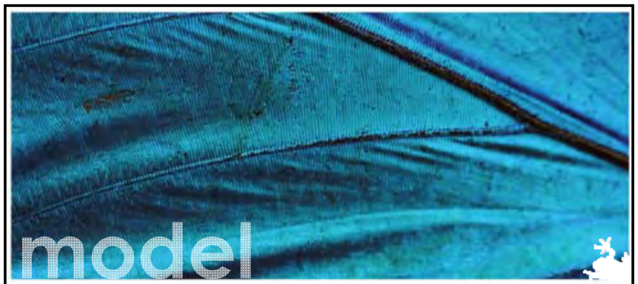

Trehalose
Nova
Laboratories Ltd
Biomatrica
VitRIS & HydRIS


The Soil Food Web
Biolytix
Biolytic Filtration Process

Eco-Machines



industrial symbiosis
Kalundborg, Denmark



design **from** nature

imagine the possibilities...

2:00 – 2:10
background context on sustainable SW mgt and City of Portland's program - Nicole

Stormwater Management Practices

Challenge: Peak Stormwater Flow
Impervious surfaces create huge volumes of runoff that is costly to manage and burdensome to urban operations.

More Specifically…
Impervious surfaces inhibit water from infiltrating soil, so waterways become dumping grounds for sediment and chemicals, degrading habitat.

Stormwater Management Practices

Current Strategies
Bioswale
Rain garden
Ecoroof
Living wall
Building wastewater recycling systems
Rainwater collection and reuse
Living machine
Low flow plumbing fixtures
Restoration
Drywells and French drain
Detention basin
Municipal conveyance and treatment

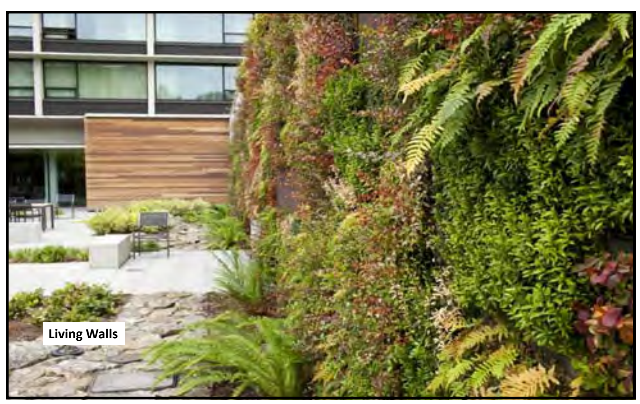

Urban Bioswale, Bureau of Transportation


East Lents Floodplain Restoration Project


Urban Rain Garden, DC Green Infrastructure


Hayden Meadows Walmart, North Portland, Walmart

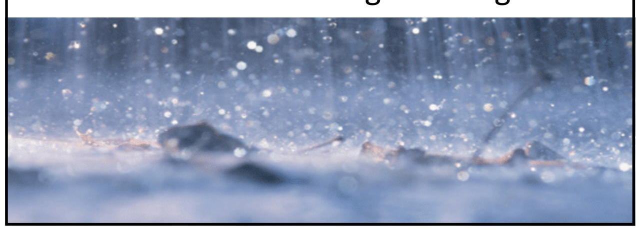

Ecoroof with solar, 79 SE Taylor St. Portland, Sustainable Business OR


Living Walls

2:10 – 2:30
interactive + break

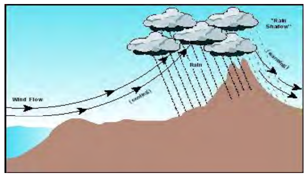
2:30 - 2:40
Our Place – Setting the Stage

Our Place – Setting The Stage

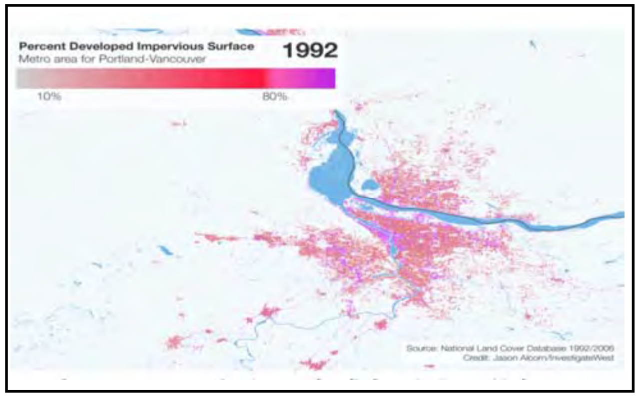


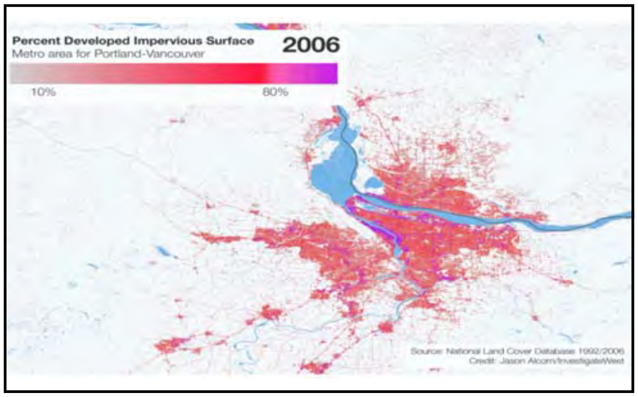
Climate Data

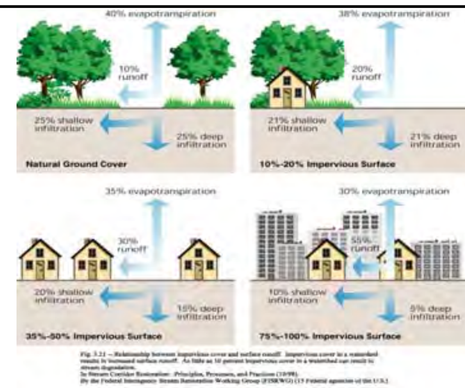
- Average Max Temp: 63 F
- Average Min Temp: 46 F
- Average Precipitation: 43 in.
- Average Snowfall: 3.1 in. Average Depth: 0 in.



Orographic Effect







Climate Change Predictions

- Warmer, dryer summers
- Precipitation will increase in the winter (15%), decrease in the summer (30%)
- Less snow, early snow melt

= More Peak Winter Rainstorm Events

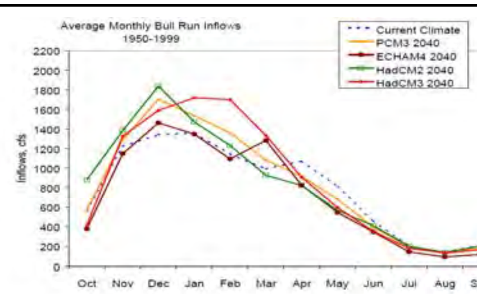
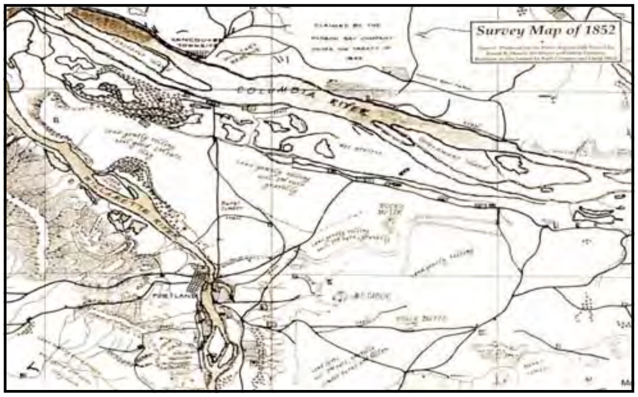
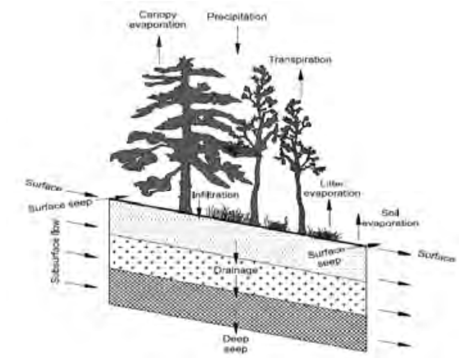


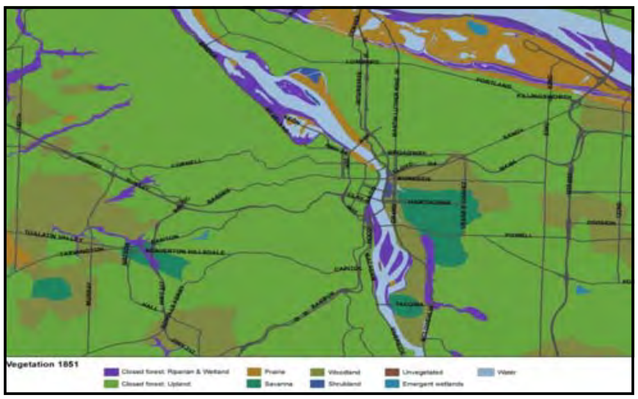
Figure ES-2. Average Monthly Flows for Current Climate and 2040 Climate Change Scenarios

2040 - Loss of 12.9 billion gallons of water annually to the Bull Run Reservoir





Altier, L.S., R. Lowrance, R.G. Williams, et al. 2002. Riparian Ecosystem Management Model: Simulator for Ecological Processes in Riparian Zones. United StatesDepartment of Agriculture, Agricultural Research Service, Conservation Research Report 46.



Ecoregions

Lowland Conifer Hardwood Forest

Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), western redcedar (*Thuja plicata*), bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*)

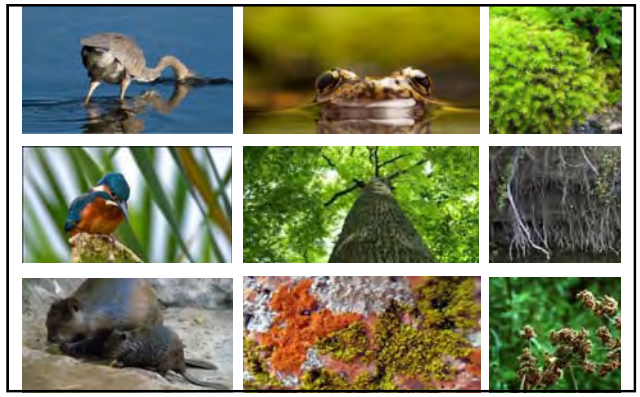
Oak and Dry Douglas-fir Forest and Woodland

Douglas-fir *(Pseudotsuga menziesii*) and Oregon white oak (*Quercus garryana*). Grand fir (*Abies grandis*) is occasionally co-dominant with Douglas-fir, Oregon ash (*Fraxinus latifolia*) is occasionally co-dominant with white oak in riparian oak stands.

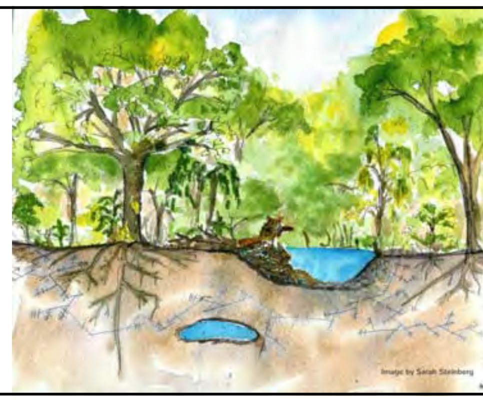
Resulting Patterns

High runoff in rivers; many streams/rivers	Connectivity waterways mountains to sea
Relatively long growing season	High productivity, high biomass
High diversity	Multiple vegetation layers: herbaceous, shrub, tree, moss, lichen, vines
Likely high symbiotic relationships	Among organisms and the physical, biological environment
Nutrient cycling, Decomposition rates	Higher than where drier; lower than where warmer.
Soil fertility	Relatively rapid nutrient cycling, fertile soil, moderate permeability
Wet and dry forest types	Dominated by species that can handle abundant rainfall and periods of drought.

Tryon Creek runs through the forest in Marshall Park

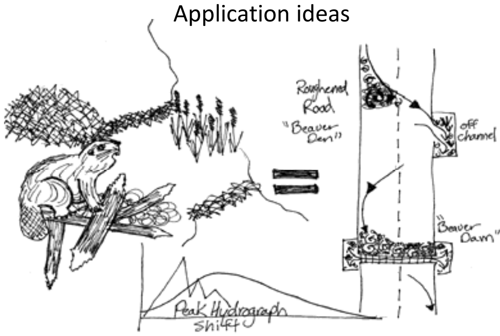


2:40 - 3:00
Our GofP strategies, DPs and app ideas

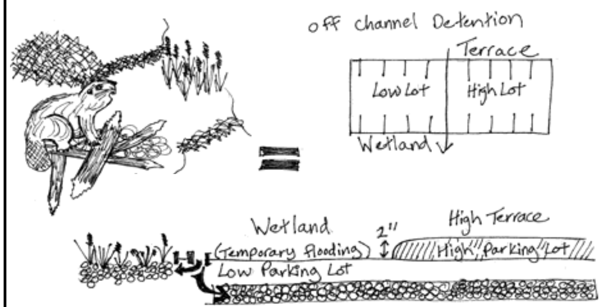


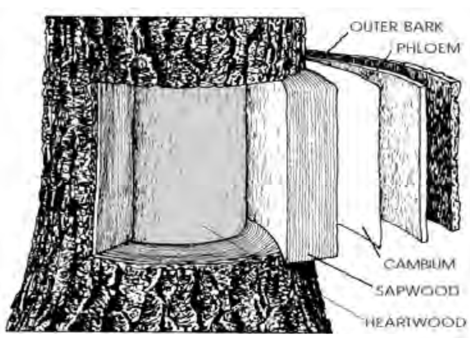

Design Principle
Interlocking matrix of mixed material spanning perpendicular to the water's flow creates a high cavity surface area that slows water for storage or increased water absorption.
Life's Principles
• Fit form to function
• Integrate the unexpected
• Use low energy processes
• Embody resiliency through variation, redundancy and decentralization
• Build from the bottom up

Application ideas



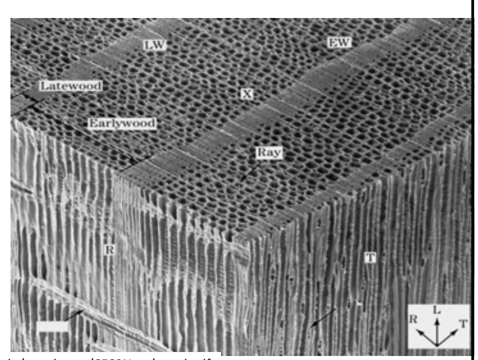
Application ideas



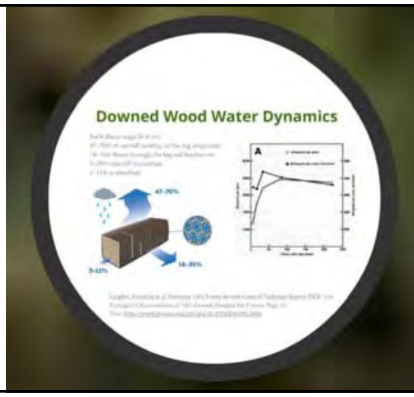


http://www.ca.uky.edu/forestryextension/Publications/FOR_FORFS/for59.pdf

Softwood microstructure



http://www.ce.berkeley.edu/~paulmont/CE60New/wood.pdf



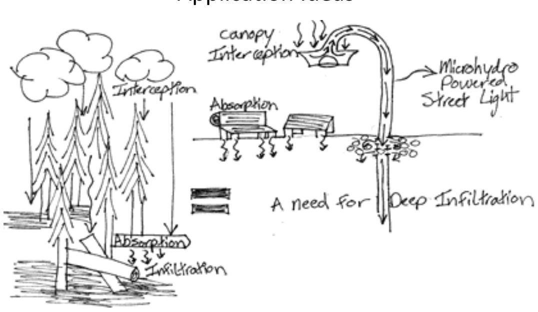
Design Principle

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

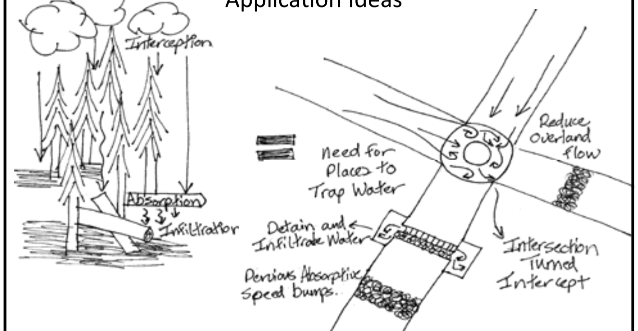
Life's Principles

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

Application Ideas

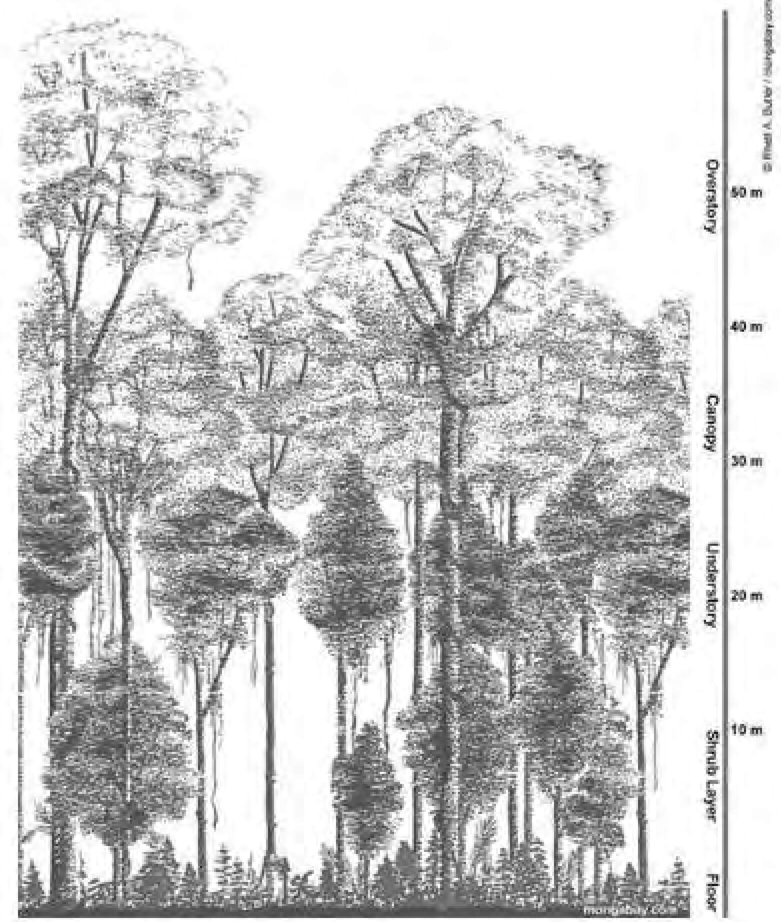


Application Ideas



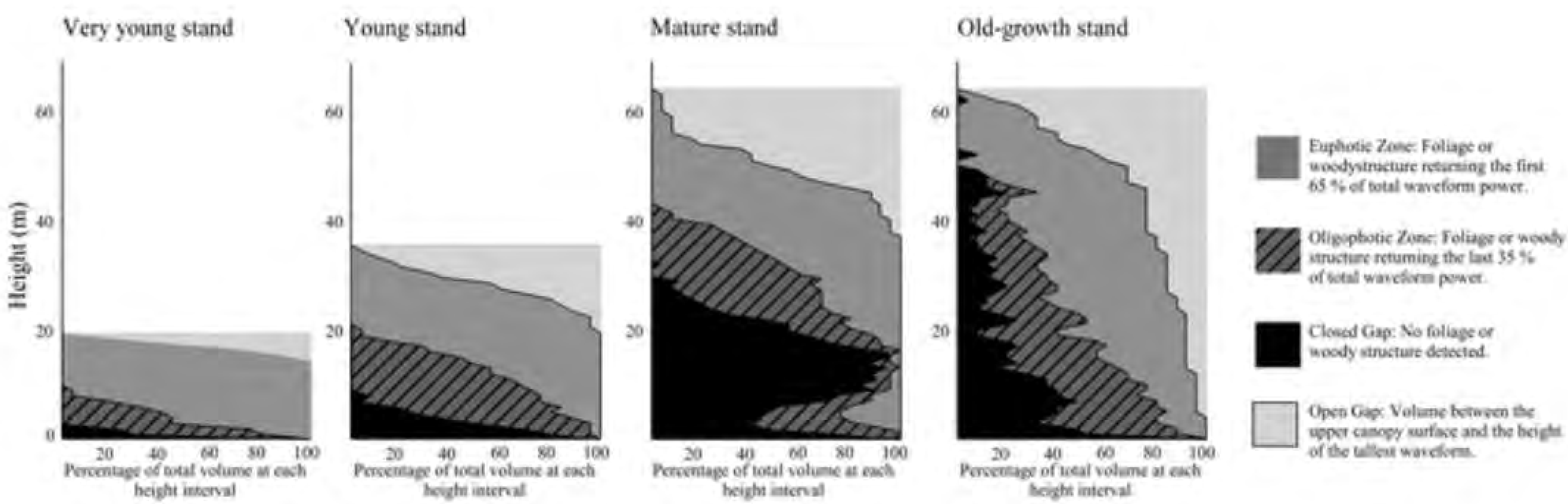
Old Growth Forest Canopy

Core Function: Slow flows and maximize interception

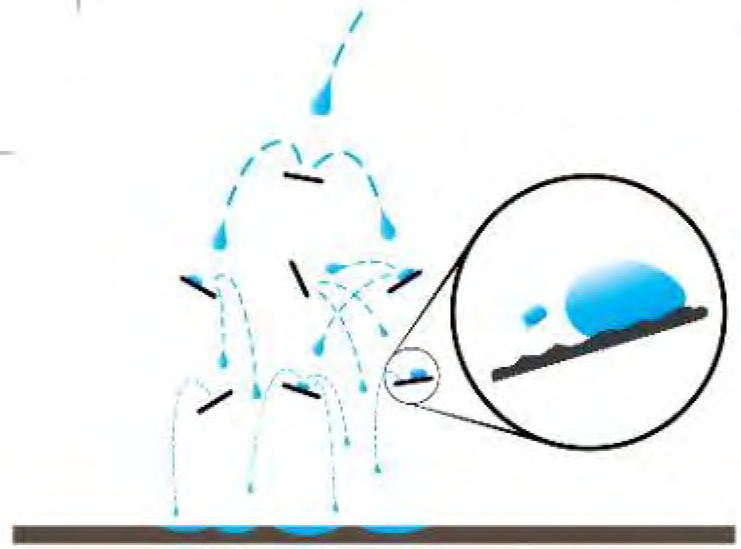


Strategy: Individual organisms grow at diverse levels and at different scales to maximize surface area by occupying all potential niches – collectively filling in 3-dimensional space.

Strategy: Individual organisms grow diverse levels and at different sc to maximize surface area occupying all potential niche collectively filling in 3-dimensio space.



new developments

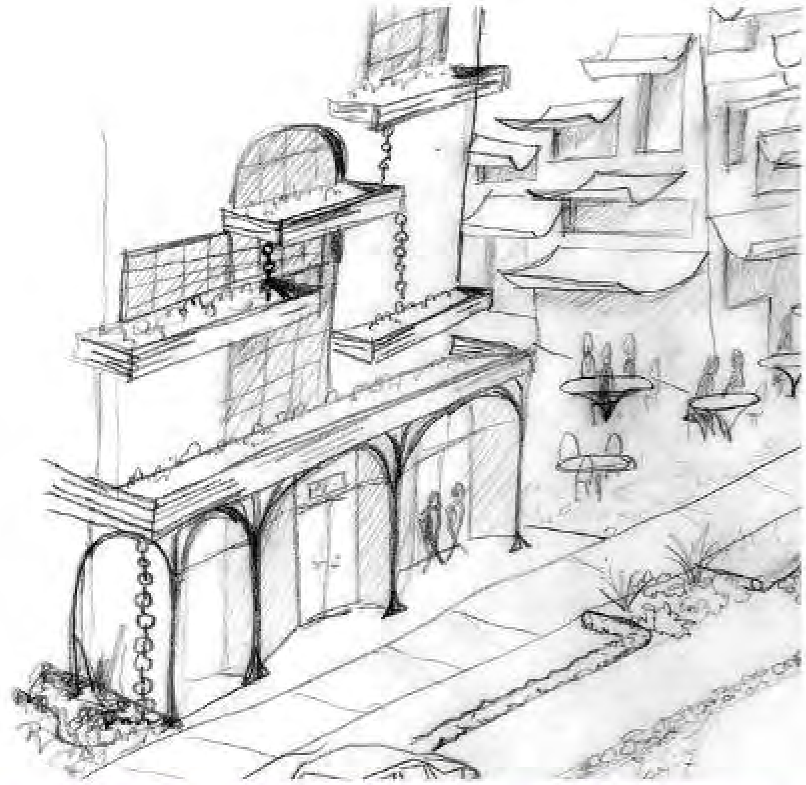


Design Principle:

Overlapping, redundant units/surfaces at multiple layers above the ground surface maximizes surface area - intercepting water and reducing erosive force.

Life's Principles:

- Incorporate diversity
- Embody Resilience through Variation, Redundancy, and Decentralization
- Self-organize



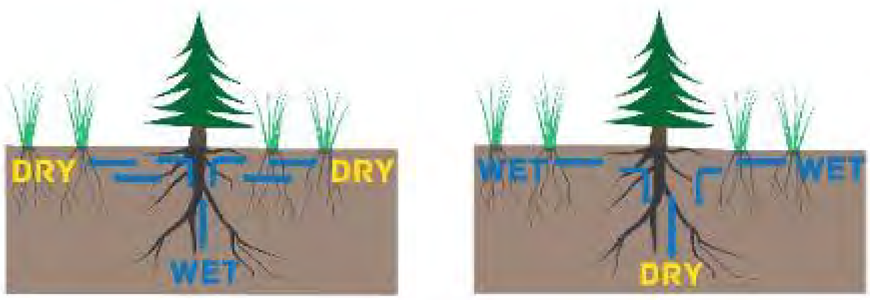
Application Ideas:

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

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

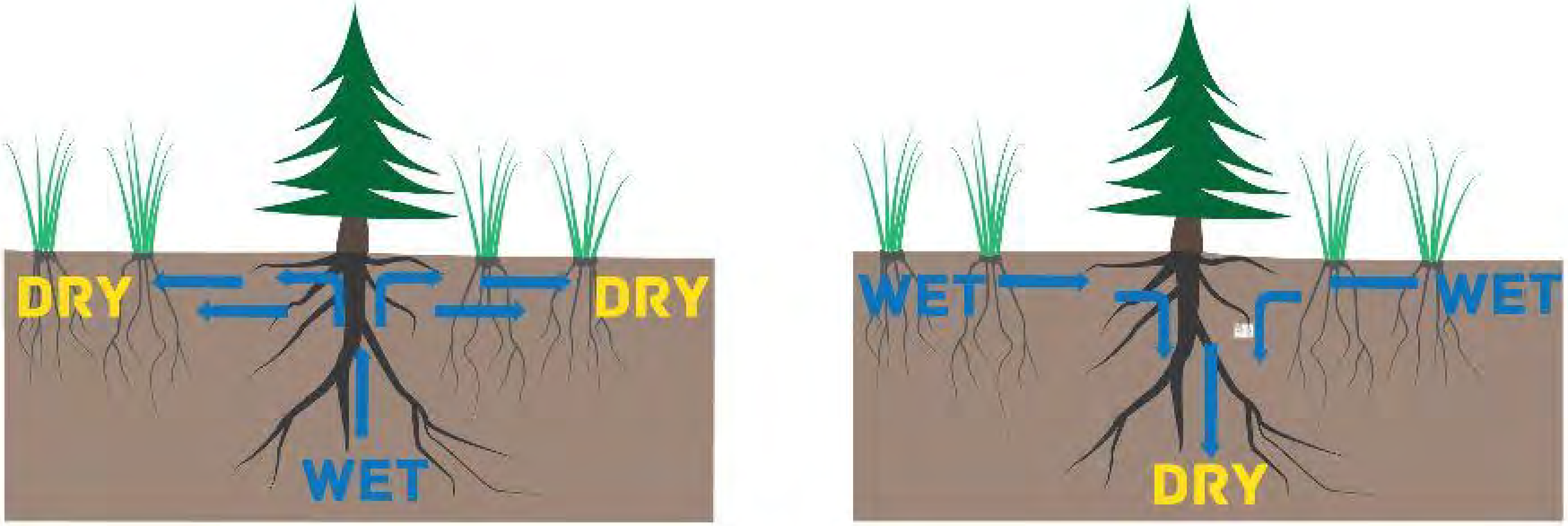
Hydraulic Redistribution

Core Function: Transport Water



Strategy: Use osmosis, capillary action, and gravity to redistribute water from areas with excess flows to those areas with greater storage capacities.

Core Function: Transport Water



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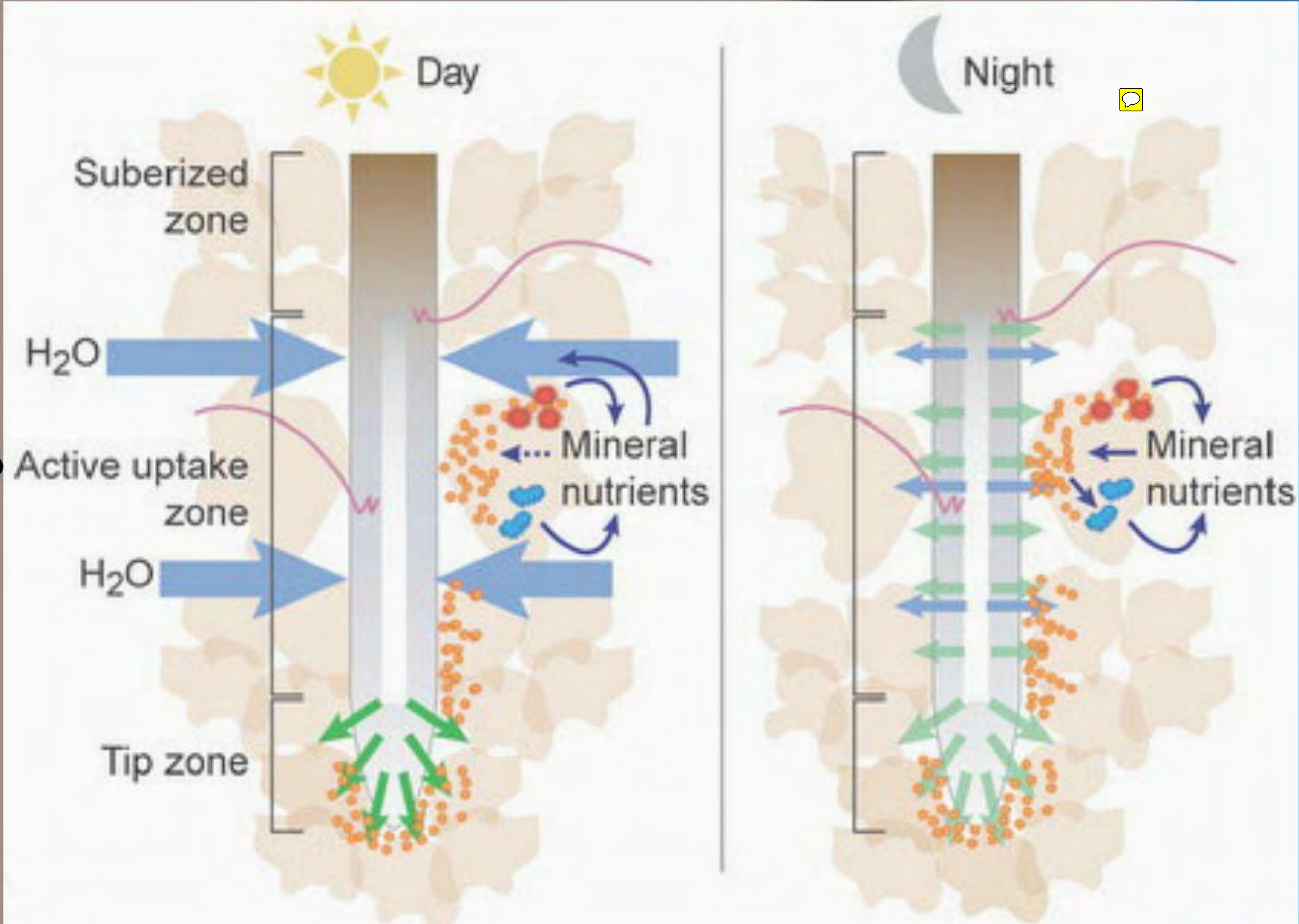


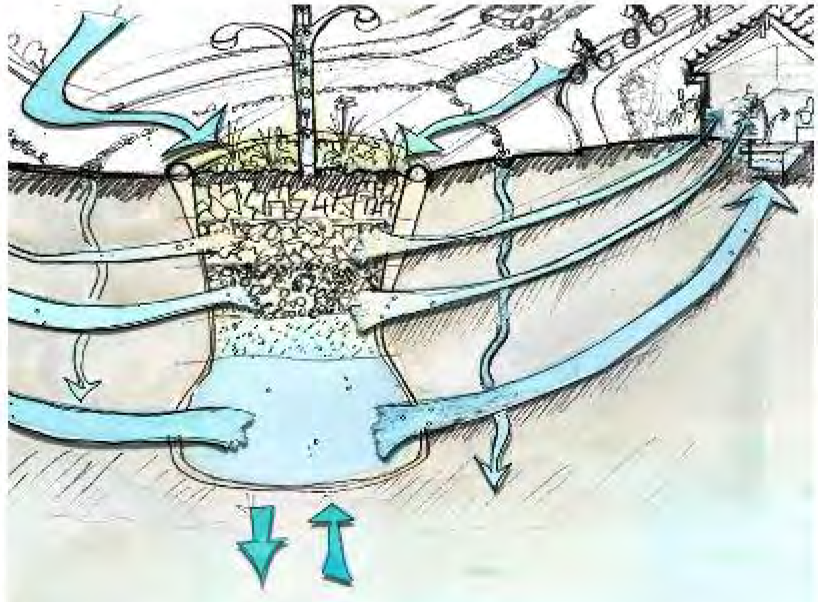
Day
Night
Suberized zone
H_2O
Active uptake zone
H_2O
Tip zone
Mineral nutrients
Mineral nutrients

Design Principle:

A subterranean network transports water - using capillary action, osmosis, or gravity - from wetter areas to where it is needed most, in order to balance the potential water gradient.

Life's Principles

- Use Feedback Loops
- Recycle All Materials
- Use Readily Available Materials and Energy
- Leverage Cyclic Processes



108

Application Ideas:

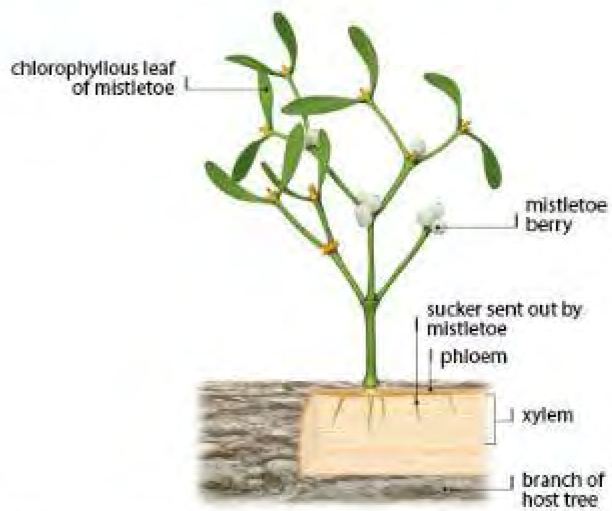
104

- Create distribution networks that can transfer water between them using passive mechanisms.
- Design piping that can transfer water using capillary action and osmosis

Irriga
garde
using
host b

Mistletoe

Core Function: Collects and transforms water



Strategy: Uses redundant branching structure to tap into distribution networks at multiple points and convert water into abundant resources to be distributed back to the system.

Design Principle:

Users connect to a resource where abundant flows exist - tapping into their distribution network at multiple locations. It uses these nutrients to produce other valuable resources for the host and ecosystem.

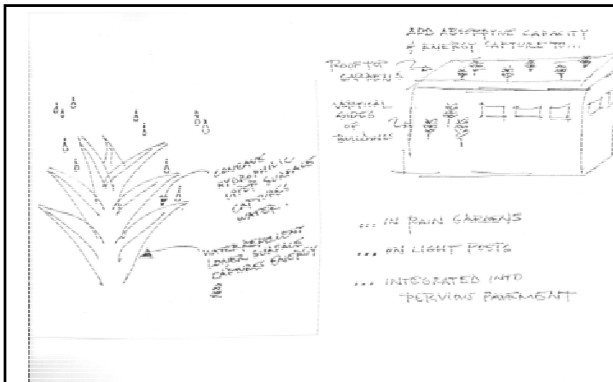
Life's Principles:

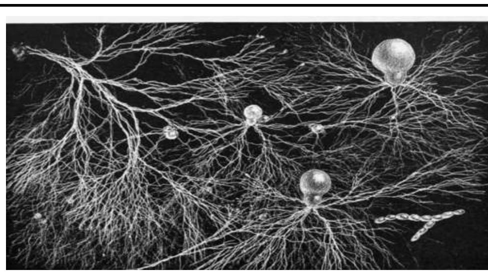
- Use Readily Available Materials and Energy
- Cultivate Cooperative Relationships
- Integrate the Unexpected

Application Idea:

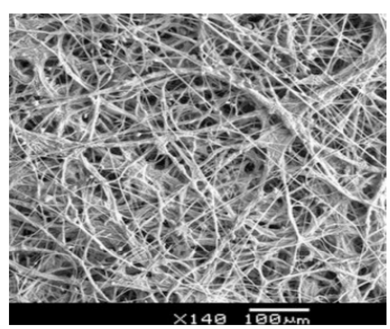
Irrigate greenhouses, aquaponic systems, and vegetable gardens with water collected by surrounding buildings, using piping and filtration systems connected inside the host building.

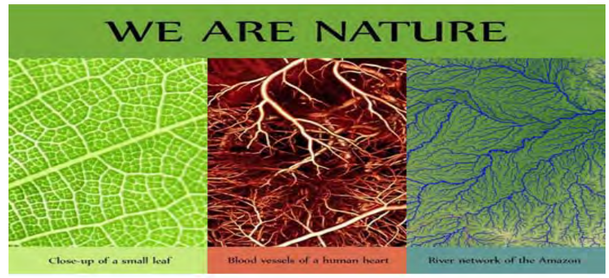
Organism: moss
Function: absorb water





Organism: Mycorrhizal fungal networks
Function: absorb water



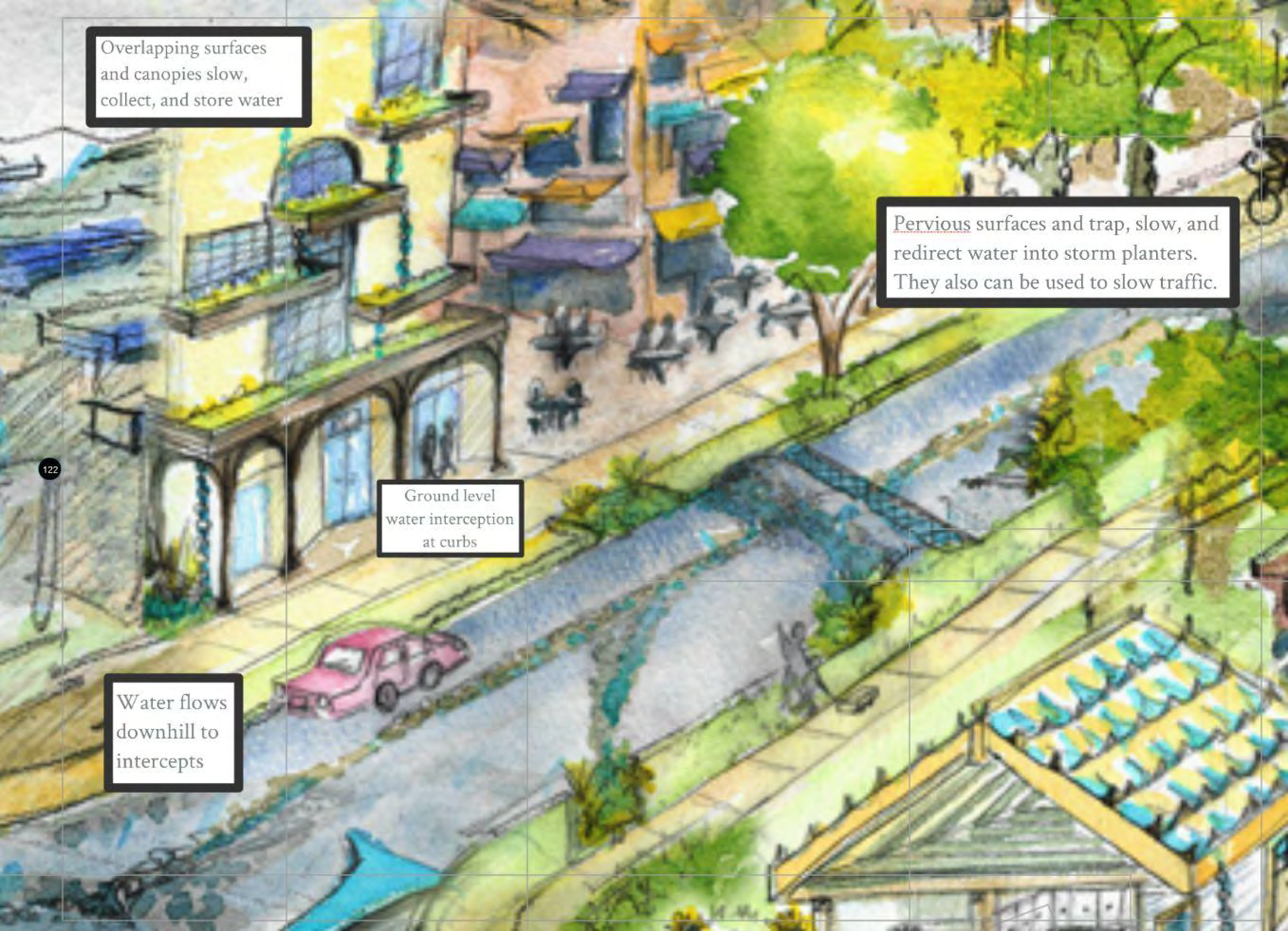


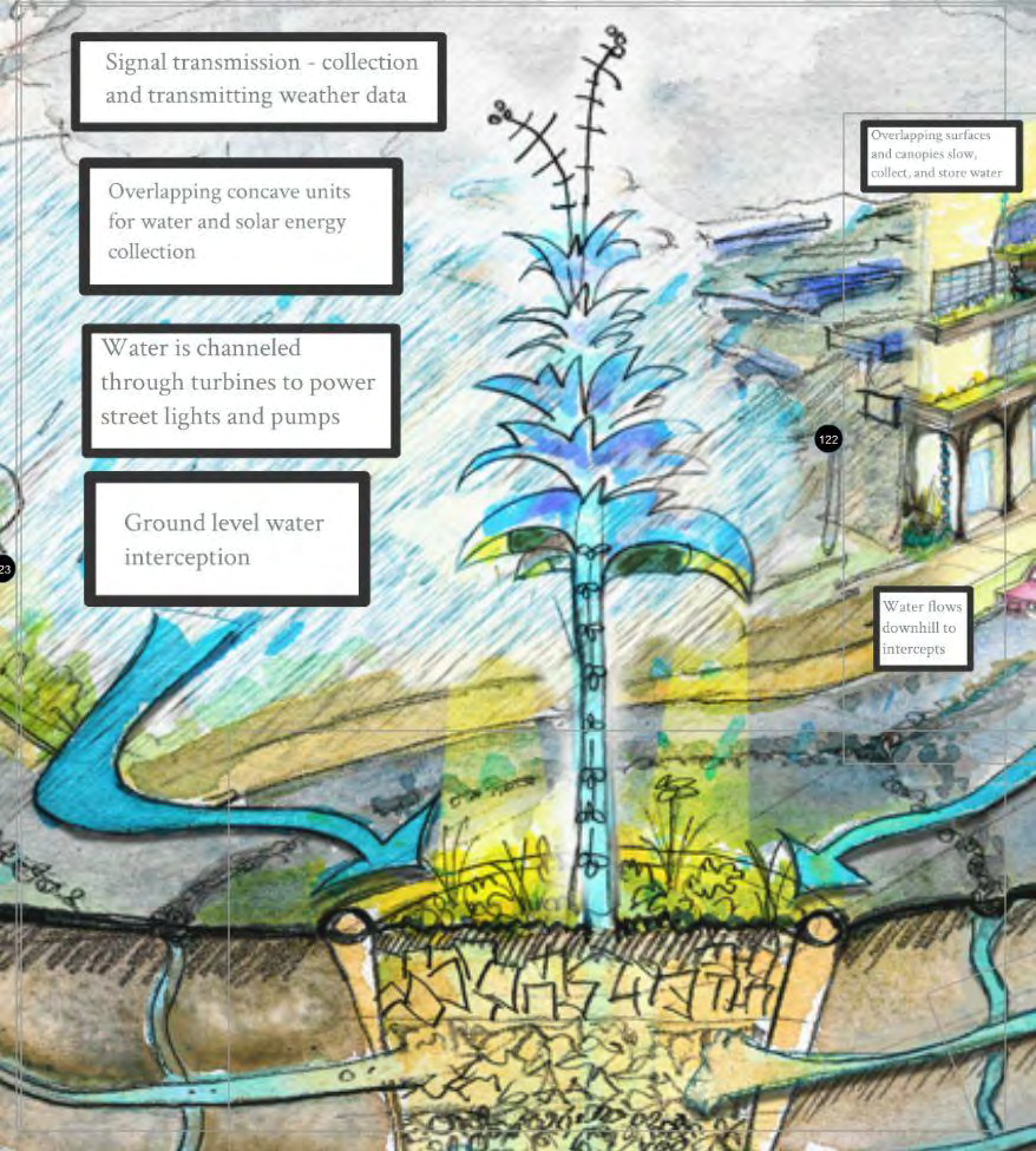
murray's law: an optimal way to distribute fluids

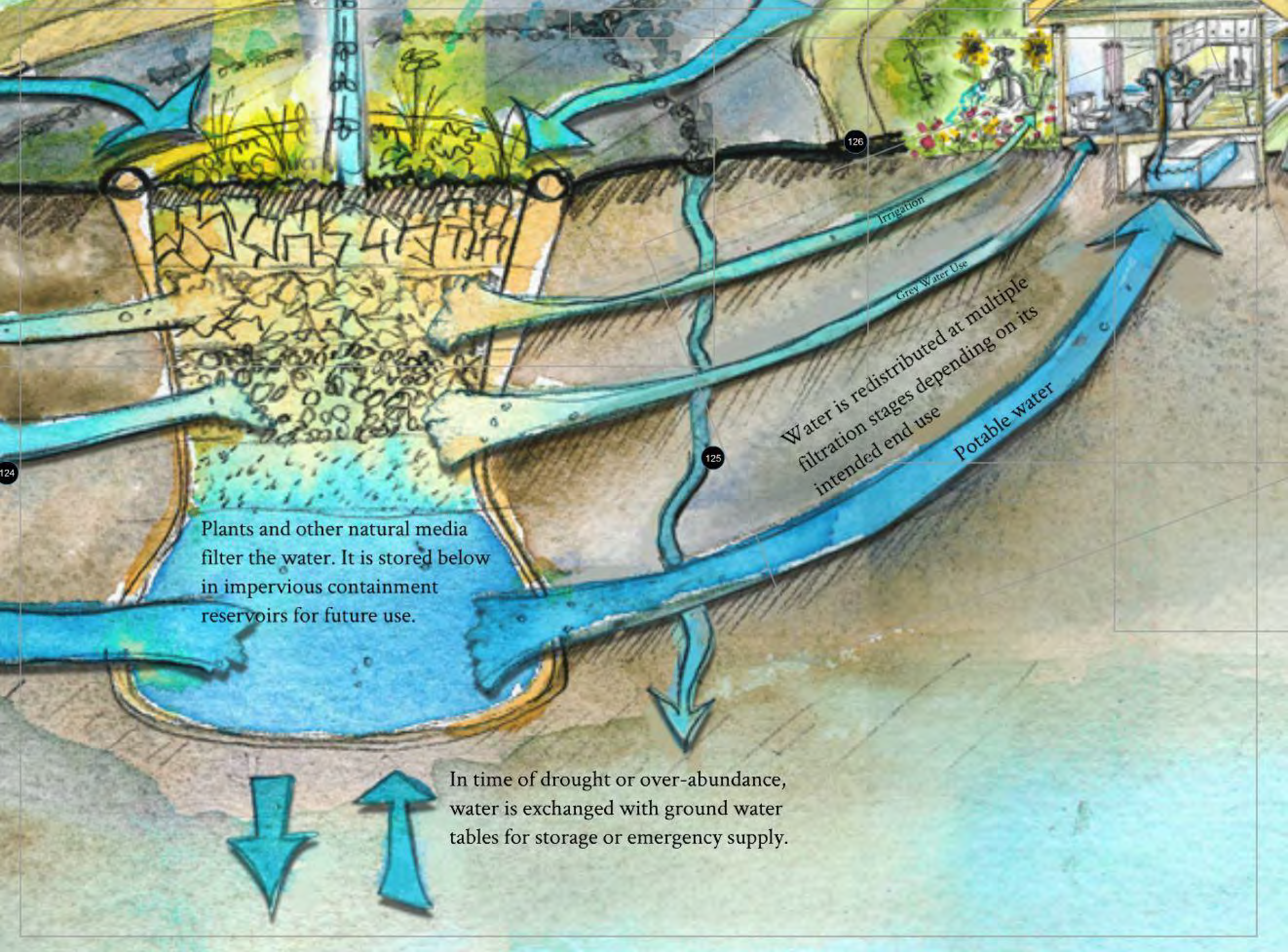
Application ideas

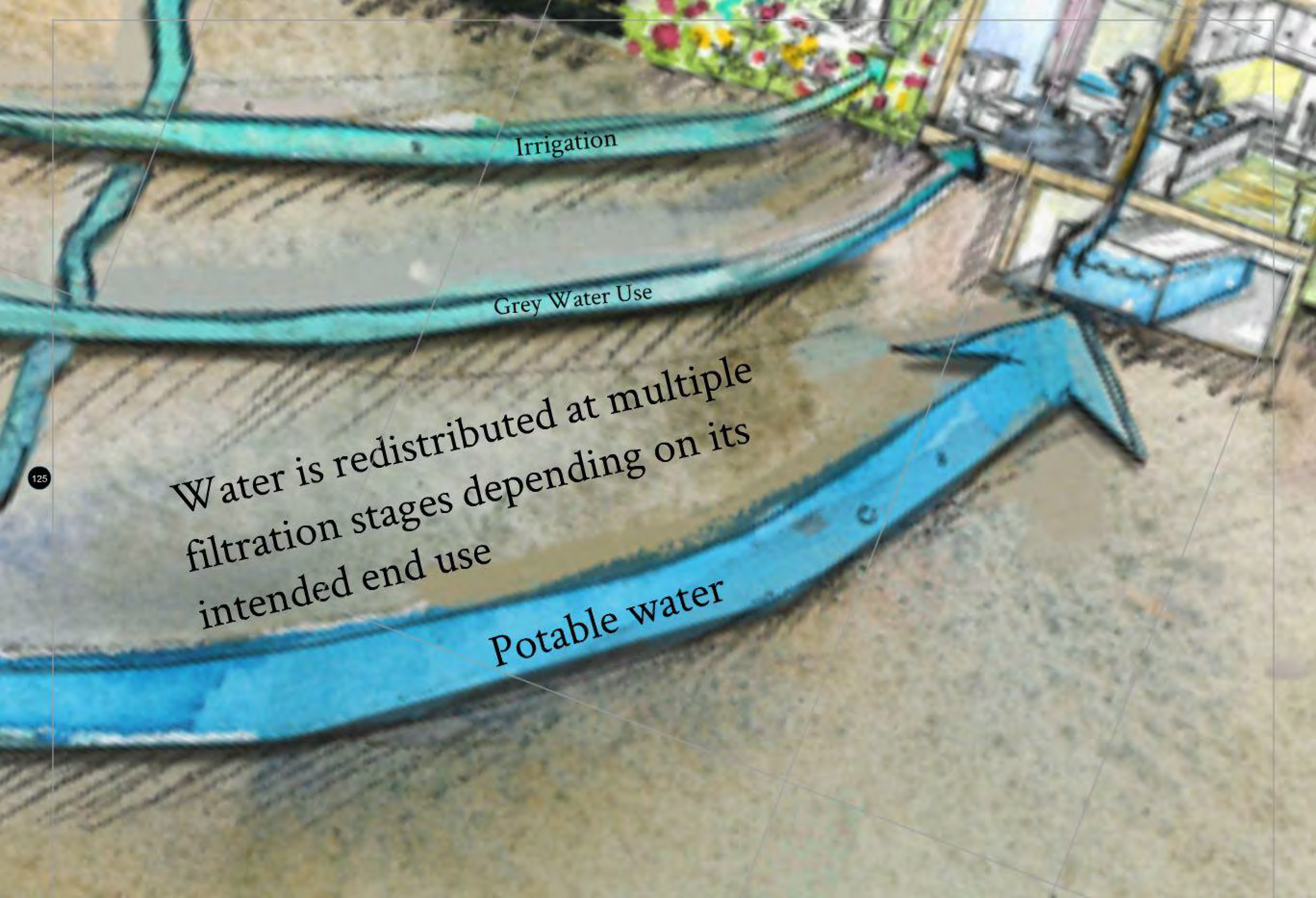
- Inoculate plantings with mycorrhizal fungi (bio-utilization)
- Incorporate high surface area in structures designed to reduce runoff/absorb peak flows
- Reduce urban runoff by integrating root design into rain gardens or pavement or ???.


Unused lots become temporary wetlands during the winter months


Overlapping surfaces and canopies slow, collect, and store water
Pervious surfaces and trap, slow, and redirect water into storm planters. They also can be used to slow traffic.
Ground level water interception at curbs
Water flows downhill to intercepts


Signal transmission - collection and transmitting weather data
Overlapping concave units for water and solar energy collection
Water is channeled through turbines to power street lights and pumps
Ground level water interception
Overlapping surfaces and canopies slow, collect, and store water
Water flows downhill to intercepts
122


126
Irrigation
Grey Water Use
Water is redistributed at multiple filtration stages depending on its intended end use
Potable water
124
125
Plants and other natural media filter the water. It is stored below in impervious containment reservoirs for future use.
In time of drought or over-abundance, water is exchanged with ground water tables for storage or emergency supply.


Irrigation
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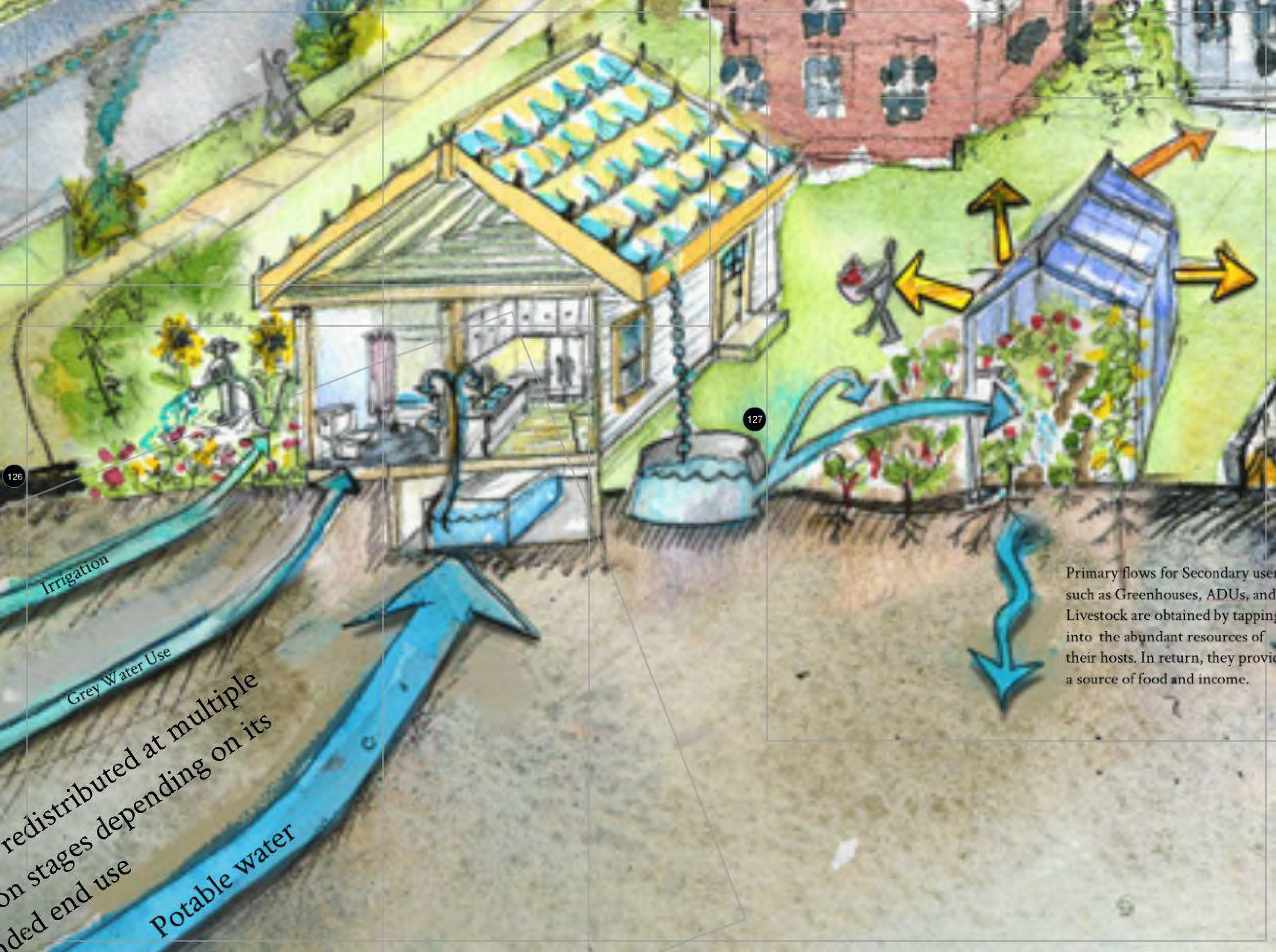
Water is redistributed at multiple filtration stages depending on its intended end use
Potable water



Irrigation
Grey Water Use
redistributed at multiple
on stages depending on its
ded end use
Potable water
Primary flows for Secondary user
such as Greenhouses, ADUs, and
Livestock are obtained by tappin
into the abundant resources of
their hosts. In return, they provid
a source of food and income.

Primary flows for Secondary users such as Greenhouses, ADUs, and Livestock are obtained by tapping into the abundant resources of their hosts. In return, they provide a source of food and income.

Break out session

- Groups of 3-4
- Ideate sustainable design concepts using Design Principles from the natural models we've shared.
- Refer to info-graphics on your table.
- Refer to Life’s Principles.
- Ideas encouraged from any scale: product, building/house, neighborhood/EcoDistrict, city (infra-structure), watershed, policy.
- We encourage 'blue sky ideation' - not necessarily time to generate 'feasible' concepts – OK to identify technical feasibility questions
- Present design concepts
  - include Organism, Design Principle/Life’s Principle emulated, design concepts.

4:35 – 5:00
What's Next? Evaluations & Closing

ONLINE COURSE
Introduction to Biomimicry (2 hours)
$79 discounted rate good until March 29, 2013
Use Network code: Network2012
shop.biomimicry.net

WORKSHOPS:
Backyard Biomimicry Workshops
1-day or 3-day

CERTIFICATE COURSES:
Biomimicry Specialist Certification Program: 8 month
Application deadline: February 1, 2013
Biomimicry Professional Certification Program: 2 yr Masters Level
Application deadline March 29, 2013

CONFERENCES
7th Annual Biomimicry Education Summit
Boston, MA: June 21-23, 2013

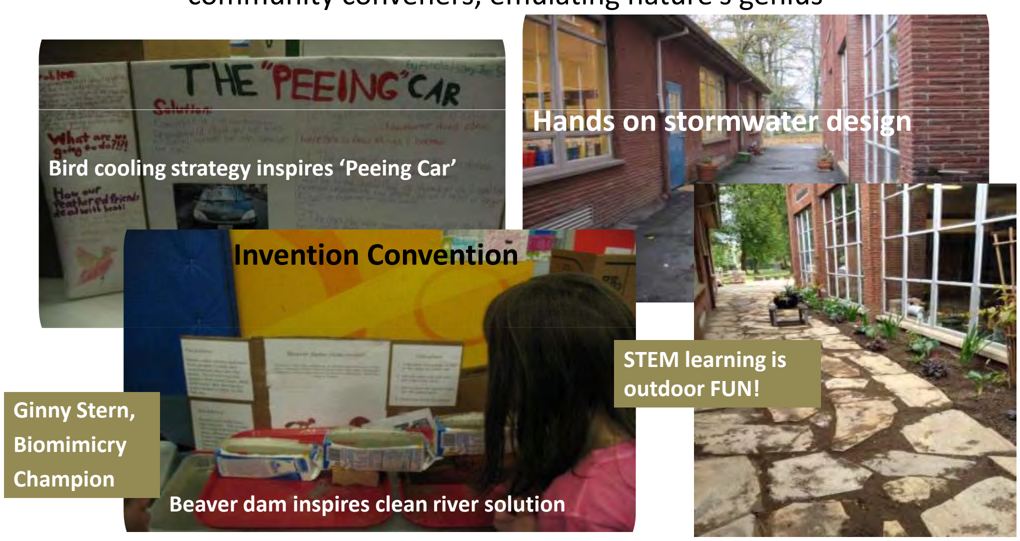
BIOMIMICRY PROFESSIONAL PATHWAYS

Learn more and register at:

http://biomimicry.net/ProfessionalPathways

Biomimicry Education Collaborative

Empowering students as stormwater designers, problem solvers and community conveners, emulating nature's genius



Closing

Share 1 of the following:

1. one word to describe how you feel
2. one take home message, or
3. one idea for future collaboration or future learning about biomimicry you'd like to explore

Appendix M - Biomimicry Oregon

We welcome your feedback!

Workshop: Biomimicry Genius of Place Stormwater Workshop – Portland, OR
Date: 1/17/13
Name (optional):

1. What did you learn today that you might apply in the future? Do you have an idea for a project or collaboration you'd like to explore?

2. Overall, what was your impression of the workshop?

3. What would you improve in a future workshop?

4. Do you see how biomimicry will inspire/catalyze innovation in your world?

5. Please rate the Genius of Place approach on a scale of 1 to 5, with 1 = Not useful to 5 = Useful and user friendly.

6. Do you have interest in learning more about biomimicry? (circle one) YES NO

7. Which of the following ways of learning about biomimicry would you most likely attend? (number in order of preference)
   ____ 2-hour online course (20% discount to $79 until March 29, 2013 at www.biomimicry.net; use coupon code Network2012. Eligible for AIA/USGBC credit)
   ____ 1-day local, interactive workshop ($250)
   ____ 3-day local, interactive workshop ($750)
   ____ 8-month BSpecialist program (face-to-face + online components)
   ____ 2-year BProfessional program (face-to-face + online components)
   ____ other (please describe)

8. Are you interested in further engagement with Biomimicry Oregon? (circle all that apply)
   a. Attend monthly networking event to learn about local biomimicry examples
   b. Initiate/participate in:
      i. place-based projects - Genius of Place, Ecological Performance Standards
      ii. built environment projects
      iii. city planning or policy projects
      iv. product or material design projects
      v. research projects
      vi. organizational design projects
      vii. education partnerships
   c. Provide financial sponsorship for a similar event or project
   d. Volunteer with Biomimicry Oregon (sign name on volunteer list)
   e. Other (please describe)

(Write on back of page if you need more space!)

Biomimicry Oregon Genius of Place Stormwater Project

Appendix N

Budget to Actual - As of 3/22/13

Task	Percent Complete	Amount: Budget: Labor	Budget: Expenses	Budget: Total	Actual: Labor	Actual: Expenses	Actual: In Kind Donations	Actual: Total	% of Budget	Hours: Budget	Hours: Actual	Hours: % of Budget
Project management	98%	$ 3,000	$ -	$ 3,000	$ 2,000	$ -	$ -	$ 2,000	66.67%	76	80.25	105.59%
Team attend bi-weekly meetings	100%	-	-	-		-	-	-	-	0	96.5	
Identify a Challenge	100%	-	-	-		-	-	-	-	12	59	491.67%
Genius of Place research	100%	4,500	-	4,500	4,000	-	-	4,000	88.89%	100	232.5	232.5%
Outreach and marketing	95%	800	-	800	400	-	-	400	50.0%	40	71.25	178.13%
Workshop	100%	3,200	1,800	5,000	2,400	445	1,600	4,445	88.9%	68	177.25	260.66%
Post-Workshop Activities	98%	-	-	-	-	-	-	-	-	0	46.25	
Summary report	95%	4,300	200	4,500	2,500	-	-	2,500	55.56%	110	131.75	119.77%
Fundraising	100%	-	-	-	-	-	-	-	-	0	9.25	
Total		$ 15,800	$ 2,000	$ 17,800	$ 11,300	$ 445	$ 1,600	$ 13,345	74.97%	406	904	222.66%
estimated to completed												

Notes:

1 Project is one month behind schedule; reports will be completed by March 3, 2013.

2 "Identify a Challenge", "Fundraising", and "Post-Workshop Activities" were added as budget line items after Bullitt Grant application submitted.

3 Hours include core team working on the project only. At least 250 hours by others engaged in the project (meetings, workshop, etc.) were donated.

4 Assumptions included in the original budget submitted to Bullitt Foundation in grant application:

Project will be about 400 hours; 300 reimbursed at non-profit discount rate of $50.00/hour + 100 volunteer hours.

Entire budget is labor except for $400 in printing cost and $1,400 facility & food for workshop.

5 **Biomimicry Oregon GofP Project Donors**

	Cash	In Kind		
Bullitt Foundation	$ 10,000	$ -		
Glumac	1,000			
Workshop participants	840			
Portland Bureau of Planning & Sustainability		500		meeting space for GofP Wkshop (assume 5 hours @ $100/hr)
Strikeforce Design		650		illustrations for workshop PREZI presentation
piazza italia		100		food for GofP Wkshop (per receipt)
Kate Schuyler		250		videotaping for GofP Wkshop (5 hrs @ $50/hr)
ESA		100		printing for workshop (per Kinko pricing)
Total	**$ 11,840**	**$ 1,600**	**$ 13,440**	

Workshop Expenses

Facilitator Travel	$ 389.05
Supplies (name tags, rct book, stickie	33.79
Parking	22.00
	$ 444.84

Biomimicry Oregon Genius of Place Stormwater Project

Appendix O
Communications Plan

Hi Mary,

This document contains some thoughts on how to document and communicate Biomimicry Oregon's Genius of Place project via:

- Earned Media
- Private Newsletters
- Private Presentations
- Social Media

You will probably gather that I have given the most thought to the resources to have documented to make a strong presentation to media, and to the approach to earned media (since the hurdle is higher there). At this point, these are ideas, many of which may not be appropriate or desirable.

In any case, a next step would be for you and me to chat about what would work, what's missing, and how to give Desired Completion Dates to these items, per the schedule we recently discussed on the phone (summarized below):

- October 5
  - Select challenge: storm water
- November 12
  - Ask nature process
    - "Five ways"
- December
  - Develop graphical depictions
- January 21
  - Day-long workshop
- March 1
  - Final project to grantor

I apologize again for my elusiveness so far. My workload at Brightworks is substantial, and I didn't anticipate how much effort would be required to do my work from Los Angeles.

Thanks again for your patience…

Brandon

Organize Resources

Organize Resources	Desired Completion	Responsible Party
Task 1: Identify Biomimicry Oregon communication leads - Mary? - Faye? - Ethan?	10/26/12	**Mary**
Task 2: Secure and document endorsements *Existing Endorsements* - Bullitt Foundation *Possible Endorsements* - Oregon political leadership? o Earl Blumenauer? o Ron Wyden? o Sam Adams? o Jeff Merkeley? o Susan Anderson? - Oregon institutional leadership? o OUS partner? o ISS, PSU o O of O If they are invested in some way, or if there are students involved… get president to write letter of endorsement - Oregon non-profit leadership? o Mike Houck? o Mercy Corps? o EcoTrust? - Business community leadership? o Dan Wieden? o Zorhab Vassoughi? o Scott Lewis? o Mark Edlen? o Ann Edlen? o Darcy Winslow o AdidaS (Nicole?) People who media covers *Documentation* - Bullitt Foundation letter of acceptance? - Bullitt Foundation letter of endorsement from executive director		**Mary, Brandon (if desired)**

- Letter of endorsement from political leader, if appropriate - Letter of endorsement from institutional leader if appropriate - Letter of endorsement from non-profit leader, if appropriate - Letter of endorsement from business leader, if appropriate		

Task 3: Develop sponsorship offer for organizations offering newsletter placements		Mary

Task 4: Consider creating Biomimicry Oregon newsletter for direct Biomimicry news and information		Mary? Ethan?

Task 5: Develop sponsorship offer for individuals offering LinkedIn, Facebook, and Twitter posts with Biomimicry news?		Mary

Earned Media

Task	**Desired Completion**	**Responsible Party**
Task 1: Develop media kit content *3-5 sentences on vision* - "The Genius of Place project is a global initiative, beginning in Oregon, to equip designers and engineers with strategies for solving problems in sustainable ways using proven methods embodied in the adaptations of organisms to their environments" or some such. *3-5 sentences on Biomimicry Oregon's connection to this vision* - The global Genius of Place project is getting its start in Oregon… *3-5 sentences on:* - Status of project to date with focus on external milestones *Quarter-page text on:* - Bullitt Foundation - Bullitt Foundation Funding Program - Bullitt Foundation Executive or Program Director - Summary of grant project/proposal - Overview of Biomimicry - Overview of Biomimicry organizations (3.8, Oregon, Puget Sound, et cetera) - Bio: Mary Hansel - Bio: Jeanine Benyus? - Bio: _____________, Bullitt Foundation - Bio: _____________, Business Community Rep - Bio: _____________, Government Rep - List of steering committee members - Schedule *Visuals* - Diagrams of Biomimicry 3.8:Biomimicry Oregon relationship? - Project schedule? - Genius of Place process? - Group shot of board? - Headshot of Mary? - Headshot of Bullitt Foundation rep - Headshot of business community rep? *Electronic Resources* - YouTube (or other) videos on Biomimicry? - YouTube (or other) videos on GoP?		**Mary, Lauren, Ethan (visuals)?**

Social Media - Include text summarizing all Biomimicry Oregon social media channels *Newsletter* - Include text offering newsletter subscriptions		

Task 2: Finalize media kit		**Brandon, Mary**

Task 3: Identify, select, and rank media targets by priority - Any in Seattle while Brandon is there in October?		**Brandon, Mary**

Task 4: Set-up meetings with targeted media in order of priority		**Brandon**

Task 5: Conduct meetings with targeted media		**Brandon, Mary, Other?**

Task 6: Conduct follow-up phone calls with targeted media to assess interest		**Brandon, Mary**

Task 7: Fulfill requests for interviews and graphics; secure run dates for successful placements		**Brandon, Mary**

Task 8: Share news placements - Biomimicry Oregon website - Biomimicry social channels - Newsletter (if developed) - Email to board members and staff - Email to sponsors - Personal email to Bullitt Foundation stakeholders - Biomimicry Oregon LinkedIn group - Personal LinkedIn pages of LinkedIn sponsors - Other?		**Brandon, Mary**

<u>Newsletter Sponsors</u>?

	Desired Completion	**Responsible Party**
Task 1: Offer sponsorship benefits to businesses or organizations offering 2-3 newsletter placements through end of project *Possible Targets* - City of Portland BPS? - Brightworks? - Portland Business Journal? - Brightworks (4,000+ newsletter subscribers) - Bullitt? - Glumac? - *Benefits* - Participation in pre-funk (Panel? Party?) with Bullitt Foundation and other endorsers before public workshop? - Sponsorship recognition in ________? *Milestones for newsletter use* - Launch/Grant announcement? - Public Workshop Promotion? - ________________		**Mary**
Task 2: Ask for newsletter parameters and summarize - Text only? - Visuals? - Word count?		**Brandon**
Task 3: Adapt GoP content to newsletter parameters and forward to providers		**Brandon, Mary**
Task 4: Review and approve newsletter placements		**Mary**

Private Presentations?

	Desired Completion	Responsible Party
Task 1: Identify organizations for private outreach		**Mary? Ethan? Nicole?**
Task 2: Contact targeted businesses for private outreach and propose on-site workshops		**Mary? Ethan? Nicole?**
Task 3: Schedule on-site workshops with interested private businesses		**Mary? Ethan? Nicole? Lauren?**
Task 4: Conduct workshops with interested private businesses - Distribute sign-in sheet asking for email addresses for newsletter subscriptions, interest in public workshop, and interest in social media connection - Pass out quarter-page flyers with Biomimicry social media contact information		**Mary? Ethan? Nicole? Lauren?**
Task 5: Call individuals giving name and email information at workshops, thank them for coming, and ask directly if they are interested in Biomimicry social media		**Mary? Ethan? Nicole? Brandon? Lauren?**

Social Media?

	Desired Completion	Responsible Party
Task 1: Determine whether to establish a Biomimicry Oregon Facebook and Twitter presence Write a tweet and call to ask if they will tweet.		
Task 2: Contact administrators of existing Biomimicry social channels and assess willingness to share Biomimicry Oregon news		
Task 3: Request sharing of online media placements in partner/supporter Facebook, LinkedIn, Twitter feeds		**Brandon, Mary**