5-2016

An Instructional Module on Permaculture Design Theory for Landscape Architecture Students

Keni Althouse
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/gradreports

Recommended Citation
https://digitalcommons.usu.edu/gradreports/793

This Creative Project is brought to you for free and open access by the Graduate Studies at DigitalCommons@USU. It has been accepted for inclusion in All Graduate Plan B and other Reports by an authorized administrator of DigitalCommons@USU. For more information, please contact dylan.burns@usu.edu.
AN INSTRUCTIONAL MODULE ON PERMACULTURE DESIGN THEORY

FOR LANDSCAPE ARCHITECTURE STUDENTS

by

Keni Althouse

A project submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF LANDSCAPE ARCHITECTURE

Approved:

__________________________  ________________________
Phillip S. Waite             Jennifer R. Reeve, PhD
Major Professor             Committee Member

__________________________
Benjamin H. George, PhD
Committee Member

UTAH STATE UNIVERSITY
Logan, Utah

2016
Copyright © Keni Althouse 2016

All Rights Reserved
ABSTRACT

An Instructional Module on Permaculture Design Theory

for Landscape Architecture Students

by

Keni Althouse, Master of Landscape Architecture

Utah State University, 2016

Major Professor: Phillip S. Waite
Department: Landscape Architecture and Environmental Planning

Permaculture guides designers to mimic patterns and relationships found in nature. It is a design theory that tailors toward many people’s desire for more sustainable living. This theory offers a unique set of design principles that are very implementable into the design process and could be of great interest to landscape architects.

The purpose of this study was to develop and implement an instructional module for landscape architecture students at Utah State University for two consecutive years. Project-based learning was implemented in order to help students better understand permaculture design theory. Effectiveness of the module was measured through an evaluation of post-module survey responses and student design projects. Results from the second year of teaching showed an increase from the first year in student interest, understanding, and desire to learn more about permaculture design theory.
An Instructional Module on Permaculture Design Theory
for Landscape Architecture Students
Keni Althouse

Permaculture is a creative design process based on whole-systems thinking. It guides designers to mimic patterns and relationships found in nature. Gaining in popularity, permaculture is a design theory that tailors toward many people’s desire for more sustainable living. This theory offers a unique set of design principles that are very implementable into the design process and could be of great interest to landscape architects.

The purpose of this study was to develop and implement an instructional module for landscape architecture students at Utah State University for two consecutive years. The next objective was to measure the effectiveness of the instructional module. This was accomplished through an evaluation of post-module survey responses and student design projects. Overall, information was well received with positive feedback. Results from the second year of teaching showed an increase from the first year in student interest, understanding, and desire to learn more about permaculture design theory.

Landscape architects can work on many different scales and contexts, from large-scale regional projects to residential planting designs. Because of this wide range of scales, landscape architects should know the importance of environmental stewardship and understand natural processes to become successful. Permaculture design theory aids in the process of understanding such processes and could benefit landscape architects who learn and understand its principles.
ACKNOWLEDGMENTS

I would like to thank my committee members, Dr. Benjamin George, and Dr. Jennifer Reeve, for their support and invaluable knowledge throughout this entire process. I’d like to especially thank my committee chair, Phillip S. Waite for being so prompt and insightful to my relentless emails of feedback requests and questions. Thank you for helping me understand the process of writing and discovering things for myself.

I’d also like to thank my family for their constant encouragement and words of wisdom. I give special thanks to my husband, Michael, for not only being patient and understanding during my several year “marriage absence”, but also for the constant encouragement to get through those rough times. I could not have done it without you!

Keni Althouse
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>PUBLIC ABSTRACT</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>v</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>vi</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>ix</td>
</tr>
<tr>
<td>CHAPTER</td>
<td></td>
</tr>
<tr>
<td>I. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>II. LITERATURE REVIEW</td>
<td>5</td>
</tr>
<tr>
<td>Teaching Approach</td>
<td>5</td>
</tr>
<tr>
<td>Permaculture History and Philosophy</td>
<td>8</td>
</tr>
<tr>
<td>Permaculture in Practice</td>
<td>13</td>
</tr>
<tr>
<td>Permaculture and Landscape Architecture</td>
<td>15</td>
</tr>
<tr>
<td>Challenges of Permaculture</td>
<td>19</td>
</tr>
<tr>
<td>III. METHODOLOGY</td>
<td>25</td>
</tr>
<tr>
<td>Objective 1: Development</td>
<td>25</td>
</tr>
<tr>
<td>Objective 2: Implement</td>
<td>30</td>
</tr>
<tr>
<td>Objective 3: Measure Effectiveness</td>
<td>32</td>
</tr>
<tr>
<td>IV. RESULTS</td>
<td>35</td>
</tr>
<tr>
<td>Objective 1: Development</td>
<td>35</td>
</tr>
<tr>
<td>Objective 2: Implement</td>
<td>66</td>
</tr>
<tr>
<td>Objective 3: Measure Effectiveness</td>
<td>67</td>
</tr>
<tr>
<td>V. DISCUSSION</td>
<td>79</td>
</tr>
<tr>
<td>Weaknesses</td>
<td>79</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 2014 Instructional Module Lecture Organization</td>
<td>29</td>
</tr>
<tr>
<td>2. 2015 Instructional Module Lecture Organization</td>
<td>29</td>
</tr>
<tr>
<td>3. 2014 vs 2015 Module Organization</td>
<td>31</td>
</tr>
<tr>
<td>4. 2014 Design Solution Evaluation</td>
<td>68</td>
</tr>
<tr>
<td>5. 2015 Design Solution Evaluation</td>
<td>71</td>
</tr>
<tr>
<td>6. Post-Module Survey Responses</td>
<td>75</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure                                      Page
1. Concept network maps of keywords from permaculture publications. ....................... 17
2. Typical “messy” permaculture garden........................................................................ 22
3. Design Process Using Permaculture Design Principles............................................ 28
4. Formula for productive and sustainable systems......................................................... 44
5. Garden layout configurations.................................................................................... 45
6. Residential zone planning map.................................................................................. 52
7. Sector diagram ........................................................................................................... 53
8. Element placement within a sector diagram ............................................................... 54
9. City plan for Mobile, Alabama.................................................................................... 62
10. Greenpoint-Williamsburg Waterfront Master Plan .................................................. 63
11. Small scale practices to increase the edge ............................................................... 63
CHAPTER I
INTRODUCTION

Permaculture is a design process that involves imagination and creativity, which uses ethics and design principles. Permaculture guides designers to mimic patterns and relationships found in nature. It can be applied to all aspects of human habitation, from agriculture to ecological building, from technology to education (Holmgren, 2002). The purpose of this study was to educate landscape architecture students about using permaculture design principles (PDP’s) within their personal design process. An instructional module was created and taught to students at Utah State University (USU) for two consecutive years. The module consisted of three parts.

The first part was a series of lectures given to the students to help them understand the basics of permaculture design theory (appendices A and B). Part two consisted of an assigned design problem where students were asked to design a residential yard using as many permaculture principles as possible all the while considering design and overall aesthetic (Appendix C). The third part of the instructional module was a post-module evaluation survey filled out by students that measured the effectiveness of the teaching structure between the two years and overall student interest in permaculture design theory (Appendix D).

Permaculture is a recently developed design theory that is gaining in popularity around the globe. Courses, lectures, workshops, and seminars are taught around the globe with thousands of attendees. However, permaculture design theory is only beginning to make its way into the realm of academia and in most cases, only to the horticulture and
agriculture departments. Very rarely do permaculture design theory and landscape architecture curriculum meet.

Out of twenty-three selected universities in the United States with an accredited landscape architecture program only four offer courses in permaculture theory and design principles. Of those four, none of the landscape architecture curricula require students to take the course for graduation. The twenty-three schools were chosen only from universities which had an accredited landscape architecture program. Schools were also chosen based on location to include universities from all major climate zones in the United States (Appendix E).

Permaculture practices vary greatly by climate, which is why a sample from climatic zones instead of geographic regions was chosen for this study. The four universities that offer permaculture courses include Ball State University, North Carolina State University, Cornell University, and University of Massachusetts, Amherst. Permaculture is most often taught in departments related to horticulture and agriculture. Although permaculture is a design theory, according to websites and course descriptions, it is not taught to students majoring in a design specific field.

**Goals and Objectives**

The purpose of this study was to develop and deliver an instructional module on permaculture design theory. The developed instructional module was delivered to landscape architecture students enrolled at Utah State University. There were three objectives in completing this study. The first objective was to develop an instructional module lasting approximately four weeks of the semester. This was completed by first researching learning methods so students would have the greatest chance of
understanding permaculture design theory. Next, extensive research of permaculture theory was completed and compiled into the format of in-class lectures.

The second objective was to implement the instructional module and improve student awareness of permaculture theory and design principles. Ways in which student awareness was improved included a series of in-class lectures, followed by exercises and a design problem, giving students opportunity to apply what they learned. By providing students the opportunity to learn permaculture design principles, an important step can be taken towards sustainable design, while protecting the public health, safety, and welfare through future, functional design work.

The third objective was to measure the effectiveness of the instructional module by providing a post-module evaluation survey. Responses from the survey given in both 2014 and 2015 were coded to determine what the students learned during the module (Appendix F). Student projects and solutions from the before mentioned design problem were also evaluated to measure the application of permaculture principles.

Information gathered from the post-module survey helped in several ways. It informed the study of the effectiveness and student interest of the format and information presented during the instructional module. Important questions to measure effectiveness included:

1. How would you define permaculture?
2. How can permaculture be practiced on the larger scale? i.e. community/region?
3. I would like to know more about permaculture for future projects and how I can apply the principles for future design.

   · Definitely Agree
· Agree
· Neutral
· Disagree
· Definitely Disagree

4. How will you use permaculture principles during the remainder of your time at USU?

Questions within the survey and not listed above were used to measure strengths and weaknesses of the instructional module. The thesis project was approached using, but not limited to, the Planting Design for Sustainability course taught during the fall semester to juniors in the Landscape Architecture and Environmental Planning Department at USU.
CHAPTER II  
LITERATURE REVIEW  

Teaching Approach

There are three main methods of learning that can be applied to this study, lecture-based, inquiry-based, and project-based learning. Each have their advantages and disadvantages when teaching various subjects. A brief summary of each is provided in order to understand these advantages and disadvantages in order to better teach landscape architecture students.

Lecture-based learning, or traditional teaching consists of a lecturer or professor presenting information to a group all at once. It is a limited form of communication as one person speaks to many with little audience participation. Advantages of lecture-based learning is the ability to tailor towards high-ability students who prefer individual learning. These students approach learning more analytically and competitively. They prefer to study alone in a self-directed way (Opdecam, Everaert, Keer, & Buysschaert, 2014). Lecture-based learning allows students to be engaged at their own level and learn at their own pace. To students, lecture-based learning requires less time, effort, and commitment in terms of attending classes (Opdecam et al., 2014). It is also an effective way to get a lot of information out to a large group.

This also leads to a disadvantage of lecture-based learning. During lectures, the amount of attention, time, and intensity of interactions between students and teachers is lessened which can result in anonymity and passivity in students (Opdecam et al., 2014, p. 405). In a class of 25-30 students, this can cause problems for the professor in keeping
all of students engaged during the lectures. Furthermore, not every professor is effective at public speaking which can in turn influence student attention and interaction.

Inquiry-based learning is the process of a professor or student posing questions to begin learning a specific subject. This allows the student to take charge of the problem and become more engaged in their learning. The purpose of the approach is to bridge a gap between learning in school and everyday life (Walan & Rundgren, 2015). This helps students understand how to think critically and find solutions through their posed questions. Much of the literature found on inquiry-based learning is tailored toward mathematics and science learning. Although effective, design students require a different form of teaching that can help them apply information to design projects rather than equations.

Project-based learning is a comprehensive teaching perspective focused on engaging students in investigation and problem solving (Blumenfeld et al., 1991). It is a model that bases learning around projects and guides students to ask questions and solve problems (Thomas, 2000).

John Dewey, a philosopher and educator, began work on project-based learning over one hundred years ago at his Laboratory School at the University of Chicago. It was there, Dewey argued “that students will develop personal investment in the material if they engage in real, meaningful tasks and problems that emulate what experts do in real-world situations” (Sawyer & Cambridge University Press, 2014, p. 318) Project-based learning “allows students to learn by doing and applying ideas. Students engage in real-world activities that are similar to the activities that adult professionals engage in” (Sawyer & Cambridge University Press, 2014, p. 317).
Project-based learning has very specific key features that relate to many subjects. It can apply to history, geography and landscape architecture. The first feature is to ask a driving question that guides the student’s project. This could be the design problem statement landscape architects are given when starting a new design solution. The second feature is to inquire about the question, taking the appropriate amount of time to discover all its aspects. This is the design process, starting with analysis, concept diagrams, schematic design, and construction documents. The third feature is to collaborate within small groups and classroom discussions. Most projects given to landscape architects are group collaborations between other classmates or disciplines such as contractors, civil engineers, municipalities, campus planners, etc.

The fourth feature is to utilize technological tools, such as computer software, to support the students learning. Software used by landscape architects consists of AutoCAD, Adobe Suite, Trimble Sketch-Up, ArcGIS, etc. The final feature that supports project-based learning is the creation of artifacts. A landscape architect’s artifacts are the poster boards and/or construction documents developed, or it can be the actual designed site built by a contractor. “Learning sciences research shows that students learn more effectively when they develop artifacts - external representations of their constructed knowledge” (Sawyer & Cambridge University Press, 2014, p. 327).

A study completed by Antephol and Herzig (1999) revealed students preferred project-based learning over lecture-based learning. However, a combination of the two can also be beneficial to learners (Antepohl & Herzig, 1999) because they can learn the information and use a project to apply what they learned.
Permaculture History and Philosophy

It is impossible to know exactly where and when plant cultivation was first invented, however, due to accelerated mass spectrometry testing of plant remains, scientists have been able to date domesticated squash, maize cobs, and common beans back 10,000 years (Waldman & Braun, 2009). Agricultural knowledge developed over centuries shows the co-existence and co-development of culture and nature.

Biological efficiency along with contribution to familial diet can be found in the corn/bean/squash system (“three-sisters” system) of Mexico and South America (Francis et al., 2003). Indigenous communities would intercrop maize plants with bean and squash for multiple reasons. Maize, a staple food item, was grown as a necessity due to its value, hardiness, and usefulness in multiple settings. The leguminous bean plant would serve as a natural fertilizer from year to year by fixing nitrogen in the soil for the subsequent year. Within a few weeks of planting, squash leaves would provide a dense canopy, covering the ground and inhibiting weed growth. Furthermore, the maize/bean/squash system helped minimize soil erosion, while making efficient use of sunlight, water, and soil nutrients due to the various root operating systems and leaf shapes of each plant (González, 2010).

Another effective system that combines culture and nature is the chinampa system practiced by the Aztecs of Central Mexico beginning in the 15th century. Swamps were reclaimed by digging channels and using the excavated soil to construct embanked fields, called chinampas. The banks were anchored by planted trees on the corners and were separated by water channels wide enough for a canoe to pass. The trees, crops, and water
channels created a sheltered space which itself raised the temperature and significantly increased productivity (Arco & Abrams, 2006).

The advancement in technology during the 1800’s brought about a shift in agricultural practices. Through research, scientists discovered the essential elements plants needed to grow and produce. Driven by the need to increase production and efficiency, agriculture turned toward the use of chemicals to provide such nutrients straight to the soil surface (Francis et al., 2003). In reaction to the overwhelming use of chemical practices, farming movements began promoting the concept of management of a farm as a living unit or whole system (Barker, 2011). These movements were very successful in terms of producing food and eliminating the menial work of farming at the time. Beginning in the 1920’s two movements began. In the United Kingdom, Sir Albert Howard began laying the social and practical groundwork for the organic gardening movement. Around the same time in Germany, Demeter Association produced the first official organic label in 1928. Beginning in the 1940’s many organizations, such as the Rodale Institute of the United States, the Soil Association of the United Kingdom, and Soil and Health of New Zealand, began forming with focus on the study and promotion of organic farming (Barker, 2011).

In the 1930’s, a different branch of organic farming started to emerge. The term agroecology, or the ecology of food systems, was coined when people in agronomy and ecology found similar interests. Scientists in ecology were working on climatic conditions and researching which crops grew best in those conditions (Francis et al., 2003). Soil scientists, entomologists, and biologist’s began working together to discover new technologies in the field of agriculture. From 1930 to the 1950’s, agroecology was
very research and technology based. Beginning in the 1960’s, agroecology began incorporating the element of design.

Beginning in 1972, Bill Mollison and David Holmgren of Australia, began developing a conceptual framework they coined as *permaculture*, or permanent agriculture. It wasn’t until 1981 that the permaculture concept matured sufficiently to be taught as an applied design system. The first course, a 140-hour lecture series, was taught to 26 students (Mollison, 1990). Since that time, permaculture has spread as an international movement and ecological design system (Ferguson & Lovell, 2014). Today there are thousands of people who have attended permaculture lectures, design courses, workshops, and seminars. Graduates of such programs form an active global network that is expanding with piqued interest (Ferguson & Lovell, 2014).

Permaculture has many definitions. For the purpose of this study it will be defined as “a creative design process based on whole-systems thinking that applies ethics and design principles” (Mollison, 1990). The philosophy behind permaculture is one of working with, rather than against nature. Permaculture as defined by David Holmgren (2002) is guided by three broad ethics and twelve design principles.

Within the permaculture movement and literature, three ethics have been adopted that encompass all action, thought, and design. These three ethics share the foundations for permaculture design and have gone unquestioned within the international movement of like-minded people (Holmgren, 2002). The ethics of permaculture, defined by Bill Mollison and David Holmgren are (1) care for the earth, (2) care for people, and (3) fair shares.
The first permaculture ethic is *Care for the Earth*. This can be taken to mean, the literal caring for the earth’s soil. The soil is key to plant growth, both productive and aesthetic. Major nutrients within the soil are what feed plants, which then in turn begins the long journey up the food chain.

Care of earth can also mean the notion of caring for all diverse forms of life, both plant and animal. Healthy respect for the earth’s natural beauty and all her forms of life is fundamental to the success of human existence (Handley, Ball, & Peck, 2006).

Historically as plant cultivation began to spread, communities began to grow around a central location. As communities grew into cities, they placed great pressure on the environment and resources around them, expanding further and further out from the city in order to support human growth within (McDonough, 2002). Resources were being taken at a rate faster than the natural environment could restore those resources. There is a fine line to keep the earth’s ecosystems and resources in balance. It is through taking care of the earth that balance can be restored.

The second permaculture ethic is *Care for People*. This ethic makes permaculture a very human-centered design philosophy. Everything designed with permaculture principles in mind should be done with the overall desire to first, care for the earth, then as efforts are made, caring for people will naturally occur. Positive change will enlighten and help those within communities and countries. “The permaculture approach is to focus on the positives, the opportunities that exist in the most desperate situation” (Holmgren, 2002).

The third and final permaculture ethic is *Fair Shares*. As history has shown us, life cycles continue and everything in nature, including ourselves, has a limited timeline
(Holmgren, 2002). But with each new decade, consumption increases with a skewed view of physical limits. One such example, is the use of water in the arid west. Drought with less winter snow fall has put the western United States into a predicament. Water is scarce for agricultural crops, however, communities still insist on having this precious resource at their fingertips. “The real cost of water has become obscured while an attitude of entitlement has grown in our society. It seems our inalienable right to turn on the faucet and have clean, pure water flow out” (Handley et al., 2006). Permaculture ethics are striving to teach about setting limits, knowing when enough is enough, and making sacrifices for future generations.

When considering fair shares, at first thought this could mean, distribution of extra money, food, or clothing; but it’s more than just material goods. There are several ways to redistribute surplus. They include restoring vegetative systems by planting trees, improving soil health and increasing humus content, growing your own food, or supporting local agriculture. Sharing knowledge and information is one of the best ways to share fairly. As the old adage states, “Give a man a fish and you feed him for a day; teach a man to fish and you feed him for a lifetime” (Maimonides & Frank, 1995).

In 1974, the preliminary principles of permaculture design were established by Bill Mollison and David Holmgren. Bill Mollison suggests that “principles can be adapted to any climatic and cultural condition, while… practical techniques… change from one climate and culture to another” (2004, p. 5). Thirty years later in 2002, Holmgren published his book *Permaculture: Principles and Pathways beyond Sustainability* further narrowing the list into 12 distinctly defined principles. The
Permaculture principles are short statements or slogans that can be used as a checklist when designing. They include:

1. Observe and Interact
2. Catch and Store Energy
3. Obtain a Yield
4. Apply Self-Regulation and Accept Feedback
5. Use and Value Renewable Resources and Services
6. Produce No Waste
7. Design from Patterns to Details
8. Integrate Rather than Segregate
9. Use Small and Slow Solutions
10. Use and Value Diversity
11. Use Edges and Value the Marginal
12. Creatively Use and Respond to Change

Principles are seen as universal, but practices, will vary greatly from place and situation. (Holmgren, 2002). What may be suggested as a best practice in the southeastern United States may not be successful in the southwestern United States due to limited resources such as water and shorter growing seasons.

Permaculture in Practice

Permaculture, though gaining ground, is still a fairly new concept just starting to spread throughout the world. It has found popularity among landowners who are trying to live more self-sufficiently, but it lacks in scientific research (see Challenges of Permaculture section). A recent Google Scholar search of “permaculture” +”case study”
revealed 3,350 results. One case study within the results completed by Jillian Du (2012) revealed similarities between biomimicry principles and permaculture methodology in the study of the Bellbunya Eco-center and Sustainable Community located in Sunshine Coast Hinterland region of Australia. They found small-scale fabrication of biomimetic and permaculture techniques were related to nutrient cycling, biodiversity, and systems resilience. The study concluded that biomimicry and permaculture design demonstrate potential to redevelop agricultural systems.

Another study of permaculture in Konso Woreda, Ethiopia (Gashute, 2012) found improvements of environment condition, productivity, and income. The researcher also found that permaculture technique brought new knowledge which fostered indigenous knowledge of the study area. The final conclusion of the study determined that permaculture has the potential to bring improvement of the natural capital which could ultimately lead to improved productivity within the study area of Konso Woreda.

Local Examples of Permaculture

Looking specifically within the State of Utah, the majority of permaculture farms remain in demonstration gardens and suburban settings. Publicized permaculture farms and learning gardens within the State of Utah are as follows:

1. Cedar Springs Permaculture Farm located in Holden, Utah is a retreat and learning center focused on hands-on learning and play while using permaculture principles.

2. Eagle Crag Permaculture Farm located in Rockville, Utah is a homestead built on the banks of the Virgin River. It is home to a large food forest, water channels, water wheel, and animal system.
3. Wasatch Community Gardens is a non-profit group located in Salt Lake City, Utah. Their mission is to empower people of all ages and incomes to grow and eat healthy, organic, local food. They currently have 29 community gardens along the Wasatch Front that offer space and resources for community members to grow their own food.

4. True Nature Permaculture Farm currently located in Boulder, Utah will be relocating to collaborate with Northern California’s Heartwood Institute. There they will teach permaculture programs and build a 200-acre research demonstration farm.

5. USU Permaculture Initiative begun by Roslynn Brain, Extension Sustainability. Beginning gardens are located in Moab and Logan, Utah. Though small, the hope is the permaculture initiative will become a collaborative garden to teach and involve students across colleges and departments at USU.

**Permaculture and Landscape Architecture**

The theory of permaculture is closely related to the practice of landscape architecture. A review article completed by Rafter Ferguson and Sarah Lovell (2014) contains a network graph that illustrates key words found in permaculture references from 1978 to 2013. It contains 1,330 edges, with each edge representing the co-occurrence of one word pair. The size of node or colored dot represents how many times a particular key word was found in the evaluated literature. Figure 1 shows the full 100-node network for each time interval and the complete set, illustrating the changing centrality and contextual significance of key terms over time.
As illustrated, the network map changed over the years. However, conceptual clusters organized around terms always listed *design* as the one of the core terms. The importance of design in permaculture literature is evident and has been since the beginning when Bill Mollison and David Holmgren first coined the term. Landscape architects use the design process every day and they the potential exists to involve PDP’s into their process.

Designing or design is a learned process that is complex, personal, and creative. Although the products of designs can be very different, designers go through a similar series of steps called the ‘design process.’ There are different levels of expertise and knowledge when it comes to the design process. For those who are more familiar with and experienced in this process, it isn’t divided into different steps and actions, but it is an undivided whole with often unconscious steps, “actions based on common practice or routine, and moments of reflection and exploration” (Dooren, Boshuizen, Merriënboer, Asselbergs, & Dorst, 2014, p. 54). The design process is a multi-disciplinary problem-solving operation that often includes architects, engineers, and landscape architects (Bemanian & Shahidi, 2011).
Figure 1. Concept network maps of keywords from permaculture publications. Note: node size denotes centrality of concepts, links represent concept co-occurrence, link width represents co-occurrence frequency, and color denotes conceptual cluster of tightly interlinked concepts. a Publications 1978-1992 (N=51). b Publications 1993-2002 (N=115).
Figure 1. c Publications 2003-2013 (N=157). d Entire series 1978-2013 (N=230).
Landscape architects have a unique mission in the present and future. “Every time humans interact with the land – whether to solve a problem, to move between places, or to build – there is an opportunity for landscape architects to become involved and assist in producing a positive outcome” (Foster, 2009). Foster also emphasizes the importance of stewardship of the environment and understanding of natural resources to become a successful landscape architect.

PDP’s implemented into the design process could help remind landscape architects of natural processes as well as aesthetic quality. Because permaculture is still growing, teaching this theory to landscape architects could help them stay current on design trends in order to better serve many varied clients throughout their career.

Permaculture principles are centered on function of space, infrastructure, and plant relations. Landscape architects are taught and trained to design spaces with an aesthetic quality. In teaching landscape architecture students the function of a site and its natural system, permaculture gardens can become beautiful and functional spaces. "If a space is well designed to function seamlessly for its intended use, it will be used; if it is used, it will be loved; and if it is loved, it will become beautiful" (Beck, 2013, p. 51).

**Challenges of Permaculture**

Permaculture is a social and international movement that has caught the attention of many people with varying backgrounds. Workshops, courses, and lectures are taught all around the globe to those who desire a more sustainable living. Creating self-maintaining and regulating systems is the Holy Grail of permaculture design, something that designers strive for, but might never fully achieve (Holmgren, 2002). Entropy or lack
of order within a natural system also makes designing a self-maintaining system unlikely. With this in mind, there are five major limiting factors to permaculture.

The first challenge is permaculture’s isolation from scientific research (Ferguson & Lovell, 2014). This isolation means that permaculture is not considered a science, but strictly a theory and a design process. The second challenge is the limitation caused by oversimplified claims (Ferguson & Lovell, 2014). As stated above, the principles are easy to understand and lead designers to believe the practices will be easy to achieve. Though permaculture claims it uses sustainable practices this may never be fully achieved. Sustainability can only be proven in the future when those who claim it aren’t around to defend or receive criticism. Although nature untouched by humans is considered sustainable, it is not the manmade system that permaculture is. Permaculture guides designers to mimic patterns found in nature. Mimicking is when “a person copies the behavior or speech of other people: a person who mimics other people; also: an animal that natural looks like something else (“Merriam-Webster Dictionary and Thesaurus,” n.d.). In this case, permaculture designers are striving to mimic and make a landscape look like those found in nature. To copy nature would be very unlikely for designers since natural systems are ever changing and are never in a statis.

The third challenge is permacultures lack of a clear definition which leads to confusion and hindrance of rigorous scientific discussion (Ferguson & Lovell, 2014). Without a clear definition, scientists find themselves discussing what permaculture is, rather than what aspects of permaculture can be researched and studied further. Several definitions were taken from common permaculture literature in order to illustrate the lack
of a concise definition. Definitions of the term *permaculture* among common literature are as follows:

- “Permaculture is permanent agriculture” (Mollison, 1990).
- “A creative design process based on whole-systems thinking that uses ethics and design principles” (Mollison, 1990).
- “A philosophy of working with, rather than against nature; of protracted and thoughtful observation rather than protracted and thoughtless labor; of looking at plants and animals in all their functions, rather than treating elements as a single-product system” (Mollison, 2004).
- “Consciously designed landscapes which mimic the patterns and relationships found in nature, while yielding an abundance of food, fiber, and energy for provision of local needs” (Holmgren, 2002).
- “The creation of ecological human settlements, particularly the development of a continual agricultural system that imitates the structure and interrelationships of natural ecosystems” (Barker, 2011).
- “An approach to designing spaces to make those who use them more resilient, self-reliant, and sustainable” (Bowness, 2014).
The fourth challenge facing permaculture is the consideration of many people that permaculture gardens are “messy”. Nassauer (2002) discusses in her paper, *Messy Ecosystems, Orderly Frames* how the general public perceives ecological landscapes. She mentions, “Ecological quality tends to look messy, and this poses a problem for those who imagine and construct new landscapes to enhance ecological quality. What is good may not *look* good and what looks good may not be good” (Nassauer, 2002). Generally, picturesque landscapes contain function and attributes from European garden design. These attributes are described using the terms such as cared for, clean, neat, maintained, mown, no weeds, row plantings, and well kept. These terms rarely describe the typical permaculture landscape that appears “messy”, but has great ecological quality (figure 2).

*Figure 2.* Typical “messy” permaculture garden in Essex County, England (Chris, 2012).

Convincing the general public, that finds clean and neat landscapes attractive, to use permaculture principles can become tricky because of preconceived notions of what a landscape should look like. People see landscapes through their preferred, cultural lenses. In order to promote and design landscapes with ecological quality, such as permaculture
gardens, designers need to start translating ecological patterns into cultural language that people will recognize as maintained, well cared for, and attractive. Nassauer (2002) has identified cues in which landscapes look well cared for.

The first cue is mowing, even if it is just a small strip of plant material. One example given is mowing around pathways, leaving the rest of the landscape to function naturally to ensure ecological quality. The small strip of mowing becomes the cue for people to recognize that the landscape is well cared for. The second cue is using flowering plants and trees. Utilizing lots of color in the landscape is an ornamental practice that many people find attractive. The third cue is placing wildlife feeders and houses within a landscapes. Many ecological landscapes promote wildlife habitat, however, placing feeders and houses makes the intention recognizable to the public and they will then expect to see wildlife, instead of viewing them as a nuisance.

The fourth cue for making a landscape appear well cared for is using bold patterns. Clearly visible patterns are easy to identify and indicate human intention. The fifth cue is to design plants in rows, lines, and trim shrubs. Very similar to the first cue of mowing, trimming and formal plantings require a lot of maintenance and isn’t necessarily “ecological”. However, placing more formal garden designs closer to where human traffic is, such as along a walking path, helps the viewer to recognize the pattern. The sixth cue is to implement architectural details, fences, lawn ornaments, and paintings. These are all considered structural cues that signify human intervention within a landscape. The final cue for making the landscape appear well cared for is the addition of foundation plantings. Within Nassauer’s (2002) studies, she found that foundation plantings are a cultural expectation within the suburban home landscape. Designing an
ecological landscape that utilizes cultural cues places the landscape within an organized frame that is associated with care, maintenance, and looks attractive.

The fifth and final challenge of permaculture gardens is planning how to maintain them, especially in an urban setting where water run-off could be harmful to local water bodies and its quality. Nitrogen and phosphorus compounds from agricultural run-off are important factors in the cause of eutrophication (Lu et al., 2009) - excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, can cause a dense growth of plant life and death of aquatic animal life from lack of oxygen (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

Especially in urban settings, gardens are watered on a regular basis without any plan or system to catch run-off water. Food producing gardens are rich in nitrogen and phosphorus in order to be most productive. Although in many instances law requires that storm water to be retained on site, there is always the chance of some water running into water bodies or leaching into groundwater. In areas where food producing gardens are close to streets, the chance of nutrient run-off increases. All excess nutrients travel through water runoff and into storm water catchment systems, and then to water bodies. Landscape architects have the opportunity to design waste and storm water systems that prevent run-off into creeks and streams. In order to ensure good water quality, gardens and landscapes should strive to include aesthetically pleasing catchment systems to ensure water and excess nutrients stay on site. This can be done through constructed wetlands, storage tanks to recycle the water, or large planted buffers that include heavy nitrogen feeders.
CHAPTER III
METHODOLOGY

There are three main objectives to this study. The first was to develop and prepare a permaculture instructional module. The second was to implement and teach the module to students at USU. The third was to measure the effectiveness of the instructional module by providing a post-module evaluation survey. In the remainder of this study, each objective will be discussed and clarified in its own section. Chapter 4 and 5 of this study contain the products and results of each objective.

Objective 1: Development

The first step was to research permaculture theory and understand the background, teachings, principles, and information about permaculture. This was initiated by attending a permaculture workshop in September 2013 to learn the foundations of permaculture theory as taught by Joel Glanzberg (2013). Following the workshop, development of the first permaculture garden on the Logan campus of USU began. Further information was gathered for this study through research, designing, and hands on practice at the USU garden.

Research on teaching methods and different kinds of learning was then conducted. From the research, a combination of lecture-based and project-based learning was chosen for objective 1. Lecture-based learning was chosen in order to inform the students about permaculture theory. The majority of students within the classes had not heard of permaculture before, so the lectures allowed for students to learn all of the different concepts. Lecture slides were provided to the students so they could return and receive further clarification on certain topics (Appendix A and B).
Project-based learning was also chosen for the study in order to give students an opportunity to apply their new knowledge of permaculture to an actual site. As design students, the majority of their work is completed through projects. This allows for students to gain real-world experience during school before they enter the professional world of landscape architecture.

After gathering the needed material and information, a series of power point presentations were created in order to present the information in lecture form. For the 2014 instructional module, information on how to make an effective power point presentation was primarily gleaned from Garr Reynolds book entitled, *Presentation Zen: Simple Ideas on Presentation Design and Delivery* (2012). Utah State University School of Graduate Studies offers a training series in which they give different presentations on thesis document preparation, succeeding in research fields, etc. After attending a presentation delivered by Ann McEntire (2015) titled, *How to Create Gorgeous Slides*, the 2015 instructional module was edited to incorporate the ideas and slide styles learned during the presentation.

The 2014 instructional module contained four lectures organized by topic and implementation strategies. Permaculture principles were introduced during the first lecture and reiterated throughout the remaining lectures when practices and implementation strategies were taught. Table 1 illustrates the four lectures and which topics were taught during each.

The 2015 instructional module consisted of six lectures containing specific sections on each permaculture principle. The amount of lectures compared to 2014 was increased from four to six in order to accommodate a new teaching structure. David
Holmgren’s 12 permaculture principles can be hard to remember, so in order for students to remember and relate to each principle, they were organized into the steps of the design process (see figure 3). A summary of every principle was introduced during each lecture followed by practices and implementation strategies. Table 2 illustrates the six lectures and which principles were taught during each.
Design Process using Permaculture Design Principles

- **INVENTORY & ANALYSIS**
  - Observe & Interact
  - Apply Self-Regulation & Accept Feedback
  - Use & Value Renewable Resources & Services

- **DETERMINE YOUR NEEDS**
  - Catch & Store Energy
  - Obtain a Yield
  - Produce No Waste

- **FUNCTIONAL DIAGRAMS**
  - Design from Patterns to Details
  - Integrate Rather than Segregate

- **CONCEPT DESIGNS**
  - Use Small & Slow Solutions
  - Use Value Diversity

- **FINAL DESIGN**
  - Creatively Use & Respond to Change
Table 1
2014 Instructional Module Lecture Organization

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Lecture 1: Ethics and Principles</th>
<th>Lecture 2: Analysis and Patterns</th>
<th>Lecture 3: Home Garden</th>
<th>Lecture 4: Community Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>What’s Happening Now?</td>
<td>Site Analysis through the Permaculture Lens</td>
<td>Structural Modifications</td>
<td>Growing Food in the City</td>
<td></td>
</tr>
<tr>
<td>History</td>
<td>Pattern Understanding</td>
<td>Garden Layout</td>
<td>Planned Suburban Areas</td>
<td></td>
</tr>
<tr>
<td>Introduction to Permaculture (Principles &amp; Ethics)</td>
<td>Region Specific Garden Design</td>
<td>Community Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Forests, Animal Systems, and Application</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2
2015 Instructional Module Lecture Organization

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>What’s Happening Now?</td>
<td>Catch and Store Energy</td>
<td>Observe and Interact</td>
<td>Design from Patterns to Details</td>
<td>Use Small and Slow Solutions</td>
<td>Creatively Use and Respond to Change</td>
<td></td>
</tr>
<tr>
<td>History</td>
<td>Obtain a Yield</td>
<td>Apply Self-Regulation and Accept Feedback</td>
<td>Integrate Rather than Segregate</td>
<td>Use and Value Diversity</td>
<td>Community Strategies</td>
<td></td>
</tr>
<tr>
<td>Thinking and Design Revolution</td>
<td>Produce No Waste</td>
<td>Use and Value Renewable Resources and Services</td>
<td>Use Edges and Value the Marginal</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Objective 2: Implement

The difference between 2014 and 2015 was the overall structure of lectures and studio time given during class. The first iteration separated the lecture and design problem into two discrete tasks. The 2014 module began on September 30\textsuperscript{th} and finished with the post-module survey on October 28\textsuperscript{th}. The structure of the module first presented the information through several class periods, followed by several more class periods of studio time to complete the design problem. This was effective in that it gave students longer chunks of time to work on the design problem, but posed a problem when students tried to recall what was taught in the beginning of the module. Such problems proved evident through their final design solution.

The 2015 module began on October 6\textsuperscript{th} and concluded with the post-module survey on November 3\textsuperscript{rd}. The information presented in the 2015 lectures remained the same as the 2014 lectures. However, a different teaching structure was applied to help alleviate the problems found in 2014. Each class period began with a short lecture followed by studio time to work on portions of the design problem that were applicable to that day’s lecture information. Once lectures were finished on October 22\textsuperscript{nd}, there was one concluding day before presentations (October 29\textsuperscript{th}) where students had the entire class period to work on the design solution. This structure of allowing studio time throughout the module proved more effective as the students were able to concentrate on a few permaculture design principles and apply them to their design process the same day instead of having to recall all twelve principles from several weeks earlier (see table 3).
To supplement the presentation slides, students were given a lecture outline to act as a place to take notes and write key thoughts (Appendices G and H). Students were not required to use the supplemental outline. Along with the lectures and afore mentioned outline, an in-class exercise was done to help students practice design and implementing permaculture principles. Given a basic base map, students were asked to create their own design using the learned permaculture principles at the site of the new USU Permaculture Garden (Appendix I).

As mentioned previously, a design problem was assigned to the students to complete for clients within the region. The design program was determined by the clients, while problem deliverables were assigned by the researcher and course professor (Appendix C). There was no variation in the design problem from 2014 to 2015; the same site, clients, program, and deliverables were required of the students in both years. Students in 2014 were given the design problem statement on October 7th and were given

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Lecture</td>
<td>Lecture</td>
</tr>
<tr>
<td>Week 2</td>
<td>Lecture</td>
<td>Lecture</td>
</tr>
<tr>
<td>Week 3</td>
<td>Studio Time</td>
<td>Lecture</td>
</tr>
<tr>
<td>Week 4</td>
<td>Studio Time</td>
<td>Lecture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Studio Time</td>
<td>Lecture</td>
</tr>
<tr>
<td>Week 2</td>
<td>Studio Time</td>
<td>Lecture</td>
</tr>
<tr>
<td>Week 3</td>
<td>Studio Time</td>
<td>Lecture</td>
</tr>
<tr>
<td>Week 4</td>
<td>Studio Time</td>
<td>Lecture</td>
</tr>
</tbody>
</table>
until October 23rd to finalize their design and present to the clients, totaling approximately 10.5 hours of class time dedicated to completing the design solution.

Students in 2015 were given the design problem statement on October 6th and were given until presentations on October 29th; totaling approximately 9.5 hours of class time dedicated to completing the design problem.

**Objective 3: Measure Effectiveness**

The third objective was to measure the effectiveness of the instructional module. After the design problem was assigned, students in both years were given the opportunity to form their own teams to complete their design solution. Each team consisted of four undergraduate students in the junior class. The graduate students in their second year formed their own team. In 2014, there was one team of five students because of enrollment numbers. Students worked in their respective teams to complete the design problem and present their final design solutions to the clients.

The format for student presentations was the same in both years. Each team was given 15 minutes to present their process and design, allowing two to three additional minutes for questions and comments from the clients, researcher, and professor. Design projects were graded and assessed using a grading rubric (Appendix J) by the researcher and course professor, looking for proficiency in applying permaculture principles to the final design along with the inclusion of design basics such as drawing scales, north arrow, title, course information, etc.

In addition, each project was evaluated to identify how many permaculture principles were present within the design receiving a score from 1 to 12. One point given for each principle present in the design. Projects received a point for a principle if a
conscious effort and annotation was present on the final board layout. For example, the highest scoring design solution from 2014 (Appendix K) shows a design that consciously implements the principle of *Integrate Rather than Segregate* by placing the chicken coop within the primary vegetable garden to benefit both systems. narration to explain design intent was also included to provide clarity. A project from 2015 (Appendix N) shows how the design *Obtains a Yield*, but lacks design and narration on how it *Catches and Stores Energy*. Therefore, this particular team received a point for the principle *Obtain a Yield*, but not for *Catch and Store Energy*.

For evaluation and reference, projects and associated teams were assigned a number based on the year the module was taken. In 2014, there were seven teams which were numbered from 1 to 7. In 2015, there were six teams; numbered from 8 to 13. In the following chapter, results and scores for each team are listed and discussed. In order to compare years, a composite score was identified. Total points from each team in 2014 were added together and divided by the total number of teams (7) to get a score rounded to the nearest tenth and out of 12 points total. The same was done in 2015, except with 6 teams instead of 7. The composite score (12 being the best) shows how effectively the entire class incorporated principles into their final design.

Post-module surveys (Appendix D) were given on the last day of the module for each year. Questions used to measure effectiveness of the lectures and student interest in permaculture included:

1. How would you define permaculture?
2. How can permaculture be practiced on the larger scale? i.e. community/region?
3. I would like to know more about permaculture for future projects and how I can apply the principles for future design.

   - Definitely agree
   - Agree
   - Neutral
   - Disagree
   - Definitely disagree

4. How will you use permaculture principles during the remainder of your time at USU?

   From these responses, student attitude and opinion of the instructional module was assessed through survey coding. Key words were found in each response to determine patterns of student understanding and percentages were calculated (see Appendix F). For example, one student responded “It is a design philosophy; designing in a way that allows all the parts to work together harmoniously; mimics natural systems”. The key terms of design, work together and systems were used in final percentage calculations.
CHAPTER IV

RESULTS

Objective 1: Development

For the purpose of this study, David Holmgren’s 12 principles were organized into a design process for landscape architects, specifically juniors at USU (see figure 3). Because this study is focused on the creation of an instructional module, the lecture information is the result of the project. The remainder of this section outlines all of the literature and information taught in the permaculture instructional modules, organized by the 2015 lectures using the design process.

Introduction

What’s Happening Now?

World temperatures have risen 1.5° Fahrenheit in the last century; 65 percent of that has happened in the last 40 years. In land locked regions such as the intermountain west, temperatures are rising at 1.8 times the global rate. Primary causes for warming include deforestation and the release of greenhouse gases, specifically CO₂ into the atmosphere. This means for arid regions such as Utah, it’s likely there will be less snow, but more precipitation in the form of rain fall, and more evaporation which causes dryer soils (personal communication with Robert Davies, January 28, 2015). Each consequence comes with its own repercussion’s. Salt Lake City Utah receives 90-95 percent of its annual water from snow pack. Dryer soils causes erosion, and with added rain fall, landslides become a possibility.

McDonough (2002) discusses how the environment and industry are at odds with one another: extraction, manufacture, and disposal tend to be harmful to the natural
world. Environmentalists may view industry as bad due to its foreseeable destructions, while industrialists could often view the environment as an obstacle to production and growth. McDonough discusses different industries and making things in order to reduce pollution and waste; he takes nature as a model for making things and teaches that waste equals food.

Walker and Salt (2006) further discuss how increased population has changed the natural world and what will need to increase in order to meet the demand of population. Between the years 1960 and 2000, our world population doubled. At the same time, food production increased by 2.5 times, while water use doubled. Wood harvests for pulp and paper product tripled, and timber production increased by more than half.

**History and Background of Permaculture**

Agriculture dates back more than 10,000 years ago (Waldman & Braun, 2009). Natives of Mexico and South America used the corn/bean/squash (or “three-sisters” system) cropping system (Francis et al., 2003). Having all three gave them different kinds of food throughout the year. Maize was a staple food used for all sorts of things; within the system, the stalk acted as the support for the bean plants. Beans being legumes, provided valuable protein and acted as nitrogen fixers within the soil, providing needed nutrients to the plants surrounding it. The squash plants provided a dense canopy with their leaves covering the ground and inhibited weed growth and other competition to the system (González, 2010).

Another productive system was used by the Aztecs starting in 15th century. They reclaimed swamp lands by digging channels and using the excavated soil to construct banks called chinampas for crops. The banks were separated by channels large enough
for a canoe to pass through while planted trees on the corners anchored the banks in place. The trees, crops, and water channels created a sheltered space which itself raised the temperature and significantly increased productivity (Arco & Abrams, 2006).

A more recent timeline shows where permaculture theory originates. Beginning in the early 1800’s, the advancement of technology brought chemical use into agriculture for increased productivity through pesticides and additional nutrients and fertilizers (Francis et al., 2003). Beginning in 1920, in reaction to the overwhelming use of chemicals; Sir Albert Howard in the United Kingdom began the organic gardening movement which quickly flourished around the globe (Barker, 2011). A few years later, in 1930, agroecology, or ecology of food systems started to emerge through the combination of agronomists and ecologists. At the time, it was research based aimed at discovering new technologies in the field of agriculture. It wasn’t until 1960 that agroecology began implementing design thinking into research (Francis et al., 2003).

Around this same time, Bill Mollison and David Holmgren of Australia began organizing a creative design process which they called *permaculture*. “Despite a high public profile, permaculture has remained relatively isolated from scientific research” (Ferguson & Lovell, 2014, p. 251). Many ideas and practices come from tested results, as shown in the “three-sisters” system and chinampas, however, permaculture as a whole is solely a theory and design process that uses ethics and design principles (Mollison, 1990). It’s a philosophy of working with, rather than against nature; of protracted and thoughtful observation rather than protracted and thoughtless labor; of looking at plants and animals in all their functions, rather than treating elements as a single-product system (Mollison, 2004).
Ethics are moral principles that govern or guide a person’s behavior. The three permaculture ethics encompass the user’s action, thought, and design. The first ethic is *Care of Earth*. This means to care for the earth’s soil, for without healthy soil, there is no life. It’s a conscious decision to care for the earth’s natural resources and all forms of life (both plant and animal). The second ethic is *Care of People*. This ethic makes a very human-centered philosophy of caring for neighbors, community, and country. The third permaculture ethic is to *Fair Shares*. This ethic focuses on the positive aspect of sharing. This can be sharing excess materials, such as food, clothing or money, but it can also mean teaching people excess knowledge, planting trees within communities, improving soil health through conscious efforts and supporting local agriculture (Holmgren, 2002).

**The Thinking and Design Revolution**

The information era has come and with it comes the thinking revolution. A large part of the thinking revolution comes from the emergence of design as a universal skill along with literacy. Design is fundamental to humanity (Holmgren, 2002). The 9 design thinking guidelines, as introduced by Holmgren, provide reminders which can help designers from falling back into conventional thinking. They are as follows:

1. **All observations are relative:** Observations both direct and indirect influence reality as the observer sees it. Ethics are the filters that determine what is seen and how. The rush to judgment frequently clouds observations of what is right and wrong. Consider pests, plants, and animals; how can they be incorporated into a system so they are no longer a hindrance or chore?

2. **Top-down thinking, bottom-up action:** When studying a site, it’s important to take a step back and look at the entire physical context of where the site rests. The
natural environment has no regard for property boundaries. Top-down thinking is when a designer looks at the larger picture and takes into account what is entering the site (i.e. wind, water, sun) and what is leaving the site. Bottom-up action focuses on the leverage points that are available for small-scale elements or individuals to influence large-scale systems. It also looks at what actions made on-site will influence the larger scale.

3. **The landscape is a textbook**: Observation from the five senses is key. The sense of sight, although extremely important, isn’t the only sense that should be used. Oftentimes something about a site can only be observed through smell or sound. What designers observe in nature can be the answer to tough design problems.

4. **Learn from your mistakes**: Designers should make smart decisions, and if a design fails, lessons should be learned to make the next design better. It’s also very important that designers not repeat their mistakes.

5. **Elegant solutions are simple sometimes even invisible**: Enormous complexity often indicates poor design. A really effective design solution may be remarkably simple. Frequently, users don’t notice good design, they notice how the design makes them feel. But when the user views a bad design, it is noticed.

6. **Make the smallest intervention necessary**: In attempting to adjust systems to fix problems, designers need to be careful to not damage or disrupt other processes that are working perfectly. Good design is often unnoticed, so large-scale interventions are likely to do more harm than good to the natural systems on site.
7. **Avoid too much of a good thing:** When designers experience a positive result from an action, there is almost always a powerful temptation to repeat the action, working on the often misguided idea that if some is good, more is better.

8. **The problem is the solution:** Designers have a unique opportunity to make things which are viewed as problems and turn it into a solution to a design problem. For example, a cold north wind can be viewed as a problem, but if the home, and surrounding vegetation are placed strategically, the wind can be used to cool the house in the summer time. The best solutions are often found in places and cultures where the problem is extreme; for example, Southern Italy has wonderful and aesthetically pleasing solutions to steep slopes, while Australia, due to lack of annual rain water, has found many ways to catch and store rain when it does fall.

9. **Recognize and break out of design cul-de-sacs:** A design cul-de-sac is the norm, or what everyone else is doing or has already done. Designers should recognize these patterns and come up with creative solutions to a design problem.

**Determine Your Needs**

As a designer, determining the client’s needs is part of the process where the most client interactions take place. The designer meets with the client, gets to know them and what is desired for the project. General or specific requirements could be expressed and many design ideas are discussed.

**Catch and Store Energy**

True to its slogan, catching and storing energy is an important step in creating a regenerative landscape. Designers should seek to “prevent energy from leaving any system before the basic needs of the whole system are satisfied” (“Permaculture design
fundamentals: Introduction to regenerative sustainability,” n.d., p. 23). The first step in the process of catching and storing energy is to identify available on-site resources as well as any entering the system. There is a difference between energy sources and energy storages, though the distinctions can be vague. What may be a source for one element or organism could be a storage for another.

Important energy sources include, solar, wind, bio-mass, and water. Each energy source can be captured through various methods and stored to improve the resiliency of the system. Energy storages found in landscapes include, water, living soil, trees, and seed. Through proper management of these storages, designers can help restore ‘natural capital’ back into landscapes (Holmgren, 2002).

In order to imitate nature, a designer should first be aware of how nature catches and stores energy. For example, solar energy is used by plants to turn water and carbon dioxide into carbohydrates by the photosynthesis process. These carbohydrates are the “start of the chemical energy supply chain that provides for the needs of all other living things” (Holmgren, 2002, p. 31). Solar energy also drives the climate systems that provide energy in the form of rain, wind, and fire. Other examples of energy sources include using wind energy for power and pumping, biomass for fuel and construction, and water run-off for irrigation, production, and power generation.

The first energy storage is water. It can be found in vegetation, soil, springs, creeks, rivers, lakes, ponds, pools, gravel and sand streambeds, swamps, and wetlands. Because water is such an important entity, the traditional practice of collecting water and sending it off-site needs to be changed. Designers should find new and creative ways of utilizing its available energy and resource by keeping it on site.
The second energy storage is living soil. Soil ecosystems have evolved to catch and store nutrients which are sources of energy for plants and animals. Soil has the ability to catch and store nutrients from adjacent systems and becomes the most important storage for nutrients in arid climates, like Utah. Designers should implement ways to build soil humus because it is more effective at storing nutrients, water, and carbon for plants.

The third energy storage are trees. According to Holmgren (2002), trees are long-lived perennial plants that efficiently absorb water and nutrients that might otherwise be lost to annual plants. Trees provide a food source for humans and animals alike. The woody biomass is important in reclaiming degraded land and providing fiber and fuel. Timber forests in particular are very important as they provide biomass at rates similar to grasslands, but wood in trees provides long-term storage which can be stable for years (Holmgren, 2002). Trees also act as a long-term storage of carbon dioxide, minimizing the effects of climate change (personal communication with Robert Davies, January 28, 2015).

The fourth energy storage are seeds. Once a favorable variety of plant has been found, maintenance of a seed line by regularly growing and saving seed is a very important example of catching and storing energy. The potential value of a seed is very high, as it can produce year after year. A diverse permaculture garden can become a landscape storage of genetic information (Mollison, 1990).

Another aspect of catching and storing energy is through recycling. Designers should seek to stop the flow of energy off the site and instead direct it into cycles (Mollison, 2004). For example, instead of sending kitchen scraps and/or garden debris to
the landfill, put them into compost bins or add them straight to the soil to increase organic matter. Household gray water can also be saved to water containers and pots.

**Obtain a Yield**

Landscapes should be designed as a system to provide self-reliance at all levels (plants, animals, and humans alike) by using captured and stored energy effectively to maintain the system and capture more energy. Designers should find new ways to obtain a yield by making low energy intensive systems with high production (“Permaculture design fundamentals: Introduction to regenerative sustainability,” n.d.). Hardy, self-reliant species are very important in a low-energy, sustainable system. By selecting locally-adapted, self-producing plants where possible, the designer can minimize the need for additional inputs. The first priority in creating a healthy farm landscape, rangeland, or forest is to use vigorous and self-producing plants which can seed on their own and are adapted to the local climate (Holmgren, 2002).

Since food crops are much more demanding of fertility and nutrients than trees and grasses, designers should concentrate energy of soil-improving activities to those small areas of most concentrated fertility need, allowing less demanding areas, or those already adapted to the local soil to grow (Hemenway, 2001).

Society’s expectations or traditional landscaping is often just a cover of disharmony and unsustainable practices (Holmgren, 2002). Permaculture designers can still give priority to fundamental and resource-hungry needs such as food, clean water, and shelter, while providing complex but passive environmental services and social functions as by-products of an integrated design (Mollison, 2004). By-products include things such as wildlife habitat and recreation opportunities.
Along with self-reliance, there are other physical, emotional, and psychological benefits of gardening and growing food. Young children exposed to gardening are more likely to grow up with a deep and intuitive understanding of their dependence on nature. They are also more likely to make connections and understand where food comes from and grow food as an adult (Lundgren, 2004). Those growing food should realize that most natural systems go through phases of growth and accumulation, leading to abundance. Designers and users need to learn to match harvesting activities to these phases of abundance in order to make a low-energy landscape. Using a diversity of crops and extending yields over time, and producing maximum yields with minimum amount of energy equals a more productive and sustainable system (Holmgren, 2002) (figure 4).

\[
\text{Diversity of Crops + Extended Yields + Maximum Yield Production} \quad \frac{\text{Minimum Amount of Energy}}{} = \text{more Productive and Sustainable System}
\]

*Figure 4. Formula for productive and sustainable systems*

Over time, permaculture designers have developed practices that can be implemented into general landscapes to help users obtain a higher yield. For small scale intensive systems, plant stacking is encouraged when space is limited and high yield is desired. Plant stacking is when several different varieties of plants occupy the same area and use each other’s characteristics to grow (Mollison, 2004). The “three-sisters” system first used by indigenous communities is a good example of plant stacking. The folk practice of companion planting, such as the use of insectary hedgerows, is the placing of vegetables and herbs next to each other for beneficial growing effects on another, helping to deter pests, and attract pollinators (Holmgren, 2002).
Another practice for small scale intensive systems is to design edible forest gardens, or food forests which are “edible ecosystems; a consciously designed community of mutually beneficial plants and animals intended for human food production” (Jacke, 2005). However, forest gardens provide more than just a variety of foods. Jacke (2005) introduced the seven F’s as a way of determining what benefits a forest garden provides; food, fuel, fiber, fodder, fertilizer, “farmaceuticals”, as well as fun.

Gardens can be designed using many different configurations; the most popular within permaculture gardens are those that increase the growing edge (discussed in Use Edges and Value the Marginal). The patterns most frequently used within gardens are round, key-holed, sunken, raised, or spiraled beds (see figure 5). Kitchen door herbs are most often placed in a raised spiral, or herb spiral as its proximity is close to the living space. This helps to minimize the amount of work put into harvesting.

*Figure 5. Garden layout configurations*
Gardens should also be designed with diverse plantings and animals systems. Having a diversity of plants helps with pest and disease control and resistance. It also provides yield during different times of the growing season. Designing for animal systems helps encourage pollinators, while acting as foragers, heat sources for adjacent buildings, pest control, and food sources. Although beneficial, adding animals to any system can complicate planning and management. When considering animal systems, the designer should always keep in mind the needs, products, and functions of the animal in order to place it in the correct location (Mollison, 2004). As a simplified model, consider the basic needs, products, and functions of a chicken and coop, residence, and greenhouse. The chicken needs food and shelter. It provides food and a heat source while its natural characteristic is to scratch the ground. The residence can provide food for the chicken through household scraps. The greenhouse benefits from the chicken in soil health and pest management by providing a place for the chicken to scratch and eat insects during the spring and fall when plants aren’t actively growing and producing. The greenhouse can also be heated at night through the connection of an adjacent chicken coop.

Obtaining a yield relates to the three permaculture ethics in that the food grown goes to the users and immediate family (Care of People); the parts of the crop that aren’t eaten, such as vines and stalks go to compost and soil improvement (Care of Earth); and any surplus of food not needed by the immediate users is shared with the community (Sharing Resources and Surplus) (“Permaculture design fundamentals: Introduction to regenerative sustainability,” n.d.). Obtaining a yield is an important piece to the philosophy of permaculture design.
Produce No Waste

According to Bill Mollison (1990), a pollutant is an output of any system component that is not being used productively by any other component of the system. This definition encourages landscape architects to look for ways to minimize pollution and waste through designing systems to make use of all outputs. In most ecosystems, the outputs of one living thing are the inputs for another, i.e. “waste is food” (McDonough, 2002).

The principle of Produce No Waste, is more a reminder to designers and consumers to live with less and reuse what we have. A typical pattern often found goes from extravagant consumption, to habitual norm, and leads to an addictive necessity. David Holmgren (2002) lists four “R’s” to help remind consumers to not produce waste; reduce, reuse, repair, and recycle.

Inventory and Analysis

Inventory and analysis is a very important part of the design process. It is during this stage where the project site is analyzed and studied. How well a designer conducts inventory and analysis influences the success and longevity of a design.

Ian McHarg (1995) discusses the importance of understanding the climate, geology, physiography, hydrology, groundwater, soils, plant associations, and wildlife of the site. These can be simplified into four inventory categories; earth, biological, energy, and social (Holmgren, 2002). Earth consists of understanding the topography, soils, nutrients, and water drainages and patterns of a site. The biological resources include plant, animal, and insect life. Energy resources include wind, water, and fiber. Finally, the social resources of a site comprise of its potential for teaching and recreation.
(Holmgren, 2002). All of these things ensure a designer understands the site to the fullest in order to create a successful design.

**Observe and Interact**

Good design depends on a harmonious relationship between nature and people in which careful observation and thoughtful interaction provide the design inspiration and patterns (Holmgren, 2002). Permaculture designers use careful observation and thoughtful interaction to reduce the need for both repetitive labor and for non-renewable energy. Traditional agriculture is labor intensive, industrial agriculture is energy intensive, and systems using permaculture principles are information and design intensive. The process of observing, recognizing patterns, and appreciating details is the foundation of all understanding when it comes to permaculture. Sometimes tools like GIS systems, although very helpful, often substitute for or cover up a deficit in simple skills of reading the landscape (Holmgren, 2002).

When observing a project site, some important things to consider include views and overlooks, microclimates both cool and warm, and wind direction and strength. Other landscape elements that need to be observed during this step in the design process include soils and plants. Soils are very important when it comes to the health and vigor of a landscape. They should be tested, analyzed, and improved through the addition of mulch and compost. Designers should know when it is appropriate to use annual plants vs perennial plants. Local plant communities and native species should also be considered and implemented into designs. Designs should also seek to be *furiouly efficient* by stacking functions (Hemenway, 2001).
Each element within a landscape should perform more than one function. For example, a grape arbor is not only a support for grape vines, it can provide shade, privacy, and aesthetic quality. Also, each process or system within a landscape should be supported or performed by more than one element. An example being an irrigation system. The first option for irrigation might come from a water harvesting tank, the second from an in-ground system connected to city water lines, and the third option could come from a simple garden hose and watering can. This ensures the system can be taken care of no matter what emergencies or situations happen (Hemenway, 2001).

**Apply Self-Regulation and Accept Feedback**

Self-regulation is the ability of a system or individual to control themselves. When applying this to designers, it is a landscape that is able to take care of itself through natural functions and processes (Holmgren, 2002). There are two aspects to consider when trying to design a system that is self-regulating:

1. Positive feedback: adding something to a system to encourage it to grow or do something.

2. Negative feedback: negative in this sense is not a synonym for *bad*, but of taking something away. It is the brake that prevents a system from falling into holes of scarcity of instability. Introducing an animal to control weeds is a negative feedback that keeps the system in balance.

Self-maintaining and regulating systems are the Holy Grail of permaculture design, something that designers strive for, but might never fully achieve. One of the most important evolutionary responses of organisms to higher-order control is to develop internal self-regulation mechanisms which control excessive growth or inappropriate
behavior (Holmgren, 2002). An example is wildlife producing in the spring time when there is enough food for healthy growth. Nature is quick to restore imbalances either through natural selection, or evolution. The common characteristic of all permaculture systems is that the energy needed for the system is provided by the system; its goal is self-sufficiency (Mollison, 2004).

Use and Value Renewable Resources and Services

Renewable resources are those which are renewed and replaced by natural processes over reasonable periods without the need for major non-renewable inputs (Holmgren, 2002). Permaculture design should aim to make the best use of renewable natural resources to manage and maintain yields, even if some use of non-renewable resources are needed in establishing the system. Renewable energies such as wind, often have irregular and limited flow rates. For these reasons, renewable energies are often times displaced by fossil fuels which have a very high and regular flow rate (Mollison, 1990).

It’s important to understand both the broad patterns and specific requirements of renewable resources so that designers can make the best use of what renewable resources can offer and ensure use is within the renewable limits of the resource. Designers should seek to make the best use of nature’s abundance and work with nature rather than against it (Mollison, 2004). In order to Use and Value Renewable Resources, the designer should first identify and inventory said resources.

When planning for a site, designers should consider local climate and site microclimates in order to increase production. The following elements influence a site’s microclimate: topography, water, structures, and vegetation. When considering topography,
consider sun vs shade facing slopes as well as cliffs and rocky outcrops. Exposed rock traps heat during the day from the sun, and releases it at night which can create a longer growing season for adjacent plants. Farmer, Sepp Holzer (2011), discusses the importance of using every possible space available. He plants squash against rocky outcroppings because they need a longer growing season to mature.

Bodies of water can help modify surrounding temperatures while reflecting light and heat to surrounding areas. Structures can be used as light reflection as well, while shading surrounding areas to cool the climate instead. Vegetation modifies the climate in many different ways. Vegetation cools an area through transpiration and shading. It also heats an area by protecting locations from the wind and through convective heat transfer which is the transfer of heat from one place to another (“Merriam-Webster Dictionary and Thesaurus,” n.d.). Vegetation takes up heat during the day, and then at night when air temperatures drop, the vegetation transfers some of that stored heat to surrounding areas (Hemenway, 2001).

In order to use surrounding renewable resources, permaculture literature has identified various analysis techniques that simplify the process while being conscious to use energy efficiently. The first technique is called zone planning or zoning which means to place elements within the landscape according to how much it is used or how often it needs to be serviced (Mollison, 2004). Zone 1 is the most used or visited and closest to the main living/working area. Zone 5 is the least used or visited and furthest away from the main living/working area (see figure 6). The number of zones is dependent on the size of property and/or the designer’s discretion. Typically only 5 zones are used in order to keep the plan simple. When placing coniferous trees in a plan, they are considered a zone.
5 plant, because they don’t require constant care. On the other hand, fruit trees need pruning and harvesting on a more regular basis, so these would be placed in zone 2 or 3. Slope, soil, aspect, and infrastructure can all cause particular zones to shrink or expand (Mollison, 2004).

Figure 6. Residential zone planning map (“And The Plot Thickens: Permaculture Zones,” n.d.).

The second analysis technique is sector planning. It analyzes wild energies and elements coming from outside the site and passing through it. Wild energies include sun and light, wind, fire, rain, flooding, runoff, etc. In order to analyze these outside energies
a sector diagram is made (see figure 7). Based on the sector diagram, elements can then be placed in the right sector (see figure 8). For example, evergreen trees used as a windbreak should be placed in the wind sector, while deciduous trees should be placed in the hot summer sun sector to shade the home. A water barrier or swale can then be placed in the fire sector to help protect the house and property from potential wildfires.

Figure 7. Sector diagram
**Figure 8.** Element placement within a sector diagram

**Functional Diagrams**

Functional diagrams are a very important step of the design process, especially when designing with permaculture principles. It is during this step when the design is laid out graphically to find connections and patterns between elements in order to make a cohesive, aesthetic system.

**Design from Patterns to Details**

David Holmgren (2002, p. 127) states, “the commonality of patterns observable in nature and society allows us to not only make sense of what we see, but use a pattern
from one context and scale to design in another.” Patterns are found everywhere in nature. They happen in both space and time; space meaning how something is arranged, time meaning how the system changes and evolves. For example, patterns of erosion can be found on river banks based around times of high floods (Holmgren, 2002).

Patterns found in nature include symmetry found in animals, living/moving things, and snowflakes. Spirals are found in helixes, vortexes, global air currents, seashells, and fingerprints. Branching patterns are the most commonly found pattern in nature, e.g. tree branches and river systems. Cracking patterns and nets are found as a result of expansion and contraction; they’re found in tectonic plates and dried mud. Waves are disturbances that carry energy as they move and are found in wind and surface waves of water and sand. Meandering patterns are also found in river systems and are places of productive, healthy systems (“Permaculture design fundamentals: Introduction to regenerative sustainability,” n.d.).

Each pattern serves a purpose; understanding these patterns and their meaning is a very effective way to design because it gives us a broader perspective on the interactions between elements of a system (“Permaculture design fundamentals: Introduction to regenerative sustainability,” n.d.). The Biomimicry Institute in Missoula, Montana strives to find patterns in nature and apply them to design. Biomimicry is “an approach to innovation that seeks sustainable solutions to human challenges by emulating nature’s time-tested patterns and strategies” (“The Biomimicry Institute: Inspiring Sustainable Innovation,” n.d.). Every year, the institute issues a design challenge asking for submissions in solving the world’s problems by taking examples from nature.
Important infrastructure can be sited by reading the landscape and noticing natural patterns in order to put the right element in the right spot (Mollison, 2004). Contour patterns help landscape architects and engineer’s site roads and accompanying infrastructure. Following contour patterns lessens the likelihood of erosion and decreases grading costs. Sun and shade patterns inform the designer where to place built structures such as a house and greenhouse, as well as elements, such as a garden that depend on appropriate amounts of sunlight. Slope patterns also inform the designer where to place the main structure such as a house. The top of the slope typically reveals wonderful views, but has increased wind speeds and wildfire danger. The bottom of the slope lessens the chance wildfire, but sits in a frost pocket with greater chance of flooding. Placing the house in the center of a slope avoids frost pockets and floods below and receives a cooling breeze from above (Mollison, 2004).

Most importantly, patterns should be understood in order to design for catastrophe to avoid loss of life and property (Mollison, 2004). Typical within the arid west there is a risk of wildfires. Fire sectors should be identified and managed by clearing fire fuel, taking into account wind speed, direction, and topography, and using resistant plants with high water content and produce little mulch and leaf drop.

**Integrate Rather than Segregate**

The purpose of a functional and self-regulating design is to place elements in such a way that each serves the needs and accepts the products of other elements (Holmgren, 2002). There are two things to glean from this principle; (1) each element should perform *multiple functions*, and (2) each important function should be supported by *multiple*
elements. Every plant and animal has different characteristics, requirements, outputs, and potential uses; designers should seek to use them within the design.

An example found in nature is a tree. First, the trunk and branches support leaves that collect solar energy. Second, the sapwood conveys water and nutrients to the canopy leaves and carbohydrates to the roots. Third, the trunk and branches provide habitat for animals and insects that can benefit the tree and wider ecosystem. Each part of the tree works in cohesion with each other to improve the overall system. Another example mentioned earlier in the section Obtain a Yield discussed how to plan and place a chicken coop, residence, and greenhouse so that all three work together and provide for the larger system.

Having a backup system is an important function if the element which performs the function originally fails. Considering the before mentioned system of the chicken, house, and greenhouse, the designer should consider which elements perform the same function. Food for the home residents comes from the greenhouse and chicken; likewise, food for the chicken comes from house scraps and the greenhouse (in the form of insects and unused produce). Having multiple backups within a system ensures its success and longevity.

Segregated elements within a landscape are much easier to maintain. Consider city zoning; if the residential and commercial areas are separated, they are easier to maintain whether it be through infrastructure maintenance, laws, and codes. When placed together in a mixed-use zone; laws, codes, and requirements need to change in order to accommodate both commercial and residential buildings. Another example of segregated vs integrated systems is a conventional garden plan. Wide spaced rows provide less
competition for sun, water, and nutrients, but allow more space for insects and weeds to grow inviting competition to plants anyway. Integrated systems can be used in creating for self-generating systems. Looking back to the city plan, a mixed-use development in essence provides for itself in housing, food, entertainment, shopping, etc. or the daily “necessities” both provided for and needed by the community.

Utilizing and planning for guilds is also a great way to integrate elements and plantings within a system. A guild is a “human-made assemblage that mimics a natural community, often times designed around a tree species that supports the guild” (Hemenway, 2001). A community is a natural grouping of species in the wild. Using nature as an example, designers should seek to mimic what is happening in local plant communities and imitate natural growing processes. There are four steps/questions to consider when beginning to design a guild. These questions form the backbone of a potential guild (Hemenway, 2001).

1. Research and find local plant communities
2. Which plants provide food? Either for animals or humans
3. Which species are common to more than one plant community?
4. Does the community contain any known nitrogen fixers or other nutrient accumulators?

**Concept Designs**

After diagramming elements and associations with all of their functions, concept designs should be made to find the best form composition and layout of each element. Concept designs are “quick and dirty” alternatives, providing the designer many different concepts to find the best option for the final design.
Use Small and Slow Solutions

Like natural systems, change can take a long time to occur. Small and slow solutions are easier to maintain than large and fast solutions (Holmgren, 2002). Small scale, minimum movement solutions include:

1. Households and small garden spaces
2. Stacking of plants to make full use of soil, water, and sunlight in small areas
3. Multi-purpose buildings and integrated land-uses that pack more functions onto less land

There are several examples found in nature and cities that exhibit large and fast solutions that do not function. The first example is found in the city of Detroit, Michigan. When the motor industry exploded during the first half of the twentieth century, Detroit was one of the fastest growing cities in America. Peaking at 1.8 million people in 1950, it has since collapsed to approximately 670,000. Streets were not planned for pedestrian use, but for motor vehicles. In so doing, extremely spread out suburbs litter the landscape, with abandoned communities throughout (Mills, 2015). Detroit is a good example of growing too large, too fast, and not being able to support itself because the lack of economic diversity. On a smaller scale, many varieties of Elm (*Ulmus*) and Cottonwood (*Populus*) trees exhibit weakness by growing too large and too fast. As they grow quickly, their trunks and branches do not have the integrity to support such large branches and these tend to break and crack easier than the slower growing tree varieties such as Redwoods (*Sequoia*) or Oaks (*Quercus*).
Use and Value Diversity

Diversity needs to be seen as the balance and tension in nature between variety and possibility on the one hand and productivity and power on the other (Holmgren, 2002). “Diversity increases adaptability and resiliency” (Mollison, 2004). Monocultures are a major cause of vulnerability to pests and diseases – thus requiring the use of chemicals, fossil fuels, and energy. Diversity of elements and functions within a design is one of the key characteristics of an integrated system (Holmgren, 2002). Diversity of plant varieties and species provides some degree of security or insurance against seasonal failures or pest and disease attack. It’s important that designers use a variety of plants that produce a high yield and are easy to harvest such as annual vegetables and other varieties that are drought tolerant and pest and disease resistant such as native berries.

Many people see the emphasis on diversity in permaculture as meaning that a random mix of species makes a system stable. Bill Mollison (1990) says “it is the number of functional connections between species that counts, rather than the number of species, which makes for stability in a system” (Holmgren, 2002). For example, botanical gardens are very diverse but not stable because they lack functional connections that contribute to a self-regulating system.

Use Edges and Value the Marginal

Edges exist all around us. Within the natural and developed environment, “edges are dynamic, diverse, and productive sites” (Holmgren, 2002, p. 230). Designers should maintain awareness and make use of edges and margins at all scales and in all systems. Design that sees the edge as an opportunity rather than a problem is more likely to be successful and adaptable.
There are many types of edges in the natural environment, however, only a few will be used for examples in this study. The first category of edges are those found in natural landscapes. They consist of coastlines and ecotones. Coastlines are shallow waters filled with nutrients that support fish, wildlife, and coral. They include not only oceans, but rivers, lakes, and wetlands. Looking past plants and animals, coastlines also support a large diversity of recreation and development. An ecotone is “an edge between two bio-regions where the disturbance of species from both regions overlaps, creating greater biodiversity than in either of the respective regions” (Holmgren, 2002, p. 224). Such edges can support a greater number of species (both plants and animals) because resources can be used from both. An earlier example is the chinampa systems that use resources from both the water canals and land berms.

The second category and example of edges are found in cultivated landscapes. These landscapes consist of irregular fields bordered by hedgerows, woods, and small patches of trees among tightly clustered villages and a network of roads, lanes, streams, and ponds. All of these edges are carefully maintained to decrease susceptibility to disease and increase wildlife habitat and multi-use functionality (Holmgren, 2002).

The second cultivated edge is found within Mediterranean terracing. From the 14th to 16th century, terracing stony hillsides was practiced to increase agriculture productivity by “heroic construction and meticulous maintenance of the landscape edge” (Holmgren, 2002, p. 227). The third cultivated edge is between the urban and rural fringe. Urban sprawl, guided by generations of urban planners, is one of the defining characteristics of modern, car-based communities. It is the constant edge between town and country, human and natural world.
The final cultivated edge is found in urban landscapes; the city shopfront. Most often shopfronts are a limited resource, but in high demand. City shopfronts are the interface between public domain and the street and private stores. Malls are a good example of taking that edge and enclosing it for the maximum exchange of goods and money, taking out the benefits of activity and aesthetics.

Large scale examples of increasing the edge for production, recreation, and aesthetics include a city plan for Mobile, Alabama (figure 9) as well as a connected greenspace and park master plan in New York City between Greenpoint and Williamsburg as shown below in figure 10. Small scale practices of increasing the edge include, but are not limited to the implementation of herb spirals, keyhole gardens, ponds, and hedgerows (see figure 11).

Figure 9. City plan for Mobile, Alabama (“Projects A-Z: EDSA,” n.d.)
Final Design

Making the final design is the process of taking the best concept and forming it into the plan which will be implemented. The final design contains the needed information for construction and future maintenance of the project site.
**Creatively Use and Respond to Change**

There are two parts to this principle; (1) designing to make use of change in a deliberate and cooperative way and (2) creatively responding or adapting to large-scale system change that is beyond our control or influence (Holmgren, 2002). Flexibility becomes very important to the life of a design when dealing with powerful external forces. Resistance and rigidity are factors that might cause a system to break under stress. For example, many trees and buildings, as they grow taller exhibit some level of flexibility in order to withstand powerful winds.

The designer should always keep in mind that every resource is an advantage or disadvantage. It is up to the designer to find ways for the resource to benefit the overall system. Permaculture theory and design is imagination and information intensive (Mollison, 2004). It all depends on the creativity and imagination of the designer. They should know and understand the permaculture principles and guidelines in order to be creative and find new ways of designing.

**Community Strategies**

When designing smaller spaces in urban and suburban environments, greater care must be taken in design to intensify food production and minimize wasted space. A good way to do this is by using spirals, keyholes, trellis and vertical space, as well as stacking and clumping plants. Small urban spaces require the most thought and attention to detail as these are the spaces that cannot waste space. Utilization of windowsills, roofs, narrow walkways, decks, patios, and vertical elements help to maximize available space and efficiency.
When designing in a cold region such as the intermountain west, the main consideration is to prolong the growing season. This can be done through the use of cold frames, greenhouses, plastics, and glass. Designers should take special care in identifying and modifying climate where possible by using reflected heat from walls and rocks, planting under vegetation that will exude heat, and avoiding low frost pockets within the landscape. Another key component is to put the right plant in the right place; use plants adapted to the local climate to ensure success.

Dryland gardens have several problems associated with the climate. They include, high soil pH, excessive evaporation, heat and high stress to plants, salty soils dry winds, and low water supply. The key is to design a system that will eliminate these problems as much as possible by using mulch and compost, planting windbreaks, and using greywater from the home and other sources.

Many communities have been planned using permaculture principles (whether intentional or not), they include:

1. Village Homes in Davis, California – buildings were designed and oriented for maximum exposure for solar panels. Water catchment and drainage swales were designed throughout the site in order to efficiently save and use water. Greenbelts and common areas were designed throughout the community in order to maximum space and production.
2. Blacksburg, Virginia – utilizes greenbelts and common areas for shared resources and inputs.
3. Daybreak, Utah and Mt. Sterling Farms in Hyrum, Utah – community garden plots are available to residents to grow their own food, as well as designed green belts and common areas for shared resources and community recreation.

**Objective 2: Implement**

The second objective was to implement the instructional module and improve student awareness of permaculture theory and design principles. Student awareness of permaculture theory was primarily measured through responses of the post-module survey.

The overall organization of the 2014 to 2015 instructional modules varied based on student and professor feedback. In 2014, lectures were given followed by the design problem, in which students had the rest of the module to work on the design solution and refer back to lecture slides and notes. Although effective in that it provided all the material, several students stated in their response they would have preferred lectures to be broken up a bit. With many responses echoing the same issue, the 2015 organization was changed in order to improve student attention and interest during lectures (see Table 3). In 2015, lectures were split up by sections pertaining to the design problem and students were given the opportunity to work on the project throughout the instructional module instead of solely at the end. This proved effective for most students.

Many students had not heard of permaculture before receiving the instructional module, so lecture power points and outlines served as a very important reference that students were able to return to for further information. Sixty-four percent and thirty-eight percent of student responses in 2014 and 2015 respectively mentioned they used the provided material in order to remember what was taught. Interestingly and unforeseen by
the researcher, images placed within the power points were also used by students for design inspiration and ideas.

Although permaculture has a lot of new language such as herb spiral, keyhole garden, and guild, no comments were made from students about mis-understanding certain words or concepts. As unknown and new phrases were defined in lectures, many students mentioned having gone back to the lecture slides for specific definitions. Several topics, by student interest, were requested be covered in more depth including, plant varieties and combinations, guilds, and overall design and garden layout.

**Objective 3: Measure Effectiveness**

The third objective of this study was to measure the effectiveness of the instructional module by analyzing responses from the post-module survey and grading student design solutions.

Students in 2014 were given approximately 10.5 hours of class time to finish their design solutions, while those in 2015 were given 9.5 hours of class time. Design solutions were evaluated to identify how many permaculture principles were present within the design receiving a score from 1 to 12. One point given for each principle present in the design solution. Projects received a point for a principle if a conscious effort and annotations were present on the final board layout.

In order to compare the two years, a composite score was found. Total points from each team in 2014 were added together and divided by the total number of teams (7) to get a score rounded to the nearest tenth and out of 12 points total. The same was done in 2015, except with 6 teams instead of 7. The composite score (12 being the best) shows how effectively the each year incorporated permaculture principles into their design
solution. Composite scores were used only to compare the two years within the study.

Because the project was used for an assignment with the Planting Design for Sustainability course, a separate grading criteria was used to give the students a letter grade based on design aesthetic, if program elements were included, and how well they used the and incorporated the basic function of design, ie form, color, texture, etc (see Appendix J).

Table 4.  
2014 Design Solution Evaluation

<table>
<thead>
<tr>
<th>Team #</th>
<th>Principles Used</th>
<th>Composite Score</th>
<th>Additional Thoughts</th>
</tr>
</thead>
</table>
| #1     | - Obtain a Yield  
- Produce No Waste  
- Observe and Interact  
- Use and Value Renewable Resources  
- Integrate Rather than Segregate  
- Use Edges and Value the Marginal | 6               | Space within the site was used efficiently. Use of slope was very effective. Analysis was thorough. |
| #2     | - Obtain a Yield  
- Observe and Interact  
- Use and Value Renewable Resources  
- Integrate Rather than Segregate  
- Use and Value Diversity  
- Use Edges and Value the Marginal | 6               | Integration of guilds made for a diverse planting plan. Lots of wasted space within the vegetable garden area. |
| #3     | - Catch and Store Energy  
- Obtain a Yield  
- Produce No Waste  
- Use and Value Renewable Resources  
- Integrate Rather than Segregate  
- Use Small and Slow Solutions  
- Use Edges and Value the Marginal | 7               | Did not contain the most principles, however, design was the most functional of all. Use of space was very well thought out. |
| #4     | - Catch and Store Energy  
- Obtain a Yield  
- Produce No Waste  
- Observe and Interact | 9               | Used the most permaculture principles, and created a functional |
<table>
<thead>
<tr>
<th>#</th>
<th>Requirements</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>#5</td>
<td>- Catch and Store Energy - Obtain a Yield - Observe and Interact</td>
<td>4</td>
<td>Good form composition, but lacked in utilizing all of the provided space.</td>
</tr>
<tr>
<td>#6</td>
<td>- Obtain a Yield - Observe and Interact - Use and Value Renewable Resources - Integrate Rather than Segregate - Use and Value Diversity</td>
<td>5</td>
<td>Well thought out design with good use of space. Contained lots of variety with emphasis on biodiversity.</td>
</tr>
<tr>
<td>#7</td>
<td>- Obtain a Yield</td>
<td>1</td>
<td>Overall, an incomplete design. Lacked the primary functions of permaculture.</td>
</tr>
</tbody>
</table>

Overall, the class in 2014 did fairly well in designing the site by planning for a diversity of plant materials, and ensuring all of the required elements requested from the clients were present. However, more permaculture principles could have been used along with utilizing all the space more efficiently instead of leaving blank areas. Also, a common mistake found in most designs was the lack of a cohesive form composition. Every group was able to incorporate some form of production outside of the requested annual vegetable gardens. Overall, the seven teams from 2014 obtained a composite score of 5.4 out of 12.
Appendix K shows team #4’s design solution. Many of the permaculture principles were used and annotated within the design. Some principles to note, by adding a large composting area as well as a pond to store any excess water, team #4 took great care to _Reduce Waste_ and _Catch and Store Energy_. The vegetable garden was designed with swales to guide water from the pond through the beds to saturate the soil and provide additional moisture to the plants. This demonstrates the principle _Use Small and Slow Solutions_.

Appendix L shows team #7’s final design solution. This design scored the lowest as it only demonstrated one permaculture principle, _Obtain a Yield_. Many plants, both edible and medicinal were incorporated into the design, however, overall it was an incomplete design solution with much of the ground surface unmanaged without a plan for function or production. Great care was taken by this team to create an aesthetically pleasing rain water harvesting system, but it doesn’t seem to match the rest of the design. Such a visually obstructive element should be supported by other large elements, such as adjacent trees, large retaining walls, or other supporting buildings.
Table 5. 
2015 Design Solution Evaluation

<table>
<thead>
<tr>
<th>Team #</th>
<th>Principles Used</th>
<th>Composite Score</th>
<th>Additional Thoughts</th>
</tr>
</thead>
</table>
| #8     | - Catch and Store Energy  
- Obtain a Yield  
- Produce No Waste  
- Design from Patterns to Details  
- Integrate Rather than Segregate  
- Use and Value Diversity  
- Use Edges and Value the Marginal | 7 | Only group to attempt a form composition from a pattern found in nature. Effort was acknowledged, but overall, the design was very weak. |
| #9     | - Obtain a Yield  
- Observe and Interact  
- Use and Value Renewable Resources  
- Integrate Rather than Segregate  
- Use Edges and Value the Marginal | 5 | A strong design and form composition, but lacked space utilization – many areas not planned. |
| #10    | - Catch and Store Energy  
- Obtain a Yield  
- Produce No Waste  
- Observe and Interact  
- Apply Self-Regulation and Accept Feedback  
- Integrate Rather than Segregate  
- Use Small and Slow Solutions  
- Use and Value Diversity  
- Use Edges and Value the Marginal | 9 | A very aesthetically pleasing and functional design. Clients most enjoyed this design and found everything to be very implementable. |
| #11    | - Catch and Store Energy  
- Obtain a Yield  
- Produce No Waste  
- Observe and Interact  
- Apply Self-Regulation and Accept Feedback  
- Use and Value Renewable Resources  
- Design from Patterns to Details  
- Integrate Rather than Segregate  
- Use Small and Slow Solutions  
- Use and Value Diversity | 12 | Incorporated all of the design principles, and provided a functional and pleasing design. Great care was taken to study and research permaculture |
| #12 | - Use Edges and Value the Marginal  
- Creatively Use and Respond to Change | principles outside of lecture content. | 3 | A functional design, but lacked in a cohesive form composition as well as plant diversity. |
|-----|---------------------------------|-----------------------------------------|---|------------------------------------------------------------------|
| #13 | - Obtain a Yield  
- Observe and Interact  
- Integrate Rather than Segregate | 4 | Extra research was completed to incorporate additional practices, but contained lots of unused, wasted space. |
|-----|---------------------------------|-----------------------------------------|---|------------------------------------------------------------------|
|     | - Catch and Store Energy  
- Obtain a Yield  
- Produce No Waste  
- Use and Value Renewable Resources |                                                   |   |                                                                  |

The 2015 class did a much better job than the 2014 class of integrating permaculture principles into their final design. A greater portion of this class was more invested and interested in the theory of permaculture and it is reflected within their designs through additional research and inclusion of practices not mentioned in lectures. Team scores in 2015 also show an improved knowledge of permaculture theory by the increased number of principles applied. The increase in knowledge is attributed to the improved teaching method for 2015. Lectures were spread out through the module allowing students more time to internalize the information being taught.

Organizing permaculture principles into the design process also helped students retain the information and apply them into their design solution. With a clear illustration (see figure 3) students were able to refer to the graphic during each step of the design process and ensure they were using as many principles as possible. Compared to 2014,
the teams did a much better job in creating a cohesive form composition, but struggled in utilizing all of the available space. Overall, the six teams in 2015 obtained a composite score of 6.7 out of 12; a 1.3 point improvement from 2014.

Appendix M shows team #11’s design solution. Found on the second page of their project, the team identified each of the 12 permaculture principles and how they were ultimately incorporated into their final design. The project *Creatively Uses and Responds to Change* by recognizing the gradual warming climate by planting water-wise and drought resistant plants throughout the design (except food producing plants which in general need more annual water). A creative composting system that *Uses and Values Renewable Resources* has been proposed in the design and was really admired by the clients.

Appendix N illustrates team #12’s final design. The chief problem first seen within this design is the lack of one single form composition. Rectangular and circular forms are both used to create very different spaces. They *Obtain a Yield* by providing many edible and medicinal plants but lack practices and strategies for *Catching and Storing the Energy* these plants produce. It is overall a functional design, but lacks in aesthetic quality.

As a general note for 2014 and 2015, more time would have been beneficial for students to complete their design solution so as to fully analyze the site and design with more creativity. Many students resorted to what they already knew, because it was familiar and under time constraints, they were able to produce a project worthy of presentation and grading. More time would have offered them the chance to explore, understand the site, and design in a way that was unfamiliar.
Survey responses exhibited some positive results. Information gathered from the post-module survey’s helped inform the study of the effectiveness and student interest in format and information presented during the instructional module. For a complete reference to survey responses, see Appendix F.
Table 6.
Post-Module Survey Responses

<table>
<thead>
<tr>
<th>QUESTION/YEAR</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: How would you define permaculture?</td>
<td>50% - high yield</td>
<td>46% - high yield</td>
</tr>
<tr>
<td>Q2: How can permaculture be practiced on a larger scale? i.e. community, region, etc.</td>
<td>46% - community/public gardens</td>
<td>50% - community/public gardens</td>
</tr>
<tr>
<td>Q3: How did you use the Power Points and/or lecture handouts in your design tasks?</td>
<td>64% - reference material</td>
<td>38% - reference material</td>
</tr>
<tr>
<td>Q4: What content from the lecture portion was directly applicable to you project?</td>
<td>43% - information on zone and sector analysis</td>
<td>42% - information on guilds</td>
</tr>
<tr>
<td>Q5: Was there anything from the lecture that you would like to know more about? What permaculture topic should be covered in more depth?</td>
<td>21% - plant varieties, which plants to use in design</td>
<td>17% - applying principles to the larger scale; more information on what plant varieties to use</td>
</tr>
<tr>
<td>Q6: Explain how the project helped or didn’t help your understanding of permaculture.</td>
<td>18% - real world applications and applying principles to an actual site; plant selection and benefits</td>
<td>10% - gave a good introduction and foundation of permaculture</td>
</tr>
<tr>
<td>Q7: Was the time frame on <strong>only lectures</strong> sufficient?</td>
<td>61% - yes</td>
<td>79% - yes</td>
</tr>
<tr>
<td></td>
<td>39% - no</td>
<td>21% - no</td>
</tr>
<tr>
<td>Q8: I would like to know more about permaculture for future projects and how I can apply the principles to future design.</td>
<td>32% - definitely agree 46% - agree 22% - neutral 0% - disagree 0% - definitely disagree</td>
<td>46% - definitely agree 38% - agree 12% - neutral 4% - disagree 0% - definitely disagree</td>
</tr>
<tr>
<td>Q9: How will you use permaculture principles during the remainder of your time at USU?</td>
<td>21% - multi-use/functionality; productive vs. ornamental plantings</td>
<td>25% - multi-use/functionality</td>
</tr>
<tr>
<td>Q10: If a permaculture lecture/presentation were given in your future home town, would you attend?</td>
<td>75% - yes 18% - maybe 7% - no</td>
<td>58% - yes 0% - maybe 38% - no</td>
</tr>
</tbody>
</table>
Q1. How would you define permaculture?

In 2014, the most common terms used in student definitions were high yield, sustainable, and design. Percentages of student responses with the preceding key terms were respectively 50 percent, 36 percent, and 32 percent. Key terms used by students illustrate their understanding of many key principles of permaculture, referring back to the studies definition of permaculture, a creative design process based on whole-systems thinking that uses ethics and design principles (Mollison, 1990). The class in 2015 used the key terms high yield, sustainable, and reduce impact on environment. Very similar results were found between the two years according to their definitions of permaculture.

Q2. How can permaculture be practiced on the larger scale? i.e. community, region?

Many students in both 2014 and 2015 had a hard time understanding how permaculture principles could be applied to the larger scale. The most common responses for both years was to create community and public gardens and plant edible plants within parks and public spaces. When asked what students would like to learn more about, ten percent of students asked how to apply permaculture principles to the larger scale.

Q3. I would like to know more about permaculture for future projects and how I can apply the principles to future designs. (circle one)

a. Definitely Agree
b. Agree
c. Neutral
d. Disagree
e. Definitely Disagree
The majority of both classes wanted to learn more about permaculture. In 2014, 32 percent of students responded *definitely agree* and 46 percent responded *agree*. In 2015, 46 percent of students answered *definitely agree* and 38 percent answered *agree*. Percentages show student interest in permaculture theory and their desire to apply principles to future projects.

Q4. How will you use permaculture principles during the remainder of your time at USU?

The most useful information students found within the instructional module was multi-use and functionality of elements. One student wrote, “I feel permaculture is an important aspect of landscape planning. Function of land and its multiple uses is a wise way of planning”. Several students also mentioned the desire to be more conscious of their plant choices by selecting those that are productive as well as ornamental.

Overall, the series of lectures tied to a design problem was effective in teaching students permaculture theory. Many students mentioned the lectures being a beneficial source of information and reference material to learn the basics. A student from 2015 said how difficult it was to design a plan while trying to apply the permaculture principles. Not only were they attempting to design aesthetically, but also trying to design with the maximum amount of function and efficiency. The design problem helped them gain real world experience working with a client to apply what was taught in the lectures. One student mentioned, “Working on the project caused me to apply the knowledge… and I was able to remember it better”. Another said, “Practicing permaculture and applying the principles helped to fortify the examples given in lecture”.
The majority of students thought the design problem was very applicable in learning permaculture theory. However, one student mentioned the desire to organize the project differently so instead of being teamed up, they would have liked to complete a smaller project by themselves. In order to complete the design problem on time, many groups decided to split up responsibilities and take different sections. For example, the student mentioned earlier reverted back to normal responsibilities and completed a lot of the drafting and missed the opportunity to learn about plant relationships. This student would have rather “worked on a very small plot and discovered ways/methods of researching and exploring alternatives to come up with solutions that maximized permaculture principles”. Overall, the decision to teach lectures and assign a design problem benefited the students by giving them a basic overview of permaculture theory followed by the opportunity to apply what they had learned while researching and discovering new aspects that weren’t previously discussed.
CHAPTER V

DISCUSSION

Weaknesses

The most mentioned weakness of the study was timing. Many students felt the information within lectures was very applicable and useful, but were disappointed there wasn’t more time to dive deeper into certain principles and practices of permaculture. One student from 2015 mentioned, “I would like to know more about it in some real projects”. Another student in 2014 wished to cover every lecture topic in more depth, and expand the instructional module another two weeks. Many others felt the information was too rushed and would have appreciated a few more days; this was exhibited through a comment from 2015, “if you had another week to go into more depth on a few select topics maybe that would have slowed things down a bit so we could absorb it all”. For future work and teaching of permaculture, it is suggested to either allot more time to teaching in order for students to fully understand and apply principles, or simplify the lectures using the same amount of time, thus ensuring students receive a very basic overview that is easier to remember.

The second weakness identified was a lack of information within the lectures. Two topics in particular stood out through the survey. Firstly, students desired to learn more about specific plant varieties to use in permaculture gardens, specifically edibles. In 2014 and 2015 the most frequent answer to question #5, (Was there anything from the lecture that you would like to know more about? What permaculture topic should be covered in more depth?) was what plants to use in a permaculture garden and how they can benefit each other and surrounding elements.
Teaching material could be adjusted to include more information on plant varieties and those which are adapted to Utah’s temperate climate. Landscape architecture curriculum at USU only requires students to take one semester of plant identification and it only covers a small selection of woody plant materials. A small section on perennial and annual plant identification would benefit this study and help landscape architects understand the benefits and importance of these plants to permaculture theory.

Students also desired to learn more about how to apply permaculture to a larger scale. Seventeen percent of students in 2015 mentioned the lack of information in lectures when it came to permaculture principles on the larger scale. One student said, “I’d like to know how to get permaculture to work on a larger scale. It was mentioned, but it really feels like permaculture is meant for small-scale residential purposes”. This response stems from multiple research decisions. The first being; examples given in lecture were smaller in scale to give students ideas of what design elements and practices to apply in their design solution. The second research decision was to keep the design problem on a smaller scale in which students were comfortable designing. However, this posed a problem when students tried to apply principles to a larger scale as they only related and thought in small scales. The study could benefit by giving more examples of how permaculture principles can be used on the larger scale. It could also implement a sketch problem for students to complete on a larger site, or assign a simplified program for the design problem on a larger site.

The overall module organization in 2014 proved to be a problem for students. With lectures lasting for longer periods of time at the beginning of the module, students
had a difficult time paying attention and learning all that they needed to in order to understand the theory. One student mentioned, “It is always hard to sit through 3 hours of lecture. It would be nice to have a lecture (1 hr.) then studio, developing a part or phase of the project… then another lecture on the next phase and continue the design process and progress through lectures”.

**Strengths**

The first strength of this study was the topic of permaculture itself. Students, when asked if they would like to know more about permaculture principles for future projects, 78 percent of students in 2014 agreed or definitely agreed. In 2015, 84 percent of students agreed or definitely agreed to learning more about permaculture theory. Students were also asked if a permaculture class or lecture were given in their future home town, would they attend, many replied with an enthusiastic yes, 75 percent in 2014 and 58 percent of students responded yes in 2015.

At first glance, these two questions (1) learn more about permaculture, and (2) attend a lecture in the future, should correlate. However, students in 2015 had a much harder time accepting the principles of permaculture because there was no scientific research to back up its claims. Some comments in 2015 stated the need for more information and data to prove that permaculture really benefited the environment. Others mentioned the lack of time and doubt of their future employers being interested in this design theory to give them the time to attend a lecture in the future.

The second strength was the module organization in 2015. It proved much more effective than 2014. Splitting up the lectures and allowing studio time helped the students absorb bits and pieces through the entire module. This proved easier for them to
remember principles and concepts taught in combination with likening each principle to a step in the design process. A powerful tool, the graphic (see figure 3) was very useful in helping the students recognize each principle and use it within their personal design process.

The third strength of this study was using a combination of lecture-based and project-based learning. Eighteen percent of student responses in 2014 mentioned the benefit of applying what was taught to a real-world application for an actual client. They also mentioned the benefit of having to research plant varieties and their potential benefits in relation to the landscape. The 2015 showed a much more varied response when asked how the project helped them understand permaculture, ten percent mentioned the project helped in a very basic knowledge and foundation of permaculture theory.

Future Areas of Research or Exploration

If this permaculture instructional module were taught again, there are several things that should be added. The first is to streamline the lectures and include more information on topics mentioned through the post-module survey such as plant material and applying permaculture principles to a larger scale. The second addition to the module would be to evaluate student design solutions on aesthetic and design principles instead of just looking at how many permaculture principles were used. This would allow the grading criteria to include how well they learned permaculture principles and integrated them, but also how well they are able to take those principles and design them into a functional and beautiful space.

Another aspect of future research would be to create additional presentations on permaculture design theory to teach in shorter amounts of time. The lecture portion of the
module took approximately eight hours to complete. Additional research to create “mini presentations” would be beneficial in spreading the word about permaculture design theory to the general public instead of just students. These “mini presentations” could be given through university extension courses, conference addresses, and continuing education presentations.

Finally, permaculture theory, with a lack in scientific research, requires more time and interest among academia to test its claims. The majority of permaculture literature is written by non-scientists for the general public (Ferguson & Lovell, 2014). However, with an increase in general literature, scholarly articles and peer reviewed publications has increased from 33 percent of the total literature in 1978 to 71 percent in 2008 (Ferguson & Lovell, 2014). Other search engines have revealed 3,350 results found in Google Scholar and 50 results found in Web of Science. With research on the rise, permaculture needs more time in order to be considered more than a theory.

**Conclusion**

The study consisted of three objectives. The first objective was to develop an instructional module on permaculture theory and prepare to teach to juniors in the Landscape Architecture and Environmental Planning department at USU. The second objective was to implement the module and teach the students the lecture material developed and also assign a design problem to help students apply what they learned during lectures. The third objective was to measure the effectiveness of the instructional module and receive student feedback on the lecture portion and design problem of the module. The study completed all three objectives and gleaned information for future research and advancement in teaching permaculture theory.
This study illustrates the interest landscape architecture students have in permaculture design theory. Overall, information was well received with positive feedback and a desire to learn more in the future. Although covered briefly, permaculture principles can be applied to any site, no matter the scale. All it takes is creativity, imagination, and a knowledge of natural processes and resources. Foster (2009) emphasizes the importance of stewardship of the environment and understanding of natural resources to become a successful landscape architect. PDP’s aid in the process of understanding these natural resources, which is why it is so important for landscape architects to understand the importance of permaculture design theory.

Ian McHarg known for pioneering the concept of ecological planning illustrates an effective metaphor between a farm and a city. He says, “We think of a farm as a source of cereals, root crops, beef, mutton, poultry, and eggs; but of course, farms do more than this. Consider a very large bell jar, some miles in diameter. Place it over an area of farmland. The consequences will be very small; the plants produce oxygen for the system and utilize carbon dioxide which they respire, and which is also obtained from decomposition. The numbers of men and animals in the system affect it little, nor does it limit them.

Place the same bell jar over a city. If no gases can pass through the bell jar, then the inhabitants will shortly consume all of the oxygen and will asphyxiate. If they cannot dispose of human wastes, they will be encompassed in filth. If they cannot provide food internally or import it, they will starve. The city is the source of water pollution – natural water purification occurs elsewhere. But, not so on the farmland, which is largely a self-sustaining system” (1995, p. 98).
One might read this metaphor and question the overall meaning. While farms might be “largely self-sustaining” it is not everyone’s responsibility to purchase a farm and move to the countryside. This would not be economical, feasible, or enjoyable for many citizens. Healthy communities and economies need a wide variety of occupations other than full-time farming, such as medicine, business, science and research, creative arts, and design. Permaculture design theory informs designers and managers of the landscape of certain principles and practices to include within their design process in order to design with nature, rather than against it.
REFERENCES


http://doi.org/10.1080/00461520.1991.9653139


Retrieved from


APPENDICES
A. 2014 Lecture Slides
"In brief, it is a philosophy of working with, rather than against nature; of protracted and thoughtful observation rather than protracted and thoughtless labor; of looking at plants and animals in all their functions, rather than treating elements as a single-product system."
1 element = multiple tasks

Energy Efficient Planning

Zoning

Slopes

Sector Planning

Biological Resources

Chicken Tractors
Energy Recycling

Small-Scale Intensive Systems

Plant Stacking and Food Forests
Edge Planting  Vegetable Beds

A. 36 Plants  B. 45 Plants

Beds of equal area.
Plants at the same inter-row and in-line spacing.
In (A) we fit 36 plants, in (B) 45 plants.
"Straightness" can reduce yield.

THINK OUTSIDE THE BOX

X O X
X O X
O X O
O X X
X O X
O X X
O X O
Management of Plants and Animals

Building a Garden Soil

Special climate considerations

Hydrangeas are natural pH indicators. Blooms are blue in acidic soil and pink in alkaline soil.
Tanks and Dams

Swales

Siting Important Infrastructure
In Summary:

Resources used:

- Intro to Permaculture by Bill Mollison
- Permaculture: A Practical Guide for a Sustainable Future by Bill Mollison
- An essay on energetics: the Construction of the Aztec Chinampa System by Anzo and Abrams
- In the Sweat of our Brow: Citizenship of the American Domestic Practice During WWII by Miller
- Wasatch Community Gardens www.wasatchgardens.org
- http://www.utahweed.org/wrread_wread.htm
- Geofflawton.com
The Permaculture Home Garden

House Modifications

Waste Resources from the House

Garden Layout

Path Side Vegetables
Orchards

Terraced Orchards

Animal Systems
In Summary:

Resources used:

- Intro to Permaculture by Bill Mollison
- Permaculture: A Practical Guide for a Sustainable Future by Bill Mollison
- Permaculture by Sepp Holzer
- Geofflawton.com
- http://urbanhomestead.org/
- Earth User’s Guide to Permaculture by Rosemary Morrow

Project #3:
The Suburban Permaculture Landscape
Permaculture Community Strategies

Suburban Food Forest

Solar Orientation

Planned Suburban Areas
Cooperative Productivity and Community Responsibility
Paul Wheaton – Rich Soil

Joseph’s Garden

SLC Permaculture Project

Intensive Urban Gardening

Local Permaculture:
- www.treeutah.org/permaculture.html
- www.crmpl.org
- www.truenature.org
- www.sagesway.net/sages-way-project-gallery
- www.richsoil.com/permaculture
- www.slcpermacultureproject.wordpress.com
- www.rookgardenerpoet.blogspot.com
- www.facebook.com

In Summary:

Video’s and further resources can be found at:
GEOFFLAWTON.COM
B. 2015 Lecture Slides
Permaculture Instructional Module 2015

Lecture 1: Introduction

What's Happening Now?
Rob Davies from LSU Climate Center

History and Background of Permaculture

The Thinking and Design Revolution

Define

Prototype

What's Happening Now?
Rob Davies from LSU Climate Center

What's Happening Now?

What's Happening Now?
Rob Davies from LSU Climate Center

What's Happening Now?
Cradle to Cradle by McDonough Braungart

What's Happening Now?
Resilience Thinking by Walker and Salt

History and Background of Permaculture
Three Siblings System
Permaculture is a "philosophy of working with, rather than against nature; of protracted and thoughtful observation rather than protracted and thoughtless labor; of looking at plants and animals in all their functions, rather than treating elements as single-product systems."
The Thinking and Design Revolution

The landscape is a text book.

The Thinking and Design Revolution

Familiar is useful. So long as it lasts.

The Thinking and Design Revolution

Elegant solutions are simple. Even invisible.

The Thinking and Design Revolution

More is the smallest intervention necessary.

The Thinking and Design Revolution

Avoid too much of a good thing—everything in moderation.

The Thinking and Design Revolution

The problem is the solution.

The Thinking and Design Revolution

Recognize and break out.
C. Design Problem Statement
Background

The purpose of this assignment is for the student to design a landscape using permaculture principles to create an aesthetically pleasing suburban landscape that has multiple levels of functionality. Review permaculture principles from first lecture. Remember, permaculture is a design process, and for this project, the process needs to be shown.

The Clients

The clients for this project are Brent and Abby Stuart. They are in the process of building a near-net-zero home located in Uintah, Utah for retirement and/or young families. Brent is a construction administrator for an architecture firm in Salt Lake City, Utah. Abby is a stay-at-home mom who loves gardening. Both enjoy working in the yard, but are looking to downsize their current maintenance load to something more sustainable and easy to care for.

They hope to have a yard that is productive and aesthetically pleasing. Living in a suburban community, the property needs to maintain a high level of street appeal. Brent and Abby enjoy having company over to visit and would like space in the landscape for entertaining.

A little background on Net-Zero homes: “The simple answer would be that a Net-Zero home produces as much energy as it uses. Net-Zero homes produce solar energy during the day feeding excess to the grid and then uses energy from the grid at night. (GreenHomeBuilder)”

Because this particular home is near-net-zero, it produces some energy, but not all, through solar panels located on the garage roof, and saves energy with efficient appliances and Insulated Concrete Forms (ICF). ICFs serve as a forming system for poured concrete walls. The ICFs remain in place and become part of the wall structure insulating the home from the outside elements and keeping heat and AC inside the home. Picture oversized Lego’s!

Permaculture as defined by Bill Mollison; “Permaculture is the study of the design of those sustainable or enduring systems that support human society, both agricultural & intellectual, traditional & scientific, architectural, financial & legal. It is the study of integrated systems, for the purpose of better design & application of such systems.” Applying permaculture principles to a landscape surrounding a near-net-zero home ties the entire property together with an energy saving and sustainable bow. ☀ The home uses resources such as IFC’s and solar panels to reduce its footprint. Now it is up to you to design a landscape that uses existing resources to sustain itself.

Site Description

The project site is 2100 E. 6450 S. Uintah, UT 84405. (At the base of Weber Canyon) The near-net-zero home is located on the west side of the property with open space to the east. A garage is located in the center of the property, which you will have to design around. The site has some grade change, the steepest part being behind the house to the north. Approximately 100’ from the north property line runs train tracks that are used on a regular basis.
The street on the south side of the site allows on-street parking for guests and access to the driveway. There are no fences around the house; instead, privacy screens are preferred through the use of plant material. Buildings and driveways are already set in place; it is up to the student to provide pedestrian access from the street to the house and the driveway to the house.

The Program

The program of required elements from the client is listed below.

- Paved pedestrian access from the street to the house with a minimum width of 6’. Slopes must be less than 5% and some stairs are allowed. ADA access into the house is from the north side.
- Paved access for tenants from the driveway and garage to the house.
- Paved area (patio) of approximately 400 square feet with some type of shade structure for small outdoor gatherings and relaxation. Include an area for a grill and counter for outdoor cooking.
- Private area, screened from street view. The space will be used as an outdoor retreat or secret garden. Benches and/or chairs would be valuable in this space.
- Vineyard with a minimum of 15 vines.
- Small turf area(s). Cover at least the septic tank and drainage field.
- Annual vegetable garden(s); minimum of at least 200 square feet. (be creative)
- Fruit trees and berry bushes; minimum is 4 fruit trees and 10 berry bushes.
- Perennial beds
- Location for a 2,500 gallon rain water harvesting tank. (harvested from the home roof)
- Chicken coop/run large enough for a minimum of 10 chickens.

Other elements to consider: (permaculture pluses)

- Bioswale(s)
- Options to shade the house to reduce energy costs
LAEP 3500/6350 – Planting Design
Assignment: Suburban Permaculture Landscape

- Use of slope to utilize any run-off
- Low maintenance! (minimal weeding, dead-heading, lawn edging and no hedging)
- Screens and wind/sound breaks as productive systems.

You will not be required to provide a grading plan, however if you specify a retaining wall or other structure, please specify the location and how tall. Include soil elevation at base and top of wall – the house elevation is indicated on the provided plans.

Drain fields by regulation are not allowed to have any hardscapes or food production grown above them. Drain fields are located and labeled on the provided base map. Design accordingly.

The Assignment

For this assignment you will be preparing one design of the entire property for the client.

Teams of 4 will be formed for the project (1 team of 5) Graduate Students and Exchange Students will form their own teams.

Process

Base maps for this project will be provided as an AutoCAD file and PDF document on Canvas. Provided on the base map will be locations of existing buildings, home, garage, driveways, drain fields, property lines and grading.

Deliverables

Deliverables for this project will be due on October 29; when we present to the Stuarts.

You will produce 3-4 pages at 24x36 for this project. Elements that must be included, but not limited to:

1. Color rendered plan with function labels (excluding plant material)
2. Planting plan set at an appropriate scale and plant schedule
3. Inventory and analysis (think zoning and sector analysis)
4. An element list (I provided) with benefits and functions for each element
5. Precedent images

Abby would love to see some section elevations or perspectives to imagine the yard in 3D. Brent has no trouble reading plan views.

Deliverables can be produced through hand or computer graphics (quality matters). Each sheet should include a graphic title, a scale, north arrow and copious annotation.

Presentations will start promptly at 1:30. Come dressed appropriately with 11x17 copies for the Stuart’s to take home and review. Phil and I require 24x36 prints as well as digital copies for the presentations. I will provide the thumb drive to put everything on to prepare for the presentations.
D. Post-Module Evaluation Survey
Permaculture Evaluation - 2015

Please take your time, as this is going into my Thesis.

*Apart from the amount of time given for the project...*

1. How would you define permaculture?

2. How can permaculture be practiced on the larger scale? ie. Community, region?

3. How did you use the PowerPoints and/or lecture handouts in your design tasks?

4. What content from the lecture portion was directly applicable to your project?

5. Was there anything from the lecture that you would like to know more about? What permaculture topic should be covered in more depth?
6. Explain how the project helped or didn’t help your understanding of permaculture?

7. Was the time frame on only lectures sufficient? (I know it wasn’t enough time for the project)

8. I would like to know more about permaculture for future projects and how I can apply the principles to future designs? (Circle one)
   - Definitely agree
   - Agree
   - Neutral
   - Disagree
   - Definitely disagree

9. How will you use permaculture principles during the remainder of your time at USU?

10. If a permaculture lecture/presentation were given in your future home town, would you attend? Why or Why not?
THE NINE REGIONS AS DEFINED BY THE NATIONAL CLIMATIC DATA CENTER (NCDC) AND REGULARLY USED IN CLIMATE SUMMARIES

CLIMATE PREDICTION CENTER, NOAA
F. Post-Module Survey Coded Responses
2014 Responses (28 students surveyed):

Question 1: How would you define permaculture?

*Percentage of responses with the following key terms:*
- 50% - high yield
- 36% - sustainable
- 32% - design
- 21% - functional; systems thinking; multi-use/functionality
- 11% - efficient
- 11% - low maintenance
- 7% - long term/permanent; self-regenerative; benefit to community

Question 2: How can permaculture be practiced on the larger scale? Ie. Community/region, etc.

*Percentage of responses with the following key terms:*
- 46% - community/public gardens
- 29% - food production within parks/public spaces
- 25% - community benefit/cooperation
- 14% - productive vs. ornamental plants; community outreach and teaching

Question 3. How did you use the Power Points and/or lecture handouts in your design tasks?

*Percentage of responses with the following key terms:*
- 64% - reference material
- 18% - design inspiration and precedent images
- 18% - plant reference and possible combinations

Question 4. What content from the lecture portion was directly applicable to your project?

*Percentage of responses with the following key terms:*
- 43% - information on zone and sector analysis
- 18% - plant varieties and combinations
- 14% - information on guilds
- 14% - information and techniques to use and conserve water efficiently
Question 5. Was there anything from the lecture that you would like to know more about?

What permaculture topic should be covered in more depth?

*Percentage of responses with the following key terms:*

  - 21% - plant varieties, which plants to use in design
  - 18% - guilds
  - 14% - plant combinations and how they work together
  - 11% - design and garden layout

Question 6. Explain how the project helped or didn’t help your understanding of permaculture.

*Percentage of responses with the following key terms:*

  - 18% - real world applications and applying principles to an actual site
  - 18% - plant selection and benefits
  - 14% - good overall introduction to permaculture
  - 7% - look at design differently
  - 7% - understanding that permaculture is innovative
  - 7% - helped understand systems thinking

Question 7. Was the time frame on *only lectures* sufficient?

  - 61% - yes
  - 39% - no

Question 8: I would like to know more about permaculture for future projects and how I can apply the principles to future design

  1. Definitely agree – 32%
  2. Agree – 46%
  3. Neutral – 22%
  4. Disagree – 0%
  5. Definitely disagree – 0%
Question 9: How will you use permaculture principles during the remainder of your time at USU?

*Percentage of responses with the following key terms:*
- 21% - multi-use/functionality; productive vs ornamental plantings
- 18% - efficient/functional design
- 14% - elements of recycling (i.e. energy, materials)

Question 10. If a permaculture lecture/presentation were given in your future home town, would you attend?
- 75% - yes
- 18% - maybe
- 7% - no
2015 Responses (24 students surveyed):

Question 1: How would you define permaculture?

*Percentage of responses with the following key terms:*

- 46% - high yield
- 38% - sustainable
- 25% - reduce impact on environment
- 21% - systems thinking
- 17% - design; self-regenerative
- 13% - multi-use/functionality; efficient utilization of land

Question 2: How can permaculture be practiced on the larger scale? Ie. Community/region, etc.

*Percentage of responses with the following key terms:*

- 50% - community/public gardens
- 29% - production within parks/public spaces
- 13% - productive vs ornamental plants; community benefit/cooperation;
  community outreach and teaching

Question 3. How did you use the Power Points and/or lecture handouts in your design tasks?

*Percentage of responses with the following key terms:*

- 38% - reference material
- 25% - clarification and further understanding
- 25% - design inspiration and precedent images

Question 4. What content from the lecture portion was directly applicable to your project?

*Percentage of responses with the following key terms:*

- 42% - information on guilds
- 25% - information on zoning and sector analysis
- 25% - information on plantings
- 25% - information on multi-use functionality
Question 5. Was there anything from the lecture that you would like to know more about? What permaculture topic should be covered in more depth?

*Percentage of responses with the following key terms:*
17% - applying principles to the larger scale
17% - more information on which plant varieties to use
13% - more information on what plants work well together/plant combinations
13% - more examples of local practices

Question 6. Explain how the project helped or didn’t help your understanding of permaculture.

*Percentage of responses with the following key terms:*
10% - gave a good introduction and foundation of permaculture
8% - taught how to effectively and efficiently use the land
8% - taught systems thinking
8% - understood how detailed design decisions need to be
8% - taught how diverse and functional plants can be
8% - effectively taught to look at design differently

Question 7. Was the time frame on *only lectures*?

79% - yes
21% - no

Question 8: I would like to know more about permaculture for future projects and how I can apply the principles to future design

1. Definitely agree – 46%
2. Agree – 38%
3. Neutral – 12%
4. Disagree – 4%
5. Definitely disagree – 0%
Question 9: How will you use permaculture principles during the remainder of your time at USU?

*Percentage of responses with the following key terms:*

- 25% - multi-use/functionality
- 13% - productive vs ornamental plantings
- 8% - more conscious plant selection; detailed site analysis; elements of recycling; reduce impact on environment

Question 10. If a permaculture lecture/presentation were given in your future home town, would you attend?

- 58% - yes
- 0% - maybe
- 38% - no
PERMACULTURE INSTRUCTIONAL MODULE 2014

Why it’s Important? (Phil)

History of Practices

1. Sustainable gardening history
   a. Chinampas
   b. Victory Gardens

2. Beginning of Permaculture

Introduction to Permaculture

1. Definitions

2. Permaculture Ethics
   a. Care of Earth
   b. Care of People
PERMACULTURE INSTRUCTIONAL MODULE 2014

c. Sharing Resources

3. Earthcare ethics

   a. Think

   b. Use Native Species

   c. Small-Scale and Energy Efficient

   d. Diversity

   e. Bring food growing back into cities and towns

   f. Assist People

   g. Recycle all wastes

   h. See solutions, not problems

   i. Work where it counts

Permaculture Principles

1. Relative location

2. Performs multiple functions

3. Efficient energy planning

   a. Zoning
b. Sector analysis

c. Slopes

4. Use of biological resources

5. Energy recycling

6. Small scale intensive systems
   a. Plant stacking and Food forests

7. Diversity and polycultures
   a. Guilds

8. Use of the edge and natural patterns

9. Attitudinal principles
   a. Everything works both ways
   b. Permaculture is information and imagination-intensive

REMEMBER:

10. Work with nature, rather than against it

11. The problem is the solution

12. The limit to permaculture is the information and imagination of the designer
Site Analysis through the Permaculture Lens

1. Identify resources
   a. Base maps
   b. Observation
   c. Off-site resources

2. Landform (topography)

3. Climate and microclimate
   a. Topography
   b. Water masses
   c. Structures
   d. Vegetation

4. Soils
   a. Management of plants and animals
   b. Broadscale soil reconditioning
   c. Building a garden soil
   d. Special climatic consideration
5. Water
   a. Water collection and dispersal
   b. Swales
   c. Tanks and dams
   d. Water diversion and storage in Drylands

6. Siting important infrastructure
   a. Access
   b. The House
   c. Fencing
   d. Deciding priorities

7. Design for catastrophe
   a. Fire

Pattern Understanding

1. Pattern in nature
2. Pattern in design

Summary
PERMACULTURE INSTRUCTIONAL MODULE 2014

House Modifications

Waste Resources from the House

Introduction to the Home Garden

Garden Layout

1. Kitchen door herbs
2. Pathside vegetables
3. Narrow beds
4. Broad beds
5. Barrier hedges
6. Vines and trellis

Garden Elements

Urban and Suburban gardens

1. Small urban space
PERMACULTURE INSTRUCTIONAL MODULE 2014

2. suburban lots

Cold Area Garden Design

Dry land Gardens

Food Forests

1. orchards

2. structural forests

Animal systems and Aquaculture

1. Needs

2. Products

3. Functions

Chicken "tractor" system

Permaculture Application

1. NDFS Garden Sketch

Summary
Introduction to Community Strategies

Growing Food in the City

Planned Suburban Areas

1. Solar orientation
2. Water drainage
3. Greenbelts & common areas
4. Shared resources & food production

Community Recycling

1. Separation of refuse at the source
2. Organic waste
3. Recoverable material

Community Land Access
1. Community gardens

2. Farm link: producer-consumer cooperative

The Permaculture Community

Where in Utah is Permaculture?

Summary
H. 2015 Lecture Outline
PERMACULTURE INSTRUCTIONAL MODULE 2015

LECTURE 1: INTRODUCTION

WHAT'S HAPPENING NOW?

- Rob Davies: USU Climate Center

- William McDonough & Michael Braungart: "Cradle to Cradle"

- Brian Walker & David Salt: "Resilience Thinking"

HISTORY

- Intercropping systems (three sisters)

- Chinampa systems in Central Mexico

- 1800's – chemical use
- 1920's – organic gardening movement
- 1930's – agroecology (very research based)
- 1960's – agroecology implemented design
- 1972 – Bill Mollison and David Holmgren developed “Permaculture”
  - Care of earth
  - Care of people
  - Set limits to consumption and reproduction, and redistribute surplus
THE THINKING AND DESIGN REVOLUTION

9 design thinking guidelines

1. All observations are relative

2. Top-down thinking, bottom-up action

3. The landscape is a textbook

4. Failure is useful so long as we learn

5. Elegant solutions are simple, even invisible

6. Make the smallest intervention necessary

7. Avoid too much of a good thing – everything in moderation

8. The problem is the solution

9. Recognize and break out of design cul-de-sacs

LECTURE 2: DETERMINE YOUR NEEDS

CATCH AND STORE ENERGY
- Water

- Living soil

- Trees

- Seed

- Energy recycling

- Practices

**OBTAIN A YIELD**

- Hardy self-reliant species

- Increasing fertility
- Utility vs cosmetics

- The food production strategy

- Timing and flexibility

- Practices
  - Small scale intensive systems
  - Garden layout
  - Diversity
  - Animal systems and aquaculture

PRODUCE NO WASTE

- Waste minimization
  - Refuse
  - Reduce
  - Reuse
PERMACULTURE INSTRUCTIONAL MODULE 2015

- Repair
- Recycle

- Practices

LECTURE 3: INVENTORY AND ANALYSIS

OBSERVE AND INTERACT

- Observe, recognize patterns, and appreciate details

- Practices
  - Soil
    - Perennials vs annuals
    - Multiple stories
    - Plant communities
    - Stacking functions

APPLY SELF-REGULATION AND ACCEPT FEEDBACK

- Self-regulation
PERMACULTURE INSTRUCTIONAL MODULE 2015

- Nurturing, negative feedback and self-regulation in managed systems

- Practices

USE AND VALUE RENEWABLE RESOURCES AND SERVICES

- Criteria for using renewable resources

- Practices
  - Off-site resources
  - Climate and micro-climate
  - Soils
  - Water
  - Efficient energy planning
Zoning

Sector planning

Slopes

LECTURE 4: FUNCTIONAL DIAGRAMS

DESIGN FROM PATTERNS TO DETAILS

Patterns
  - Symmetry
  - Spirals
  - Branches
  - Cracking patterns and nets
  - Waves
  - Meanders
  - Fractals
- Pattern in design
PERMACULTURE INSTRUCTIONAL MODULE 2015

- Siting important infrastructure
  - Contour pattern
  - Sun/shade pattern
  - Slopes

- Design for catastrophe
  - Fire
  - Flooding

INTEGRATE RATHER THAN SEGREGATE

- Integration in nature

- Each element performs many functions

  - Analysis of the chicken

- Each important function is supported by many functions
- Segregation vs integration

- Practices
  - Companion planting
  - Guilds

LECTURE 5: CONCEPT DIAGRAMS

USE SMALL AND SLOW SOLUTIONS

- Permaculture scale
  - Small scale minimum movement alternatives
  - Too large, too fast
  - Small and slow

USE AND VALUE DIVERSITY

- Balancing productivity and diversity
PERMACULTURE INSTRUCTIONAL MODULE 2015

- Landscape patterns of diversity and specialization

- Security from diversity

- Diversity debate in permaculture

USE EDGES AND VALUE THE MARGINAL

- Landscape edges
  - Coastline
  - Ecotones
  - Land systems

- Edge in cultivated landscapes
  - Old England
  - Mediterranean terracing

- Urban examples of using the edge
  - Urban/rural fringe
  - City shop fronts

- Practices
LECTURE 6: FINAL DESIGN

CREATIVELY USE AND RESPOND TO CHANGE

- Flexibility
- Attitude
- Everything works both ways

COMMUNITY STRATEGIES

- Urban and suburban strategies
- Small urban space
- Suburban lots
- Cold area garden design
- Dryland gardens
PERMACULTURE INSTRUCTIONAL MODULE 2015

- Applying permaculture principles

- Planned suburban areas

- Permaculture in Utah
Permaculture is all about design. For this exercise you are to create a basic design for the USU Permaculture garden.

This garden will be used by NDFS students in their cooking classes and for events. Included in the garden should be space for herbs, annuals vegetables, perennial medicinal plants, fruit trees, and shrubs.

Start with analysis (sectors) and concepts, then finalizing basic layout.
J. Design Problem Grading Rubric
<table>
<thead>
<tr>
<th>Evaluation Consideration</th>
<th>Comments</th>
<th>Excellent</th>
<th>Good</th>
<th>Adequate</th>
<th>Poor</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of Design Issues (Both Objective and Subjective Criteria)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the design represent a serious effort at the production of a quality design?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does it reflect creative thought or does it appear to be simply a thrown-together quickly without thoughtful consideration? (are there obvious design missteps?)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the design meet all stated program requirements?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the design reflect knowledge and understanding of Permaculture Principles as demonstrated in site development and element locations?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Graphic Presentation Issues / Quality of Deliverables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legibility of graphic images: Is clear, clean drawings. Are line weights appropriate &amp; accurate? Good line quality?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lettering: Is the text clear, direct, and understandable? Is lettering consistent? Are all notes written in the same style &amp; size? Is it neat? Well-arranged &amp; composed? Are leaders appropriately drawn? Do leaders cross or are they entangled with dimensions? Do the leaders have a termination? Are all reference notes, callouts, and flags in place?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet Layout Issues: Each sheet will be evaluated for these criteria:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there a title block and does the title block contain all pertinent information? Course &amp; Instructor included? All team members included. Is the same title block?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Used on all sheets? Is there a scale? North arrow?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Are the graphic images arranged and composed well on the sheet?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does each graphic image have its own title in addition to the sheet title? Are titles, notes, references, and other text composed and laid out well? Is there a ‘graphic’ title on master plan sheet?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Deliverables produced per program?</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>❏ 11 x 17 copies to client;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>❏ digital copies to client;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>❏ digital copies to instructor;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>❏ 24 x 36 originals to instructor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Process Issues:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Was the project completed on time?</td>
</tr>
<tr>
<td>Did the team demonstrate &amp; follow a clear design process including inventory/analysis, functional and/or conceptual diagrams, and at least two or three conceptual alternatives before finalizing a master plan concept?</td>
</tr>
<tr>
<td>Were all stages of the process reviewed with instructor? With the TA? With Peers?</td>
</tr>
<tr>
<td>Were all stages handed in?</td>
</tr>
<tr>
<td>Quality of Client Presentation?</td>
</tr>
<tr>
<td>Professional in verbal presentation, graphic presentation, appearance?</td>
</tr>
</tbody>
</table>

|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
|                                                        |
K. 2014 Highest Scoring Design Solution
Let It Grow
Stuart Family Self-Contained Permaculture Design

Inventory

The inventory was collected on a site visit to the Stuart home. The key points that were made during the visit were:

- Soil type
- Topography
- Vegetation
- existing structures, and planting restrictions. It was quite helpful to be able to see the locations of structures and how they beheld or played their role within the site so as to plan with them instead of just find our design working against them.

Analysis

The Analysis focused on what we could do or couldn't do and what we should do or shouldn't do. Combining the gathered inventory with the determined elements made the analysis a seamless endeavor, ensuring our design to develop with confidence.

Zone Map

The Zone Map is a predetermined observation of what locations are and how frequently. When determining these zones it was important to note circulation behaviors, desirability, and pleasant or unpleasant characteristics.

Legend

- Suitable for residence
- Suitable for water collection
- Suitable for dry storage
- Suitable for potable water
- Suitable for food production
- Restricted area
- Pathways to be preserved
- Existing roads
- Additional considerations

Concept Diagrams

Concept Diagrams are a necessary step in the design process to ensure a solid design. It is important to realize that a great design only comes after several good design concepts, and the Stuart Permaculture garden is no exception. After drawing and refining concept after concept, we are confident in the chosen tools.
Let It Grow
Stuart Family Self-Contained Permaculture Design

Rain Water Catchment System
A very important element to the Stuart Family Permaculture Design is the Rain Water Catchment System. Not only does this system collect clean water for use at the farm, it also increases the efficiency of water management, a priority in Utah and all over the world. The design for this system is intended to be rainwater harvesting, with the holding tank of 2,600 gallons, which would be filled by rain falling on the roof of the covered area (a roof area of 1,000 square feet). This system will help to reduce the need for irrigation and water usage on the farm.

Design Plan

Legend

Produce and Compost: The compost bin will be placed to the left of the greenhouse, and the produce will be harvested and distributed from this area. The greenhouse will be separated from the rest of the farm by a tree line, and the produce will be stored in the building or in the greenhouse. The compost will be used to fertilize the garden, and the produce will be used for food.

Rain Water Catchment: The rain water will be collected from the roof and stored in the holding tank. The water will be used for irrigation, and the excess will be diverted to the garden.

Fresh Trees and Berries: Fresh trees and berries will be grown on the property, and the fruit will be harvested and used for food.

Vegetable Garden: The vegetable garden will be located on the property, and the vegetables will be harvested and used for food.

Hedge Row: The hedge row will be planted to provide privacy and separation between the property and the road.

Safety: The safety of the children will be a priority in the design, and the garden will be designed to be safe for children.

Composting: The composting system will be located in a separate area, and the compost will be used for the garden.

Rainwater Harvesting: The rainwater harvesting system will be installed to collect rainwater for the garden.

Beehives: The beehives will be placed in the garden, and the bees will be used to produce honey.

Garden Pool: The garden pool will be used for irrigation, and the excess water will be diverted to the garden.

Garden Path: The garden path will be used to connect the different sections of the garden.

Schematic Design
Utah State University
LAEP - JSM00 Project
Photo:
October 23, 2014
**Let It Grow**

Stuart Family Self-Contained Permaculture Design

---

**PLANT LIST**

Utah State University
LAEP - 3500
PHD White
October 23, 2014
L. 2014 Lowest Scoring Design Solution
Program Elements

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building</td>
<td>Provides a barrier to the eastern side of the house.</td>
</tr>
<tr>
<td>Parking</td>
<td>Provides adequate parking for the site.</td>
</tr>
<tr>
<td>Access</td>
<td>Provides access to the house.</td>
</tr>
<tr>
<td>Storage</td>
<td>Provides storage for the site.</td>
</tr>
<tr>
<td>Security</td>
<td>Provides security for the site.</td>
</tr>
</tbody>
</table>

Design Intent

The design intent for the house is to create a permeable design while keeping the site very functional, as well as aesthetically pleasing. After walking with Brent, it became clear that the design should include areas for a variety of uses. Permeable design deals with saving energy and resources. To create a permeable design, the site's four important elements are provided. These include two water retention tanks, space for growing vegetables and fruits, an area for children to play, and shaded, covered walkways, porches, and shaded rest areas, and as well as other aesthetic elements which serve multiple purposes. Also included in the design is space for relaxation and passive recreation. The use of native stone and plant material contributes to the identity and feel of the site.
M. 2015 Highest Scoring Design Solution
STUART RESIDENCE
PERMACULTURE DESIGN

INVENTORY & ANALYSIS

Permaculture in Utah requires a thoughtful process that hybridizes the production-intensive principles of permaculture with the necessary adjustments that make gardening in a cold, dry climate a sustainable practice. For the Stuart residence, our goal was to design a productive, yet easily maintained, fully integrated landscape. Creating a low-stress yard was one of the main challenges of this site. It needed to be a place to entertain guests, relax, accommodate family, and also foster a symbiotic relationship with the bounty of nature.

We analyzed view sheds, circulation, water flow, and shade before moving on to creating concepts. We determined the axis from the east window towards the mountains was the most important desire line to pursue. We also mapped out where water naturally flows over the site and placed plants and the cistern accordingly. Along with water, shade was the other determining factor for where to place plants and features.

Our final concept made use of the strong axis implied by the home’s eastern kitchen wall. Site features such as a private garden, seating areas, orchard, and chicken coop line the radial walkway while the back and front yards serve as separate grow and relaxation spaces.
**Permaculture Design Elements & Functions**

**Incorporated Permaculture Principles**

- Catch and Store Energy: Catch energy from the environment, store it for later use.
  - Use solar energy, wind power, etc.
- Integrate Rather Than Separate: Work with nature, not against it.
  - Plan systems that naturally work together.
- Produce no Waste: Use resources efficiently, leaving no waste.
  - Compost, reuse materials.
- Use and Value Diversity: Utilize variety in design and function.
  - Mix crops, use different species.
- Creatively Use and Respond to Change: Flexibly adapt to change.
  - Design systems that can adapt to changing conditions.
- Use Small and Slow Solutions: Opt for gradual, sustainable changes.
  - Start small, build up.
- Observe and Interact: Understand what is happening in nature.
  - Learn from nature, design accordingly.
- Use Edges and Valleys the Right Way: Maximize natural processes.
  - Use edges for biodiversity, valleys for water management.
- Obtain a Yield: Harvest resources sustainably.
  - Collect, harvest, gather.
- Appropriate Culture and Accept Feedback: Adapt to local conditions.
  - Incorporate local knowledge and feedback.
- Design from Patterns to Details: Start with broad principles.
  - Then refine in detail.

**Vegetable Guilds**

Plant guilds are nature’s way of demonstrating the benefits of symbiotic relationships in plant communities. With a little research, we were able to determine which plant guilds best fit the site conditions of the UnEarth residence and then implemented them into the design. While we did not specify vegetables, leaving it up to the client to decide which they would like to propagate, we thought it was important to provide options that work well together.

**Compost**

**Hugelkultur**

**Chicken Coop & Greenhouse**

**Guild Structures**

**Element** | **Function** | **Benefit**
---|---|---
Red gill | Growing frame that allows visibility to the plants | Allows for better air circulation and temperature control.
Straw bale Bricks | Insulates the structure, helps retain heat | Reduces the need for additional heating and cooling systems.
Aquaponic | Combines aquaculture and aquaponics | Reduces water usage and provides a sustainable food source.
Permaculture bed | Increases soil fertility | Enhances crop yields and reduces the need for synthetic fertilizers.
Compost | Improves soil structure and nutrient content | Increases soil fertility and water retention.
Earthworms | Break down organic matter | Increases soil fertility and water retention.
Differentiation of soil types | Improves plant growth and health | Enhances crop yields and reduces the need for synthetic fertilizers.
Selective planting | Balances the ecosystem | Enhances soil fertility and reduces the need for synthetic fertilizers.
Selective pruning | Increases fruit production | Enhances crop yields and reduces the need for synthetic fertilizers.
Random planting | Increases biodiversity | Enhances soil fertility and reduces the need for synthetic fertilizers.
The rear of the house is as much about relaxation and event hosting as it is about production. Tiered herb gardens mixed with native plants means you don’t even have to bend over to gather that mint for afternoon drinks on the raised deck.

Utilizing the eastern edge of the site, the vineyard pergola offers a private space within the high-production area. After tending to the crops, trimming the trees, and tending the chickens, this is a great space to kick back with a glass of fresh squeezed grape juice.
Our planting plan takes full use of the 200-gallon water cistern located near the high point of the property. Water from the garage and house roof provides supplemental water to the rear terraced gardens. It also runs along the top of the sodum cist wall to collect for later use in the cistern. This water funnels down to a scale which follows site contours to disperse gathered water across all planting beds.
N. 2015 Lowest Scoring Design Solution
LAEP 6350-Planting Design  STUART’S PERMACULTURE GARDEN

MASTER PLAN

SECTOR ANALYSIS
The environmental impacts that affect the area were identified and located in relationship to the home. These helped form the placement of elements.

ZONE ANALYSIS
This map shows where each zone should generally be located. The zones which were attached to each program element were used to create the concept diagram.

PROGRAM ELEMENTS & FUNCTIONS

1. Small patio/private retreat
   - private gathering
   - study opportunity
   - light for outdoor gatherings

2. 2500-gallon rain water harvesting tank (underground)
   - build-up water collection
   - non-water collection

3. Terraced annual vegetable gardens
   - edible
   - edibles
   - aesthetic
   - sense of seasons
   - maintain seating

4. Perennials/annuals
   - most will do
   - before your review
   - setup for diversity
   - calls attention to house

5. Flagstone pathways
   - pedestrian access
   - challenges opportunity for vegetation between flagstone

6. Chicken coop and run for 10 chickens
   - feed source
   - recycle soil
   - integrity attractive for guests

7. Orchards
   - aesthetic
   - edible
   - screening
   -_nr
   - variety
   - space

8. Berry bushes
   - screening
   - aesthetic
   - edible
   - creates noise
   - defines space

9. Pergola
   - opportunity for growing vertical elements
   - edible gathering or sense of secret garden

10. Large outdoor area
    - fully gatherings
    - open space for flexible programming
    - landscape for flexibility in programming
LAEP 6350-Planting Design  STUART’S PERMACULTURE GARDEN

CONCEPT AND SCHEMATICAL DIGRAMS

After learning of permaculture principles, there was a need to guide our design program elements. This began on site inventory and analysis with sun, shade and where water runs on the site. These program elements were placed where existing situations were already ideal.

The form of all key shaped from the programs with strong axial lines governing flow throughout the site. This resulted in a combination of straight and curvilinear lines to generate the organic nature of the permaculture principles of the site.

WATER ANALYSIS

35 INCHES OF EVAPOTRANSPIRATION

12 INCHES OF RAINFALL

8,200 GALLONS CAPTURED

184,500 GALLONS NEEDED

WATER DEMAND

CANAL WATER SUPPLY

<table>
<thead>
<tr>
<th>TYPE</th>
<th>SF</th>
<th>KG</th>
<th>GAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GARDEN</td>
<td>1443</td>
<td>1</td>
<td>50,854</td>
</tr>
<tr>
<td>TREES</td>
<td>3342</td>
<td>1</td>
<td>72,511</td>
</tr>
<tr>
<td>TIER</td>
<td>4176</td>
<td>0.8</td>
<td>73,234</td>
</tr>
<tr>
<td>NATIVE</td>
<td>1135</td>
<td>0.1</td>
<td>2,478</td>
</tr>
<tr>
<td>TOTAL</td>
<td>8130</td>
<td>1.9</td>
<td>184,666</td>
</tr>
</tbody>
</table>

245 YEAR ROI

CANAL SUPPLIES MAX OF 70 GALLONS PER MINUTE OR 68,000 PER MONTH DURING ALLOTED SHARE TIME

PRECEDENT IMAGES
We used the permaculture design process to create a sustainable, productive, and functional landscape design. We first determined the needs of the design. Second, we created and inventory and analysis of the sites resources. Third, we explored functional diagrams to match the family and landscape needs. Fourth, we created concept diagrams to piece together each element in their appropriate spot. And finally, we created an aesthetically pleasing design that meets the functional and concept diagrams criteria.

LAEP 6350-Planting Design  STUART’S PERMACULTURE GARDEN

MASTER PLAN

SECTION 1.

SECTION 2.

PERSPECTIVE 1.

PERSPECTIVE 2.

PERSPECTIVE 3.

BLOOM CHART

Malus domestica
"Golden Delicious"
Prunus armeniaca
Prunus persica
Allium atropurpureum
Amelanchier alnifolia
Antimimum majus
Artemisia "Peeled Castle"
Rosa woodsii
Salix sericea
Fragaria vesca "Wild Park"
Rubus idaeus

Design Process using Permaculture Design Principles
O. Module CD and Instructional Module Digital Commons Link

http://digitalcommons.usu.edu/student_work/
GLOSSARY
Of Commonly Used Terms

**Agroecology:** the ecology of food systems (Francis et al., 2003).

**Biomimicry:** a new science that studies nature’s models and then imitates or takes inspiration from these designs and processes to solve human problems, e.g., a solar cell inspired by a leaf (Benyus, 2002).

**Coastline:** shallow waters filled with nutrients that support fish, wildlife, and coral (Holmgren, 2002).

**Companion planting:** the placing of vegetables and herbs next to each other for beneficial growing effects on another, helping to deter pests, and attract pollinators (Holmgren, 2002).

**Copy:** something that is or looks exactly or almost exactly like something else: a version of something that is identical or almost identical to the original (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Ecotone:** an edge between two bio-regions where the disturbance of species from both regions overlaps, creating greater biodiversity than in either of the respective regions (Holmgren, 2002).

**Eutrophication:** excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Food forest:** edible ecosystems; a consciously designed community of mutually beneficial plants and animals intended for human food production (Jacke, 2005).

**Food miles:** the distance food has been transported between primary production and consumption (Paxton, 2005).

**Function:** to work or operate in a proper or particular way (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Guild:** a human-made assemblage that mimics a natural community, often times designed around a tree species that supports the guild” (Hemenway, 2001).
**Herb spiral:** mounded garden with structure held by stones or bricks and spiraling upwards, usually planted with herbs close to kitchen doors (Mollison, 2004).

**Horticulture therapy:** treatment activities focused on the cultivation of plants (Lundgren, 2004).

**Keyhole garden:** garden area, either raised, sunken or flush formed with stones or bricks in the shape of a keyhole in order to increase the production edge and allow easy accessibility (Mollison, 2004).

**Mimic:** a person who copies the behavior or speech of other people: a person who mimics other people; also: an animal that natural looks like something else (“Merriam-Webster Dictionary and Thesaurus,” n.d.)

**Monoculture:** the cultivation of a single crop in any given area (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Natural environment therapy:** practice of exposing patients to natural environments or to any natural occurring entity (Lundgren, 2004).

**Nature based therapy:** patient treatment focusing on three different types; animal-assisted therapy, horticultural therapy, and natural environment therapy (Lundgren, 2004).

**Permaculture:** creative design process based on whole-systems thinking that uses ethics and design principles (Mollison, 1990).

**Plant stacking:** when several different varieties of plants occupy the same area and use each other’s characteristics to grow (Mollison, 2004).

**Polyculture:** the simultaneous cultivation or exploitation of several crops or kinds of animals (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Practice:** a locally adapted habitual or customary action or way of doing something (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Principle:** a universally adapted basic truth or theory; an idea that forms the basis of something (“Merriam-Webster Dictionary and Thesaurus,” n.d.).

**Rainwater harvesting:** method for inducing, collecting, storing, and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers, 1994).

**Regenerative design:** replacing the present linear system of throughput flows with cyclical flows at sources, consumption centers, and sinks (Lyle, 1994).
Resilience: the capacity of a system to absorb disturbance and still retain its basic function and structure (Walker, 2006).

Sector Diagram: analysis wild energies and elements coming from outside the site and passing through it (Mollison, 2004).

Self-organization: the capacity of a system to make its own structure more complex (Meadows, 2008).

Self-regulation: the ability for a landscape to take care of itself through natural functions and processes (Holmgren, 2002).

Sustainability: when environment, economics, art, and community are combined in harmony with the dictates of the land and needs of society (Moses, 2007).

System: a set of things; people, cells, molecules, or whatever, interconnected in such a way that they produce their own pattern of behavior over time (Meadows, 2008).

Zone Planning: to place elements within the landscape according to how much it is used or how often it needs to be serviced (Mollison, 2004).