CONTEXT SENSITIVE DESIGN: A NON-TRANSPORTATION EXAMPLE IN MICHIGAN

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ABSTRACT

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In recent decades, the conflict between environmental degradation and development of human society is has been exacerbated. This situation engages planners and designers to minimize the negative human impact, protect and create a healthy ecosystem, reclaim degraded environments while also encouraging a healthy business and cultural climate. Context sensitive design is a philosophy which can help foster such an approach accommodating environmental issues and striking a balance between stakeholders to create an environmental friendly project. In this study, I applied a Context Sensitive Design philosophy for a Ski Resort project in Michigan. I evaluated and compare the Context Sensitive Design project outcomes with three other design solutions/treatments: a Housing Unit design using Le Corbusier's theory for structures, a Forested Woodland Community and an Abandoned Surface Mine condition. To compare the project treatments, I employed a visual quality equation, two habitat models, surface water runoff, and a vegetation diversity index. The statistical results indicated that the Forested Woodland Community was significantly better than the Abandoned Surface Mine condition, but the other treatments were not significantly different from each other.

Key words: Environmental Design, Landscape Architecture, Habitat Design, Urban Planning, Landscape Planning, Surface Mine Reclamation.

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This thesis is dedicated to my parents who have given me the great opportunity to pursue my master degree and the support throughout my life.

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Chapter 1: Literature Review

As a designer or planner, people always should consider the complicated factors associated with people and natural environment surround a building or in a community. The famous landscape architect and urban planner Tom Turner (1996) pro-claimed a planning and design philosophy concerning these complicated factors to produce acceptable results in his book "City as Landscape: A Post-postmodernism View of Design and Planning". He pointed that design and environment should have "the appropriate relationship" (p. 108). With the similar original intention, the Federal Highway Administration (FHWA) and American Association of State and Highway Transportation Officials (AASHTO) cosponsored a national workshop in 1998; the theme of the workshop was "Thinking Beyond the Pavement" and also put forward a term "context sensitive design" and encouraged this idea as a planning and design philosopy throughout the country. The paper is mainly about the relationship between the context between a place or site and the proposed design, thereby formulating the theory of context sensitive design.

1.1. Post-postmodernism

In the long history of human society, each era will be branded with a label to describe the ideas, movements, characters and practices in each field, such as culture, theory, philosophy, literature, art, architecture, planning and landscape. Our society has recently experienced modernism, postmodernism, and we are now in post-post modernism (Turner, 1996).

1.1.1. Modern timeframe

The modern timeframe began approximately from European Renaissance in sixteenth century until Industrial Revolution in nineteenth century. In this era, Traditional Architecture dominates as the primarily architectural philosophy in Europe and United States. The characteristic of Traditional Architecture is mainly following established principles from Greco-Roman times. In this hierarchical society, architecture and city planning all reflect the will of ruling class. The architecture philosophy is famous of its form and ornamentation, most of the building in that time is shaped as either rectangle or square, abundant in columns, size and decoration (Ramroth, 2006, p. 14).

However, in the end of this period, the revolution brought dramatic changes in our society, people's life style, values and thoughts were changing as well. In this social environment, architecture theory is affected and inclined to focus upon function and technology in building instead of the geometry of visiaul perfection. "This functionalization of architectural theory implies its transformation into a set of operational rules, into a tool of an exclusively technological character", states Alberto Pérez-Gómez (1983) who traced the changes in architectural intentions in his book.

1.1.2. Modernism

In broader scale, the term modernism describes the period from the end of Industrial Revolution in late nineteenth century, to twentieth century (Turner, 1996, p. v). In this period of time, the rapid growth of technological advancement made the society experience earthshaking changes. The main characteristic of modernism is pragmatic. Modernism is questions the thoughts of the previous age, rejecting traditional forms of arts, architecture, literature, religious, values and life styles; modernism created a new system to correspond with a new society, economy and politics in the industrialization era. Schoenbach (2012) claimed in her book that "modernism continues to be defined by its celebration of heroic opposition, its clean break from the past, its anti-institutional stance, and its emphasis on shock and radical discontinuity" (p. 4). She also mentioned "pragmatic demonstrated an understanding of and a respect for the weight and the power of history, yet it refused to associate habit exclusively with the past" (p. 12).

For architecture, the modernism style was adopted continuously as a dominant architecture style into twenty-first century, widely known as modern architecture. Ramroth (2006) summarized five differences between Traditional Architecture and Modern Architecture:

1. In Traditional Architecture, concept and realization were two things without so much connection. In Modern Architecture, concept and realization are closely connected.
2. In Traditional Architecture, the architect was just an artist, and not allowed to create with their own will; all the architects service the hierarchy class. In Modern Architecture, the architect works as a professional, and is hired by public and private client.
3. Traditional buildings are monumental works for owners. Most of the modern buildings serve for public use.
4. Traditional buildings are focused on exterior appearance. Modern buildings are more focus on function, form follows function.
5. Traditional buildings must be treated as art, and Modern buildings must be useful and functional.

6. Traditional Architecture served the ruling class and there were few budget limitations. Modern Architecture served the public and was a times cost conscious (p. 97).

For Modern Architecture, one of the characteristic is that the rapid growth of cities and technology skills gave architects more pragmatic views, and made them give efforts to reconcile architectural philosophy and design with current social changes and technology development. In modernist times, the architect is not a tool for ruling class anymore; they do not need to design building to please them. On the contrary, in this era, architecture is a collaborative project which begins to facilitate different social groups involvement in it, and the architect assumes to more responsibilities in the whole process. Since cost and schedule are the consideration, design solutions are reviewed, commented, modified by people, including clients, building users, stakeholders and others groups in the community (Ramroth, 2006). In this circumstance, the architect needs to apply a pragmatic view to design and also balance the different interests of each group.

The idea of rejecting the past is another characteristic. The pioneers of modernism believed that in the new modern world, a new spirit existed, and architectural philosophy needed a new spatial vision. Unlike the Traditional Architecture, which pursed meaningful centre and axes, decorative motifs, and totalitarian patterns (Norberg-Schulz, 2000, p. 11), Modernism was more concerned about material use, geometric form, space and function. The new conception for space resulted from the development of science and technology, that the pioneers of modernism describe as “mobility”, “openness”, “interaction”, and “simultaneity”. Due to both the media of architecture and transportation systems, there were new possibilities of simultaneity, integration with the surface of earth, and the establishment of anew interactive relationship between inside and outside. And the invention of iron-and-glass structures set free the load-bearing wall, creating more possible choices of special organization, and last but not least, giving the architect the option to explore the vertical space (Norberg-Schulz, 2000, p. 23).

Several notable architects represent the architectural theory and lead the architectural movement in this time which include Frank Lloyd Wright, Walter Gropius, Louis I Kahn, Ludwig Mies van der Rohe, Le Corbusier and Oscar Niemeyer. The aain features and elements of Modern architecture can be seen in both Wright's and Le Corbusier's master works.

Wright was widely known for his organic architecture (meaning a program derived orchestration of the space), his impressive works are throughout the United States. He had a low opinion about the typical skyscraper and paid more attention to coordinate his designs with the natural environment. Wright's philosophy about organic design and the flowing space of connected uses can be seen from his master work, Robie House (Figure 1) and Fallingwater (Ramroth, 2006, p. 144).

Figure 1: Robie House, a representative organic work of Frank Lloyd Wright, located in Chicago, Illinois. Copyright ©2011 Yun Wang, all rights reserved, used by permission. For

Figure 1 (cont'd)
interpretation of the references to color in this and all other figures, the reader is referred to the electronic version of this thesis.

Le Corbusier was another influential architect in Modernism, he had a unique styles of his own, not only the interpretation of natural environment, but also the perception of ideal city, he advocated the vertical city as the perfect dwelling for universal man (Choay, 1960, p. 19). Corbusier had five points for architecture, including using columns to lift the structure, long strips of ribbon windows, free facades, open floor plan and roof garden. Because of the reinforced concrete system, facades and interior space can no longer be fettered by supporting walls; he used this system to create the consecutive spaces, unencumbered views, and he used roof garden to compensate the green space be consumed by building (Norberg-Schulz, 2000, p. 16-17). For city planning, he considered that create a large scale planning could improve living condition, physical and mental health, increase freedom and bring positive social changes in large cities (Ramroth, 2006, p. 150), which high-rise comprehensive apartment building are scattered in green space. Le Corbusier (1986) described the vertical cities as:

> Reinforced concrete and steel allow of this audacity and lend themselves in particular to a certain development of the façade by means of all windows have an uninterrupted view…In these towers… all the necessary services… will be assembled, bringing efficiency and economy of time and effort… At the foot of the towers would stretch the parks… The setting out of the towers would form imposing avenues; there indeed is an architecture worthy of our time (p. 57-58).

1.1.3. Postmodernism

The post-modernism follows after modernism and begins to compete with modernism in the middle of twentieth century, it attempts to keeps good things about modernism and emphasizes on difference and pluralism (Turner, 1996, p. v). Instead of trying to create an ordered and rational place, the artist, planner and designer in this era have embraced the philosophy of diversity. There are a lot different interpretations of modernism and postmodernism. Someone divide twentieth century into modernism and postmodernism while others define them as two sides of the same movement. The famous architects in this time are including Frank Gehry (Figure 2), Santiago Calatrava, and Philip Cortelyou Johnson.

Figure 2: Jay Pritzker Pavilion is designed by Frank Gehry, located in Millennium Park, Chicago, Illinois. Copyright ©2011 Yun Wang, all rights reserved, used by permission.

1.1.4. Post-postmodernism

Post-postmodernism is a new term emerging from postmodernism and also a reaction to pluralism in formal time. In modernism, the diversity in urban design might give each individual structre a unique and elegant looking form, but it is disorder when many buildings are placed together. In this age, planners and landscape architects explore approches to produce a more legible urban form. Turner mentions his explanation of present time, “Because of our inheritance, humanity has a duty to care: for natural world, for our own interest, for those of others, for future generations” (Turner, 1996, p. vi). In this circumstance, planners and designers have to reject one city, one truth, one way, one plan in modernism; he instructs to be cautious about diversity in postmodernism, and think widely, consider impacts thoroughly, and design carefully in our post-postmodernism manner.

1.2. Context Sensitive Design

1.2.1. Context Sensitive Design in Urban Planning, Architecture and Landscape Architecture

In the past, architects worked in the style of their own time; they pleased royalty, ruling class, and clients. Today, environmental issues urge designers and planners to please everything involved, not just human, which means they should realize the importance of contextual components and begin to establish a healthy relationship between project and context. Tom Turner (1996) raised the idea of context and design in his book, and he pointed out that every type of development which will have a remarkable influence on environment should be considered to establish an appropriate relationship. Several positions are summarized as following:

1) Context is relevant.

He described a man who built his house on sand, discovering for example, the lack of consideration about the soil endurance and ground stability. Context is always involved and cannot be negligible.

2) Context matters functionally

This aspect considers the inner impacts in developing process which includes ground stability, humidity, rainfall, temperature, security and many other programmatic issues.

3) Context matters environmentally

The impact on context from outward from the site is concerned, both in positive and negative way, including the impacts on air, water, soil, plants, animals and humans. Since the human intervention can cause many bad impact upon environment, "pollution" is sometimes used to define these impacts.

4) Context matters aesthetically

This concern has a comprehensive view between development and context. The range of consideration is wider than others which including materials, color, pattern, shape, size, line and views. Private concerns are important and various from person to person, but general criteria are still needed to be a guidance of the visually coherent environment (Turner, 1996).

As the designers and planners in this time, every project plan should be comprehensive and embrace every aspect. For urban planning, architecture and landscape architecture, they should all make a reasonable response to context and to community. For one thing, a detailed schedule plays a crucial role in context sensitive design. The survey and diagnosis before treatment, plus monitoring and adjustment after treatment are even more important than the treatment itself. Taking the long-term approach schedule may help to consider all the components involve in project. For another thing, "civilization rests upon balance: between reason and faith, materialism and spirituality, tradition and imagination, self-interest and altruism" (Turner, 1996, p. vi). Every community and individual holds the different views, balancing the interests thereby forming a key feature in the whole process.

Context sensitive design is an approach to minimize the impact on environment, so it is important to understand the landscape context in order to achieve a successful and sustainable design project (Loures & Panagopoulos, 2007). Water, soil, wildlife and vegetation are all the characteristics in natural context, therein, native wildlife habitat is more sensitive than other characteristics, and the impact upon this group is maybe the most visible to learn (Strauch, 1994). The principles of Context Sensitive Design included the entire natural context and other factors; it is a feasible way to achieve sustainability nowadays. United Nations General Assembly (1987) defined sustainable as "meet the needs of the present without compromising the ability of future generations to meet their own needs" (para. 1). Some people indicate that the whole world is overdeveloped, it is true, but it doesn't mean people should stop further changes. "Humanity does not have to make a single choice between environment and development… development planners and designers must take a wide view of environmental characteristics advice… between development and context" (Turner, 1996, p. 109).

To sum up, there are five principles affiliated with context sensitive design:

1) Function: as the basic requirement in each project, it is not only the definition we know, sustainability, efficiency and effectiveness should be taken into account as well.
2) Culture: respect all forms of culture, including traditions, religious, beliefs and philosophies, these are the unique characteristics distinguish from other culture, and also the most important heritage we should inherit and develop.
3) Economics: consider everything that may relate to economy, and balance the conflicts of different groups. A plan that is economically good, may be ecologically bad, a wise and imaginative plan is needed (Turner, 1996).
4) Ecological: the environmental problems are the biggest issues nowadays. For designers and planners, minimizing the negative impact is not enough, instead one must protect, restore and reclaim, forming solutions and adaptions to bring back the biological diversity.
5) Aesthetic: the beauty of the world.

1.2.2. Context Sensitive Design in Highway Transportation

Brief History

The national conference "Thinking Beyond the Pavement" (1998) was a milestone for Context Sensitive Design, also known as Context Sensitive Solution (CSS). It generated the first definition of CSD as:

> another way of saying 'to think beyond the pavement' about the impact a travel way will have on the area it traverses, including the people who live, work, or pass through the area. Context sensitive design asks questions first about the need and

> purpose of the transportation project, and then addresses equally: safety, mobility, and the preservation of scenic, aesthetic, historic, environmental, and other community values. Context-sensitive design involves a collaborative, interdisciplinary approach in which citizens are part of the design team (Federal Highway Administration, 1998).

In 1999, the Federal Highway Administration selected five pilot agencies to implement the context sensitive design approach and to share their experience with other States in their region: Connecticut, Kentucky, Maryland, Minnesota, and Utah. And in the following years, more and more departments of transportation from other states participated in Context Sensitive Design Conference; the awareness of this approach began to grow (Georgia Department of Transportation, 2006).

The American Association of State Highway and Transportation Officials and the Federal Highway Administration sponsored two national meetings to examine the implementation of CSD in transportation agencies in 2006. A new definition was presented at the conference: "Context sensitive solutions (CSS) is a collaborative, interdisciplinary approach that involves all stakeholders in providing a transportation facility that fits its setting. It is an approach that leads to preserving and enhancing scenic, aesthetic, historic, community, and environmental resources, while improving or maintaining safety, mobility, and infrastructure conditions" (Center for Transportation and the Environment North Carolina State University, 2007).

In the past, transportation departments and highway agencies were devoted to providing an efficient and safe transportation system (Oregon Department of Transportation, 2007). After the long period of development, they begin to realize other important factors may help to achieve a successful transportation. In contrast, communities have been shaping their sense of aesthetic, cultural, historic, environmental values, defining their community. Thus the transportation plans that may harm the interest of communities will be the main issue between two sides. “There have been several instances where highway projects have been delayed because their design conflicted with community desired and values” (Transportation Research Board, 2004, p. 1). Now there are more and more States beginning to use the principles of CSD to address the efficiency and safety principles while balancing the interest of stakeholders.

Principles

Context Sensitive Design is a multidisciplinary approach which brings together all important stakeholders involved in early phase to ensure safety and efficiency; preserve and enhance the harmony with aesthetic, social, economic and natural environment (University of Minnesota, 2002). Several transportation agencies have used CSD as their philosophy and guidelines. Michigan Department of Transportation has utilized this approach since 2003, and they summarized few principles as flowing:

- Incorporate early and continuous public involvement, consistent with project scope;
- Utilize effective decision making;
- Reflect community values;
- Achieve environmental sensitivity and stewardship;
- Ensure safe and feasible integrated solutions;

- Protect scenic resources and achieve aesthetically pleasing solutions (Michigan Department of Transportation).

As one of the five pilot agencies, Minnesota Department of Transportation has implemented CSD for over ten years; they developed the flowing as their principles:

- Balance safety, mobility, community and environmental goals in all projects
- Involve the public and affected stakeholders early and continuously
- Address all modes of travel
- Use an interdisciplinary team tailored to project needs
- Apply flexibility inherent in design standards and guidelines
- Incorporate visual quality considerations throughout project development (Minnesota Department of Transportation).

It can be seen that the transportation agencies are either refining or developing the existing principles. They also consider the particular shortcomings of their efforts and the important of local characteristics. However, for most agencies, decreasing the development time and costs are often the priority through the whole project. For this reason, other potential benefits could be ignored in these circumstances. In addition, a comparison in methodical approaches for evaluation between CSD and conventional projects reveals that conventional projects are deficient. Therefore, the establishment of performance measures which are based upon project outcomes is important; these measurements can provide a benefit evaluation for applying CSD. In order to ensure the integrity of the whole process, coherent and comprehensive principles should be identified (Stamatiadis, Kirk, Hartman, Hopwood, & Pigman, 2009). In the report "A Guide to Best Practices for Achieving Context Sensitive Solutions" which was organized by the Transportation Research Board, the authors claim the integrated principles as the flowing five categories:

- Multidisciplinary Approach
- Effective Decision Making,
- Reflecting Community Values,
- Achieving Environmental Sensitivity, and
- Ensuring Safe and Feasible Solutions (Neuman, Schwartz, Clark, & Bednar, 2002).

The definition and philosophy of CSD has implemented thought out the country since 1998 (Federal Highway Administration, 1998), along with transportation development, CSD has expanded from single design to all phases of projects including long range planning, construction and maintenance. Moreover, each project has its unique context; the successful experiment of one project cannot guarantee the same result for another. Consequently, obtaining experts from different professions and disciplines to define context, analyze transportation issues and find solutions are necessary and crucial (Lane, 2007; D'Ignazio et al., 2011). The interdisciplinary team can ensure the project will effectively help meet transportation safety and mobility goals by applying creative solutions to complex settings (Kaufman, 2002). In the professional team, the representatives should include project development engineers, traffic engineers, design engineers, planners, environmental designers, landscape architecture and other specialists.

The interdisciplinary team can also share experience of their own and collaborative energy to set the boarder framework and context in the beginning of development to achieve success (Georgia Department of Transportation, 2006).

In order to make an effective decision, transportation agencies should consider different values, make a sound design which follows the federal standards and meet the requirements of other regulatory agencies. A key feature concerning sound design is choosing the right person at the right time (Michigan Department of Transportation, 2006). In addition, CSD can provide a cost-effective way to ensure the whole process is smooth and seamless. All the principles that Context Sensitive Design advocate will not increase the cost, on the contrary, “the appropriate expenditures of resources at the appropriate time in the process” offer the most effective way, because this approach avoid the possible mistakes before they happen (Kaufman, 2002).

Context Sensitive Design is an approach that is aware concerning the purpose and needs of each project, balancing different interests from stakeholders, and considering the environmental sensitivities as well from the very beginning of the project (Kaufman, 2002). In reality the goal of Context Sensitive Design is to identify both the obvious and hidden needs of form-giving drivers and stakeholders for every project. “A ‘stakeholder’ is anyone who has something at stake in a specific policy or particular project; for instance, the neighbors whose yards back up to a roadway, the senior citizens who like to drive slowly on a given street to reach an activity center, the subcontractors of the municipal services agency responsible for maintaining the landscape median strips –really all who use or are affected by the facility” (Thinking Beyond the Pavement, 1998). It is important for designers to study the physical environment to identify project stakeholders, find out whose may be affected. Stay alert and aware of multicultural influences; translate professional documents into presentation that the community members are easier to visualize solutions (Meyer , Campbell, Leach, & Coogan, 2005). The most essential thing for this principle to be effective is that public opinion will differ amongst stakeholders, affecting people in the different ways, but public involvement will help and promote the success of the whole process (University of Minnesota, 2000).

Ensuring safe and feasible solutions are the important goal in CSD project which involve collaborative approach to balance the different values. In order to meet the safety goal, the transportation agencies will only accomplish the project with acceptable safety level (Neuman et al., 2002). It also requires transportation agencies to apply customized methods and technical skills in the process; stakeholder engagement and multidisciplinary can help the designer to find solutions for transportation issues and increase flexibility of project (Michigan Department of Transportation, 2006).

Performance Measurements

Performance measures can be guidance for individual project, fostering the project team to focus on the customer needs across the whole range of programmatic concerns, promoting communication between employee and managers, demonstrating the value of CSD and maintaining focus on strategies goals, strengthening the trust with stakeholders and customers (Transportation Research Board, 2004).

The development of performance measures is based on the evaluation from estimated benefits according to specific CSD principles. The potential benefits are organized by Stamatiadis et al. (2009) and listed as following:

1. Improved predictability of project delivery.

2. Improved project scoping and budgeting.

3. Improved long-term decisions and investments.

4. Improved environmental stewardship.

5. Optimized maintenance and operations.

6. Increased risk management and liability protection.

7. Improved stakeholder/public feedback.

8. Increased stakeholder/public participation, ownership, and trust.

9. Decreased costs for overall project delivery.

10. Decreased time for overall project delivery.

11. Increased partnering opportunities.

12. Minimized overall impact to human and natural environment.

13. Improved mobility for users.

14. Improved walkability and bikeability.

15. Improved safety (vehicles, pedestrians, and bikes).

16. Improved multi-modal options (including transit).

17. Improved community satisfaction.

18. Improved quality of life for community.

19. Improved speed management.

20. Design features appropriate to context.

21. Minimized construction-related disruption.

22. Improved opportunities for economic development (p.12).

Due to a different context for each project, the project team needs to evaluate each project, identify specific principles and then determine the benefits may obtain from the CSD project. Quantified the benefits and use the data to estimate and assess these benefits is necessary for performance measures. There are two ways to quantify the benefits, for these benefits which can generate quantitative results, collect the data in term of dollars saved, time saved, acres or lineal feet; for the rest benefits, semi-quantitative methods can be used to evaluate. The performance measurements used existing efforts and also multidisciplinary research team; it can be used as a measurement of CDS implementation and also guidance transportation agencies (Stamatiadis et al., 2009).

Context sensitive design is a philosophy that defines a successful project as one that is in harmony with the community and the environment, this theory can be used in a wider realms not only in transportation fields. For city planning, architecture design, landscape architecture and transportation project, the interests of stakeholders and context of environment should always be top considerations. In any case, what is desired is a functioning unit, satisfying human desires in detail as well as on a board scale (Lynch, 1984, p. 36).

Chapter 2: Methods

2.1. Purpose of Study

The purpose of this study is to explore Context Sensitive Design Theory, and explore its application in a non-transportaiont setting, such as the reclamation of surfaces mine. The philosophy of Context Sensitive Design is applying Context Sensitive Theory in environmental design, considering the five principles which including function, culture, economics, ecological and aesthetic--drawing a comprehensive plan and taking all the contextual factors into account, balancing the interest between people and environment and making the design more sustainable.

Designers, planners, citizens and governments are all beginning to establish the consciousness of environmental protection and environmental reclamation nowadays. All the designers and planners in our time are taking the environmental protection as the bottom line and making every effort to improve and restore the ecological systems. Despite the environmental awareness and the widespread attention all over the world, the severe consequences caused by human intervention are still having a bad effect on all the living things which including human as well. According to the report of Ecosystems and Human Well-Being made by World Health Organization, the ecosystems nowadays are changing at unprecedented speed, even more rapidly than any period in human history. In order to meet the enormous demand for food, water, timber, fiber and fuel, humans are fundamentally changing the diversity of life and most of these changes are irreversibly. As the result of human intervention, biodiversity is becoming less, ecosystem services are changing greatly, and human health is affected significantly. In addition, poor populations are more vulnerable from both the local and global environmental changes (Millennium Ecosystem Assessment, 2005, p. 27).

In order to provide sources in terms of food, water, timber, fiber and fuel, a lot of landforms are changed and degraded, which are all severe consequences from human activities. Surface mining is a representative landform changed entirely by human intervention for producing mineral products. Burley (2001) defined surface mining as “an endeavor to excavate substrate containing specific chemical and physical properties useful in the manufacture, construction, and development of products/commodities” (p. 1). There are numerous surface mines all over the world. Along with the excavating activities, the envrionment around a mining area may be completely destoryed. Each mine is associated with many environmental issues, such as deforestation, loss of biodiversity, soil erosion, habitat destruction(United Nations Human Settlements Programme [UN-HABITAT], 2010, p. 17-18). In the past, due to the limitation of technology, and the weak awareness of environmental protection, surface mines were usually abandoned. In recent years, people have the ability to rehabilitate the destroyed environment, and wide public concerns encouraged the government to establish laws and regulations to guide, restrain, protect, and reclaim the surface mines (Burley, 2001, p. 3). In this circumstance, a surface mine present a great opportunity to illustrated and to implement Context Sensitive Design theory.

This study attempts to use different design approaches to study the reclamation of a land area with Context Sensitive Design principles, use different assessment methods to evaluate each design.plan, and compare the results.

2.2. Study Area

Location

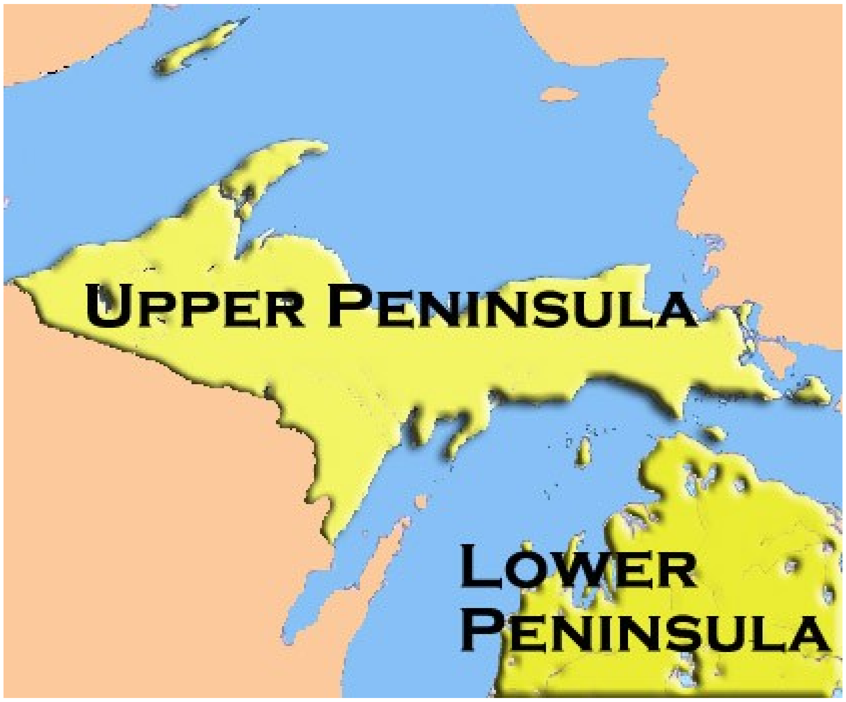


Figure 3: The location of Upper Peninsula in Michigan.

The surface mine is located in the Marquette Iron Range, Upper Peninsula (Figure 3). Iron ore deposits were found by William Burt by accident in 1884, this discovery became the initial wealth for the area and also the reason that Marquette County is the wealthiest county in Upper Peninsula. As early as in 1890s, the Marquette Iron Range provided highest quality iron ore, and is known as the richest iron source in the world. After World II, the underground mines closed and replaced by two new open pit mines: Empire and Tilden mines which are operated by Cliffs Natural Resources (formerly Cleveland-Cliffs Iron,Hunt, M., & Hunt, D, 2001). The design site is located at the south part of the new mining area, with a large basin and existing vegetation scattered around mining pit (Figure 4). There are three highways in this region, and also a lot of roads in the mining area to connect each pit. (Figure 5)

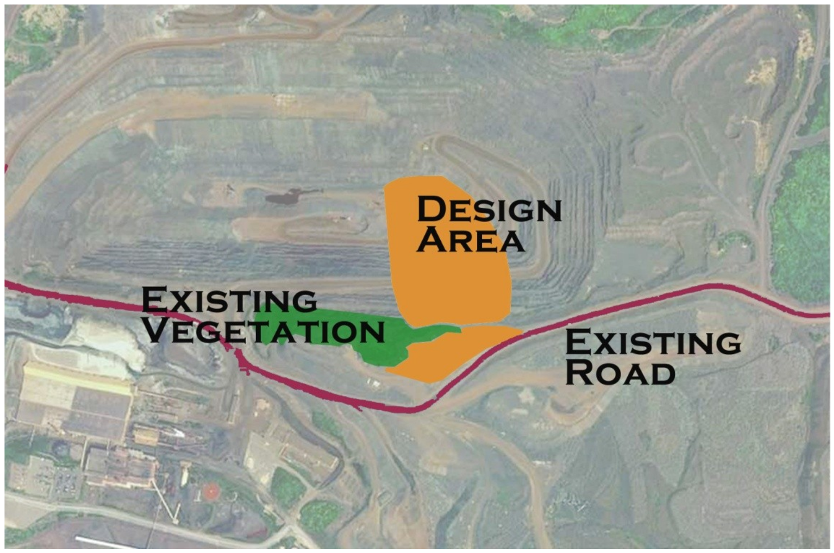


Figure 4: Design area is located at south part.

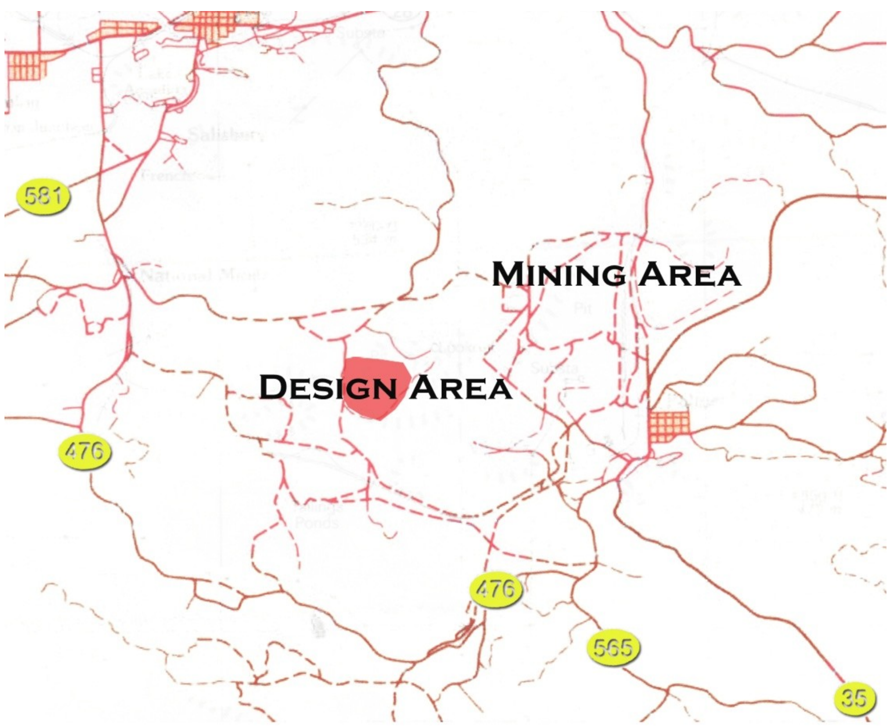


Figure 5: There are three highway in this region: Highway 35, Highway 581, Highway 476.

Ecosystems

The Upper Peninsula contains 42,610 km² almost a quarter of the land area of Michigan but just three percent of its total population. There is a large variety of wildlife, including a fair the number of mammals and birds and also native plant species (Hunt, M., & Hunt, D, 2001). The climate in Upper Peninsula is humid continental climate, with only moderate influence from Lake Superior. Winds are generally from the Great Plains which is southwest of the ecoregion. Temperatures are extremely cold in the winter (Michigan Department of Natural Resources). The average annual snowfall is about 200 inches, making it an ideal place for ski activities (Marquette County Clerk, 2011).

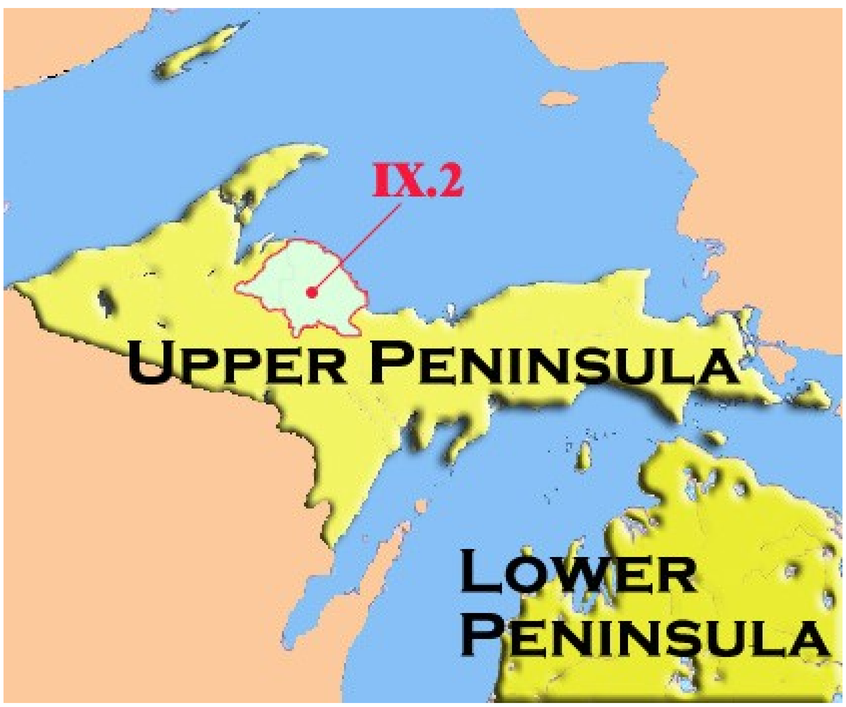


Figure 6: According to the regional Landscape Ecosystems of Michigan's Upper Peninsula, the study area is classified as subsection ix.2.

According to the classification of landscape ecosystems (Figure 6), the Marquette Iron Range is defined as being in the Michigamme Highland with exposed Precambrian bedrock, containing a variety of metamorphic, igneous, and sedimentary bedrock. The soils in this area are mostly sands, very acidic, and excessively drained, classified as Spodosols, primarily Orthods. Lakes and streams are numerous, created by glacial erosion. Hemlock (*Tsuga Canadensis,* Linnaeus, 1766), northern-hardwoods forest trees, and white pine (*Pinus strobus*, Linnaeus, 1753) dominate the outwash deposits around Marquette Iron Range (Albert, D. A., & North Central Forest Experiment Station, 1995).

2.3. Assessment Methods

2.3.1. Visual Quality

This study applied Burley's (1997) method to evaluate the aesthetic quality and determine the impact of purposed design upon existing ecosystem and landscape (p. 54). In this assessment, photographs are divided into a 6.35mm by 6.35mm with 30 rows and 38 columns; each independent variable in table 1 is measured and recorded according to the selected photographs. Each photograph will get a final score based on Burley's (1997) equation (Equation 1), which has 67 percent explanation of variation (p. 56). The equation also takes the environmental quality index into account (Table 2), the p-value for each regressor is less than 0.05, and the overall regression p-value is less than 0.01 (Burley, 1997).

Table 1: Independent Variables

Variable
HEALTH = environmental quality index (Table 2)
X1 = perimeter of immediate vegetation
X2 = perimeter of intermediate non-vegetation
X3 = perimeter of distant vegetation
X4 = area of intermediate vegetation
X5 = area of any kind of water
X6 = area of distant non-vegetation
X7 = area of pavement
X8 = area of building
X9 = area of vehicle
X10 = area of humans
X11 = area of smoke
X12 = area of fire
X13 = area of herbaceous foreground material
X14 = area of wildflowers in foreground
X15 = area of utilities
X16 = area of boats
X17 = area of dead foreground vegetation
X18 = area of exposed foreground substrate
X19 = area of wildlife
X20 = smoothness: scale 1 to 5
X30 = open landscapes: = X2+X4+(2*(X3+X6))
X31 = closed landscapes: = X2+X4+(2*(X1+X17))
X32 = openness: = X30-X31
X34 = mystery: = X30*X1*X7/1140
X44 = complexity: = variables X1 through X19 squared and then summed
X46 = sum: = variables X1 through X19 summed
X51 = wetness: = X5/X46
X52 = noosphericness: = X7+X8+X9+X15+ X16
X53 = greenness: = X1+X3+X13+X14
X63 = Shafer Index (3,4,5,6)
X80 = X63*X52

Table 2: Environmental Quality Index

Variable	Score		
A. Purifies Air	+1	0	-1
B. Purifies Water	+1	0	-1
C. Builds Soil Resources	+1	0	-1
D. Promotes Human Cultural Diversity	+1	0	-1
E. Preserves Natural Resources	+1	0	-1
F. Limits Use of Fossil Fuels	+1	0	-1
G. Minimizes Radioactive Contamination	+1	0	-1
H. Promotes Biological Diversity	+1	0	-1
I. Provides Food	+1	0	-1
J. Ameliorates Wind	+1	0	-1
K. Prevents Soil Erosion	+1	0	-1
L. Provides Shade	+1	0	-1
M. Presents Pleasant Smells	+1	0	-1
N. Presents Pleasant Sounds	+1	0	-1
O. Does not Contribute to Global Warming	+1	0	-1
P. Contributes to the World Economy	+1	0	-1
Q. Accommodates Recycling	+1	0	-1
R. Accommodates Multiple Use	+1	0	-1
S. Accommodates Low Maintenance	+1	0	-1
T. Visually Pleasing	+1	0	-1
Total Score			

In the equation, the set of regressors with a positive beta coefficient will have a negative impact on visual quality, which including occurrence of humans, vehicles, utilities and other noospheric feature. This implies that more humans, pavement, utilities, buildings, pavements, polluted environment present in the photograph, the worse the visual quality is. On the contrary, those regressors with a negative beta coefficient will have a positive association with visual quality including perimeter foreground vegetation, distance non-vegetation, wildlife and openness, those factors can all enhance the aesthetic preference. In addition, the neutral modifiers cannot be ignored though those variables have little effect on final score (Burley, 1997).

In conclusion, the equation has a preference for biospheric environment than noospheric surroundings, the vegetation, wildlife, clean water, and clean air will greatly enhance the visual quality. The dependent scores from equation around forties imply the scenery extremely good, the scores in nineties and hundreds imply the scenery extremely bad (Burley, 1997).

Equation 1

$$
\begin{aligned}
Y = 68.30 &- (1.878*HEALTH) - (0.131*X1) \\
&- (0.064*X6) + (0.020*X9) + (0.036*X10) \\
&+ (0.129*X15) - (0.129*X19) - (0.006*X32) \\
&+ (0.00003*X34) + (0.032*X52) \\
&+ (0.0008*X1*X1) + (0.00006*X6*X6) \\
&- (0.0003*X15*X15) + (0.0002*X19*X19) \\
&- (0.0009*X2*X14) - (0.00003*X52*X52) \\
&- (0.0000001*X52*X34)
\end{aligned}
$$

2.3.2. Simpson's Diversity Index

This study utilized Simpson's Diversity Index as the measurement for vegetation diversity. The degree of concentration or diversity can be measured when individuals are defined by groups (Simpson, 1949), so the biological diversity can be estimated within two aspects, richness and evenness. Richness means the numbers of different species present in the measurement range; evenness means the population for each of the species, it compares the quantitative distribution in the desired range. Sometimes, two samples have the same richness and total number; the evenness may be very different. The diversity will increase, only when the richness and evenness are all increasing (Hill, 1973)

In the equation (Equation 2), D means the diversity of selected sample, n means the total number of a particular species, and N means the total number of all selected species. The value of D ranges from 0 to 1; 0 represents infinite diversity, so the bigger the result the lower the diversity (Hunter & Gaston, 1988).

Equation 2: Simpson's Index (D)

$$\mathbf{D = \sum (n/N)^2}$$

$$\mathbf{D = \frac{\sum n(n-1)}{N(N-1)}}$$

Where:
n = the total number of organisms of a particular species
N = the total number of organisms of all species
The value of D ranges between 0 and 1

There are two other indices according to Simpson's Index: Simpson's Index of Diversity and Simpson's Reciprocal Index. Based on Simpson's Index, the Simpson's Index of Diversity is the value of 1-D, which is more reasonable. The value also ranges from 0-1, but the greater the value, the greater the environment. Simpson's Reciprocal Index is the value of 1/D, where low values mean low diversity in the quadrat, the higher the result, the greater the diversity (Hunter & Gaston, 1988).

2.3.3. Wildlife

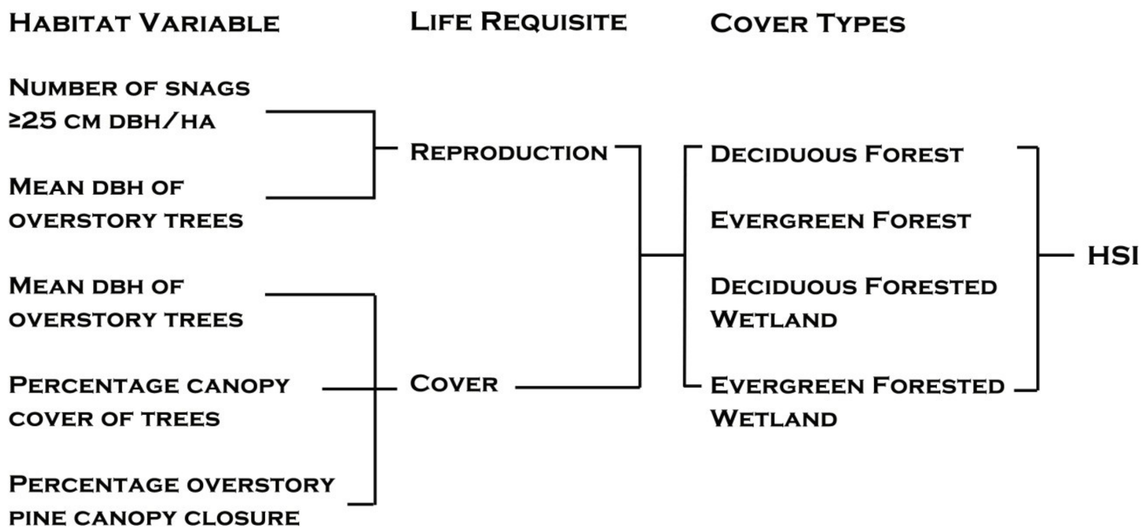
Various kinds of wild animals live in Upper Peninsula, this study mainly focus on two common birds in this area: hairy woodpecker (*Picoides villosus,* Linnaeus, 1766) and pine warbler (*Dendroica pinus*, Linnaeus, 1766). Those two birds have the different habitat, and the Habitat Suitability Index Model by Sousa (1987) and Schroeder (1982) is established by study the habitats including food, water, cover and reproduction, and get the variables.

Hairy Woodpecker

Hairy woodpecker (*Picoides villosus,* Linnaeus, 1766) inhabits mature deciduous or coniferous forests. Breeding habitats are open pine woods, mainly feed on insects, seeds and berries. The species is primary cavity nester and their mainly nest sites can be provided by a combination of tree trunks, snags and live trees. In winter, hairy woodpeckers forage large amount of seeds often in dead trees or dead parts of live trees. Usually the minimum requirement of nesting is 25cm for diameter of breast height (dbh) and 4.6m for height, and according to research, the optimum range is 25cm to 38cm for dbh, and 6m to 12m for height (Sousa , 1987).

Several habitat variables are related to suitability for hairy woodpecker, the relationship between habitat variables, life requisites, and cover types are also considered (Table 3).

Table 3: Relationships of habitat variables, life requisites, and cover types to the HIS for the hairy woodpecker.



The reproductive habitats require enough density for snags (SIV1), sufficient size and decay for nesting (SIV2). The maximum densities for hairy woodpecker require 4.5 to 5 snags per acre, and each of the snag ⩾ 25cm dbh; the optimum size for tree is the average dbh of overstory ⩾ 38cm (Figure 7). The suitability index for nesting (SIN) is based on those relationships list above (Equation 3), in this equation, if the result exceeds 1.0, it should be set to 1.0 (Sousa, 1987).

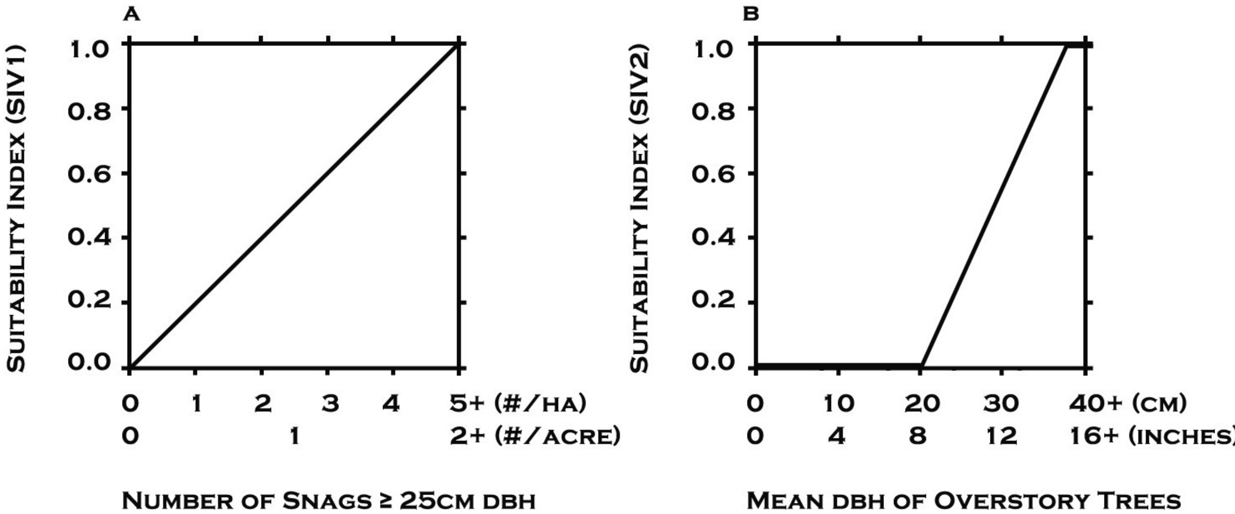


Figure 7: The relationship between variables related to reproductive habitat and suitability levels.

Equation 3: Suitability Index for Nesting (SIN)

$$\mathbf{SIN = SIV1 + (0.75 * SIV2)}$$

There are other variables affect the suitability which including the seral stage of a forest stand, the degree of canopy cover, and the percentage of pines. These variables are summarized as cover component. In the model, the best seral stage requires average dbh for overstory >25cm; the most suitable habitat for Hariy Woodpecker is 85% to 90% canopy cover; the optimal pine canopy is ≤10%, the increase of pine canopy will decrease the suitability for hairy woodpecker (Figure 8). The suitability indices for cover component is summarized in equation 4, the result will be greater than 0 only if the area is forest (Sousa, P. J., 1987).

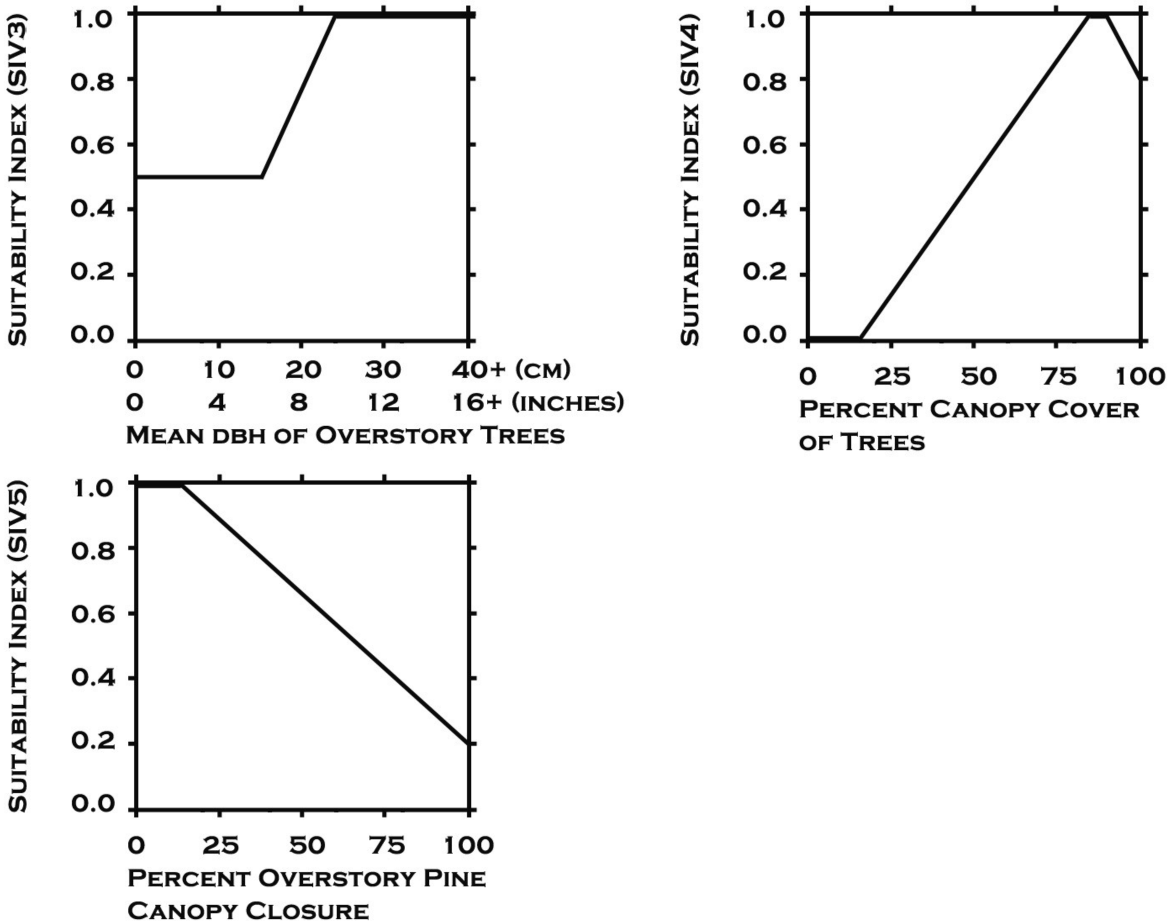


Figure 8: The relationship between variables related to cover component and suitability levels.

Equation 4: Suitability Indices for Cover Component

$$SIC = SIV3 * SIV4 * SIV5$$

The habitat suitability index (HSI) model is based on reproduction component and cover component (Equation 5); the reproductive variables can identify the habitats suitability as long as the cover component is optimal (Sousa, P. J., 1987).

Equation 5: Habitat Suitability Index (HSI)

$$HSI = SIN * SIC, \text{ or}$$

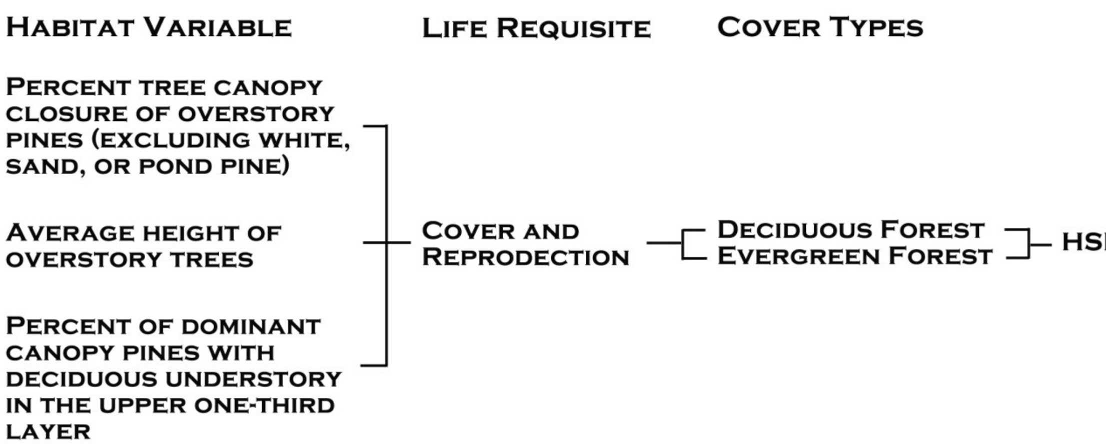
$$HSI = [SIV1 + (0.75 * SIV2)] * (SIV3 * SIV4 * SIV5)$$

Pine Warbler

Pine warbler (*Dendroica pinus*, Linnaeus, 1766) inhabits pine and pine-hardwood forests. This kind of bird is year-round resident and breeding species, mainly feed on insects, seeds and berries. The increase of pine forests will promote the growth of population for pine warbler; however, the increase of deciduous trees will decrease the habitat suitability (Schroeder, 1982).

In the HSI model, the minimum area to support a breeding population is about 10 ha. Habitat variables (Table 4) related to HIS are including percent tree canopy, average height of overstory trees, and percent of dominant canopy pine with deciduous understory in the upper 1/3 layer (Schroeder, 1982).

Table 4: The relationship between variables in the pine warbler HIS model.



The most suitable reproductive and cover habitat for pine warbler is pure, large, dense and mature pine forest. In these variables, the optimal tree canopy cover is greater than 90%; the best average height of overstory is ⩾ 20m; the preference of pine warbler requires no herbaceous understory reach the top one-third layer. Based on these variables, the suitability index (SI) is established (Figure 9). In order to get comprehensive data, these variables are combined by equation (Equation 6). The HSI for pine warbler is the same as cover and reproduction value (Schroeder, 1982).

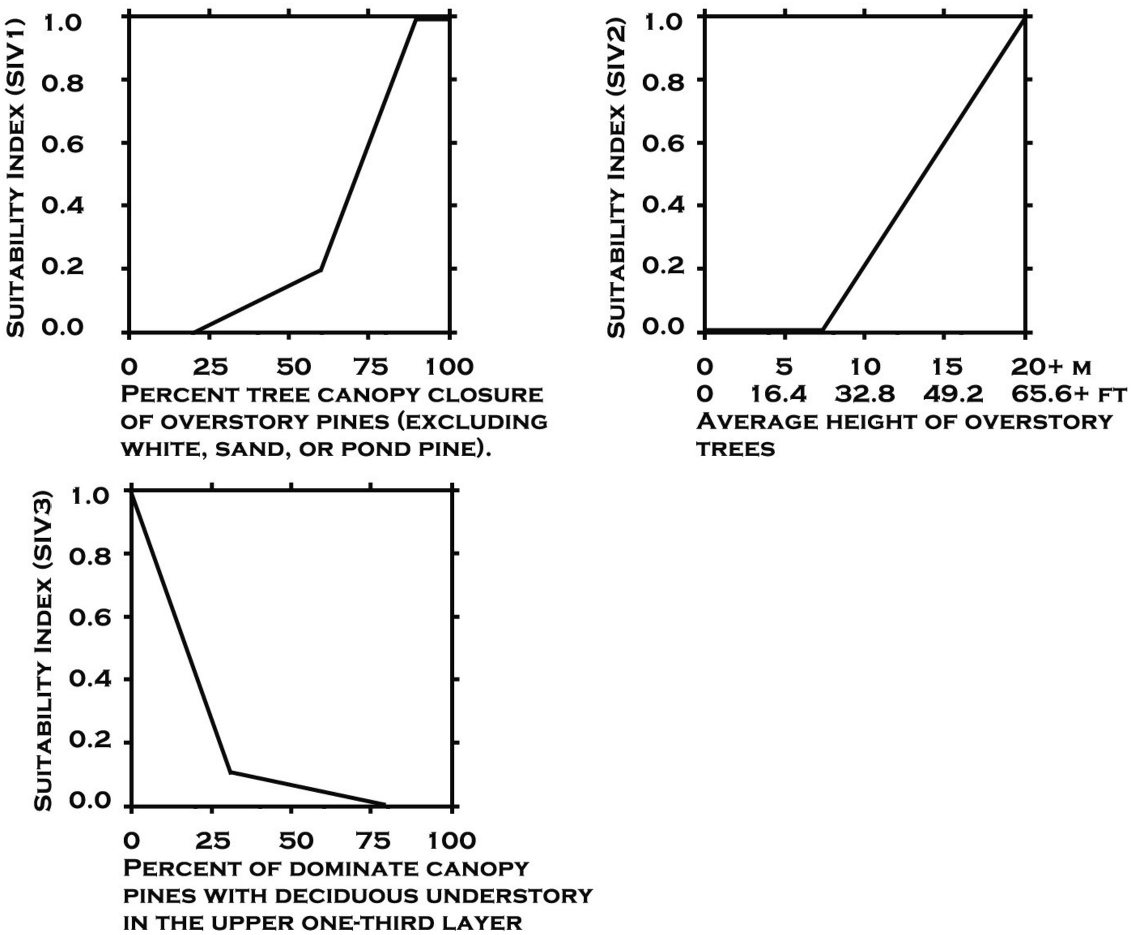


Figure 9: The relationship between variables related to cover component and suitability levels.

Equation 6: Suitability Indices for Reproduction and Cover Component

$$SIC = (SIV1 * SIV2 * SIV3)^{1/3}$$

In this evaluation part, some of the variables are assumed in the best condition, the result of each equation is not the key point, the bird's behavior and how to rehabilitate this mining surface and let it become a great habitat for wildlife is the ultimate goal.

2.3.4. Water Management

In this study, I applied the Rational Method (Kuichling, 1889) to estimate stormwater runoff. This model is established over a century ago, first introduced in New York State for sewer system development and then widely used as an assessment method for stormwater management (Stephenson, 1981). Different from other models, the Rational Equation (Equation 7) is used to determine the peak flows for small area, so it is only applied on the drainage area less than 200 acres (Ferguson, 1998).

Equation 7: Rational Equation

$$Q = ciA$$

Where:

Q = Peak discharge, cfs

c = Runoff coefficient, combined soil type, land use and slope; values in Table 3.

i = Rainfall intensity with selected interval and duration, inch/hour

A = Drainage area, acre

In this equation, the runoff coefficient reflects the soil type, land use and basin slope (Table 5), as all those factors can greatly affect the precipitation infiltration. The impermeable pavement such as roads and parking lots will prevent water from seeping into underground; in such land forms, runoff will increase and the sediment, nitrogen, heavy metal, bacteria, pesticide and other contaminants are carried into streams, rivers and lakes, which is the biggest problem of pollution. The value of rainfall intensity is taken from the Michigan Department of Transportation Drainage Manual (2006); selected intensity based on duration of 60 minutes, and frequency of 50 years.

Table 5: Rational Method Runoff Coefficients (Oregon Department of Transportation, 2005).

	FLAT	ROLLING	HILLY
Pavement & Roofs	0.90	0.90	0.90
Earth Shoulders	0.50	0.50	0.50
Drives & Walks	0.75	0.80	0.85
Gravel Pavement	0.85	0.85	0.85
City Business Areas	0.80	0.85	0.85
Apartment Dwelling Areas	0.50	0.60	0.70
Light Residential: 1 to 3 units/acre	0.35	0.40	0.45
Normal Residential: 3 to 6 units/acre	0.50	0.55	0.60
Dense Residential: 6 to 15 units/acre	0.70	0.75	0.80
Lawns	0.17	0.22	0.35
Grass Shoulders	0.25	0.25	0.25
Side Slopes, Earth	0.60	0.60	0.60
Side Slopes, Turf	0.30	0.30	0.30
Median Area, Turf	0.25	0.30	0.30
Cultivated Land, Clay & Loam	0.50	0.55	0.60
Cultivated Land, Sand & Gravel	0.25	0.30	0.35
Industrial Area, Light	0.50	0.70	0.80
Industrial Area, Heavy	0.60	0.80	0.90
Parks & Cemeteries	0.10	0.15	0.25
Playgrounds	0.20	0.25	0.30
Woodland & Forests	0.10	0.15	0.20
Meadows & Pasture Land	0.25	0.30	0.35
Unimproved Areas	0.10	0.20	0.30

Rolling: ground slope between 2 percent to 10 percent

Hilly: ground slope greater than 10 percent

For governments, companies, or a private client, a comprehensive overview plan is necessary, especially when natural environment is part of the design. One of the aims of Context Sensitive Design is consider all the factors and consequences in advance, expect and preclude the possible mistake before it happen. The assessment methods list above can be general numeric guidance, and provides a broad view for decision making and project planning.

2.3.5 The Friedman Analysis of Variance Statistic

In order to compare the outcomes of each design treatment in the four assessment methods, I utilized Friedman's analysis in this study (Daniel, 1978). The test is an analysis of variance by ranks, which may be the original observations or derived on a higher scale. The data is displayed in two-way; the rows *b* represent ranking and columns *k* represent objects. There are two hypotheses in this test:

H_0 : The values within a ranking are identical.

H_1 : At least one object tends to yield larger values than at least one other object.

The first step is to convert the original observations into ranks; the second step is to calculate the sum of ranks R_i in each column, and then use the computational formula for the test statistic (Equation 8):

$$X_r^2 = \left(\frac{12}{bk(k+1)} \sum_{j=1}^{k} R_j^2 \right) - 3b(k+1)$$

Where:

X_r^2 = Friedman two-way analysis of variance by ranks

b = Ranking

k = Objects

R_j = Sum of ranks for each column

Equation 8: The formula of Friedman two-way analysis of variance by ranks

When the amount of b and k are small, the computed X_r^2 is compared to appropriate critical values for significance. If the computed X_r^2 is greater than or equal to tabulated, we can reject H_0 at the α level of significance. For the values are not include in tabulated, the computed X_r^2 is compared to tabulated values of chi-square for significance with the *k-1* degrees of freedom. If the computed X_r^2 is greater than or equal to tabulated value of chi-square for *k-1* degrees of freedom, we can reject H_0 at the α level of significance (Daniel, 1978).

Sometimes, the reject H_0 which proved the results are not identical is not enough; the multiple-comparison procedure can help investigators to find out where the differences are located (Daniel, 1978). The comparison is used after Friedman test. When the experiment error rate is α, we can declare R_j and $R_{j'}$ significantly different if

$$\left|R_j - R_{j'}\right| \gg z\sqrt{\frac{bk(k+1)}{6}}$$

Where:

R_j = Sum of *j*th rank

$R_{j'}$ = Sum of *j'*th rank

z = A value corresponding to $\alpha / k\,(k-1)$

b =Ranking

k = Objects

Equation 9: The Multiple-comparison procedure for use with Friedman test

Chapter 3: Result

I designed four treatments on the same selected site. Three of the treatments utilized, apply various design philosophies, with the remaining treatment acting as a control (the abandoned mine treatment). Each of the four treatments were evaluated and statistically compared by examining 5 environmental variables.

3.1. The Ski Resort

In winter Marquette County has a high snow potential, making it an ideal place for winter sports. The huge open mining pit with long and extended slopes at different gradients could form the basis for a ski slope resort. Based on those potential conditions, the surface mine can be reclaimed for recreation. In this study, I designed a ski resort in one of the mining pits, restored the site by applying Context Sensitive Design theory, rehabilitated the environment, and made it more sustainable and environmentally friendly. For Context Sensitive Design, all the five principles need be concerned through the whole process, thus, the comprehensive land use plan and a rational spatial arrangement design are critical in the beginning.

This recreation project includes two parts: base area and ski slope (Figure 10). The base area includes four functions: service center, commercial center, hotels and chalets. Each of these functions are arranged based on different characteristics (Figure 11). One of the unique characters of this ski filed is that the base area is located on the top of ski slope, it can provide. good view on the high elevation. In addition this location is close to road which can support visitors and facilities better. Besides, the existing vegetation can provide good environment for visitors and a beautiful location for a ski resort. The vegetation can also be a buffer between hotels and ski slope (Figure 12).

Figure 10: The location of base area, ski slope and other existing condition.

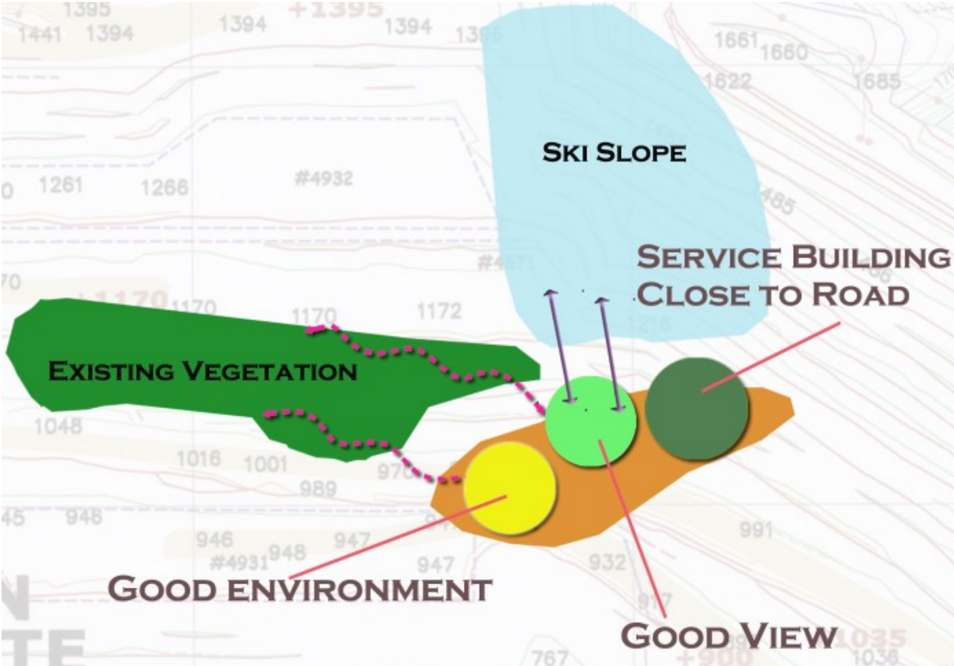


Figure 11: The functional land use plan for ski resort on existing mining site.

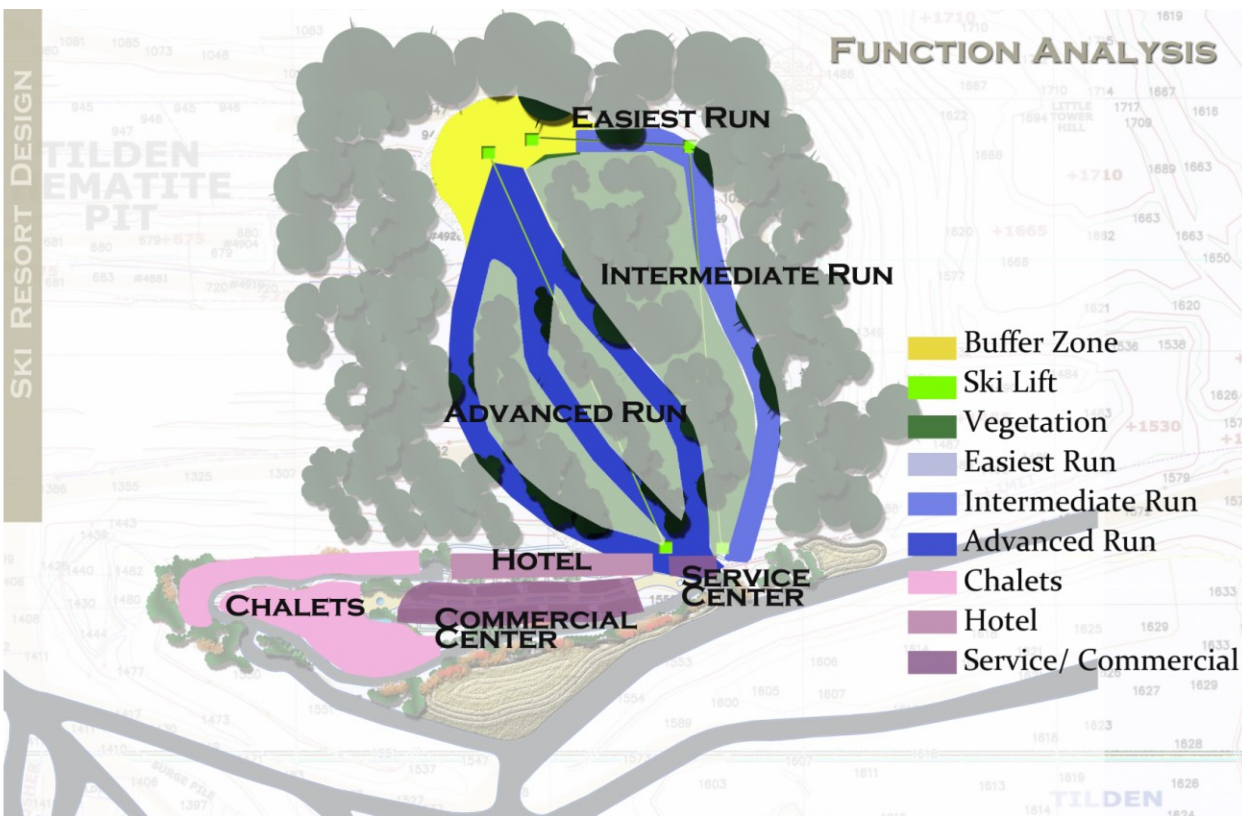


Figure 12: The function analysis for base area and ski slope.

Figure 13: The vehicle and pedestrian access for ski resort.

In order to better serve the users, plus create a comfortable and pleasant environment, the commercial center, service center and hotel area is only for pedestrians, no cars are allowed, and there is vehicles access outside this area. The main entrance is located in the east, the exit is on the other side; the minor entrance is beside the main entrance for staff of the services center. There are two big parking lots beside the main and minor entrance for public and staff, and also numbers of small parking areas along the road for commercial center, chalets and hotel (Figure 13).

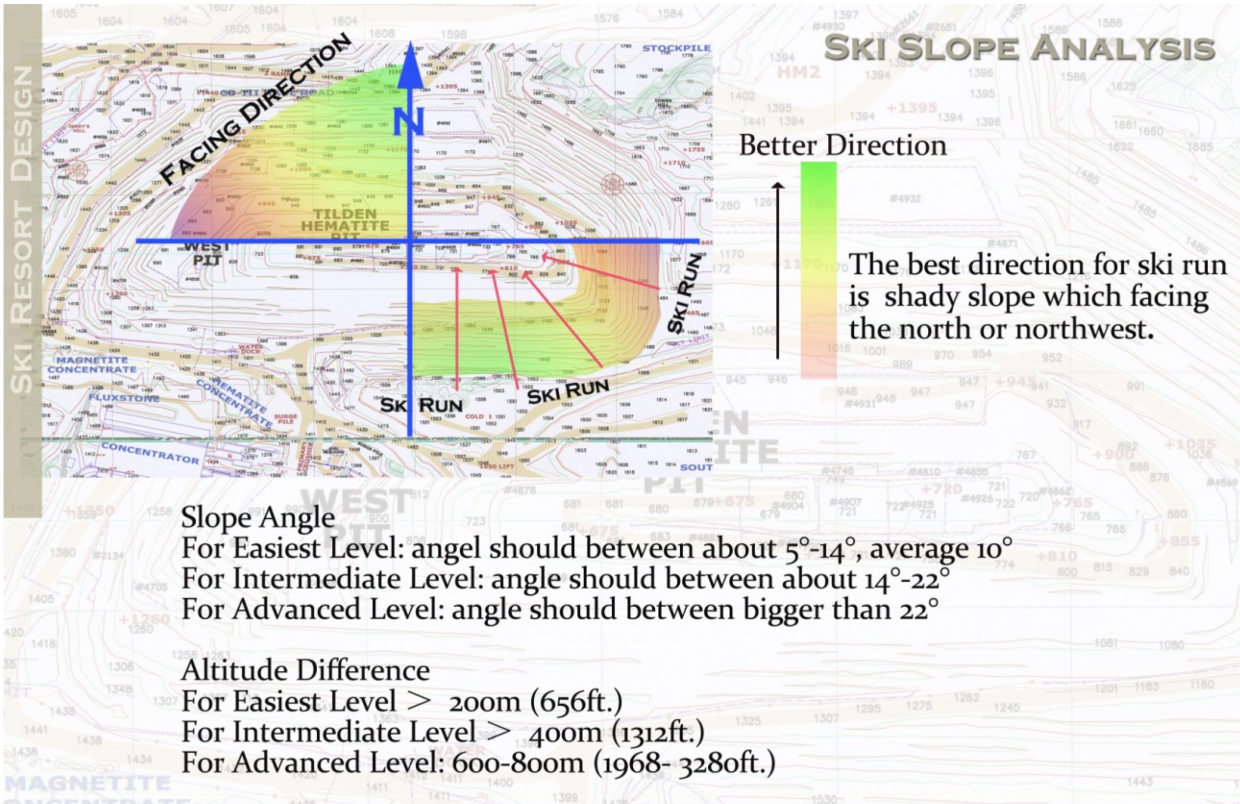


Figure 14: The ski slope analysis for ski resort.

In ski slope design, direction and slope angle are the two important factors. For ski runs, the best direction is the shady slope, which faces the north or northwest (Figure 14), in this direction, the slope will receive less sunshine to ensure abundant snow levels (Dorward, 1990). The ski runs are graded according to difficulty in order to provide an appropriate route for every skier. Different trail ratings have different slope angle, for normal ski resort there are three ski trails: easiest, intermediate and advanced (Table 6).

Table 6: The angle and altitude for ski slope.

	Slope Angle□	Altitude Difference□
For Easiest Level	angel should between about 5°-14°, average 10°□	＞200m (656ft.)□
For Intermediate Level	angle should between about 14°-22°	＞400m (1312ft.)□
For Advanced Level	angle should between bigger than 22°□	600-800m (1968- 3280ft).

After examining the sloped area area, I was able to fit the three levels for skiers in this ski resort: easiest, intermediate and advanced, with three ski lifts from top to bottom, connected to each other. The pine trees will be planted between every ski run, and also a buffer area is designed on the bottom of the slope (Figure 15).

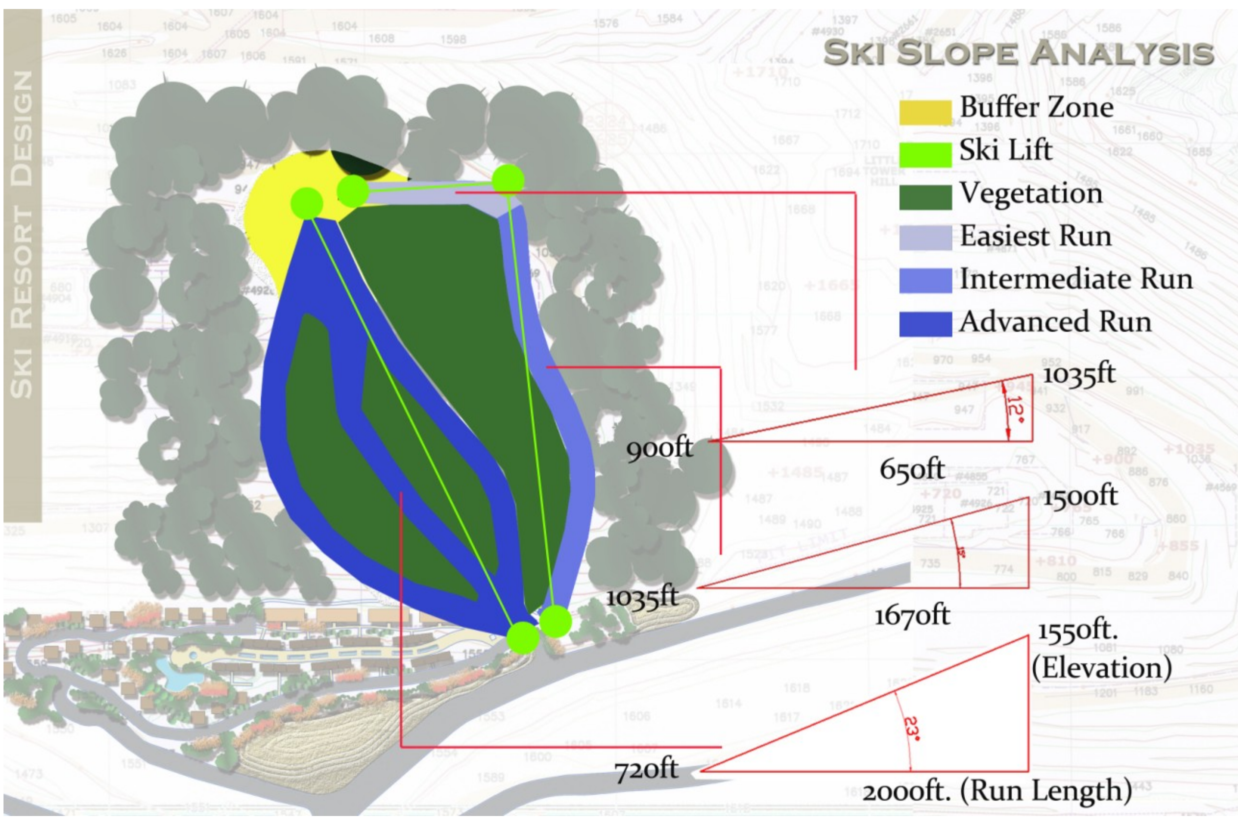


Figure 15: The plan for ski slope and ski run.

Reclamation of the natural environment is also a big concern in this project. The Upper Peninsula is sparsely populated, and is home to many types of vegetation. Considering the undesired effects that may be caused by invasive vegetation, I choose some of the native plants in Upper Peninsula to revegetate ski resort. For reconstructing this area and to make it become a habitat for native animals, I also consider environmental preferences for two birds: hairy woodpecker (*Picoides villosus,* Linnaeus, 1766) and pine warbler (*Dendroica pinus*, Linnaeus, 1766). Hairy woodpeckers prefer open pine and scattered conifer forest. The base area with the existing vegetation seems to be a good habitat site for this bird. Pine warblers are usually abundant in pure pine forest. The ski slope area appears to be a good habitat location for this bird.

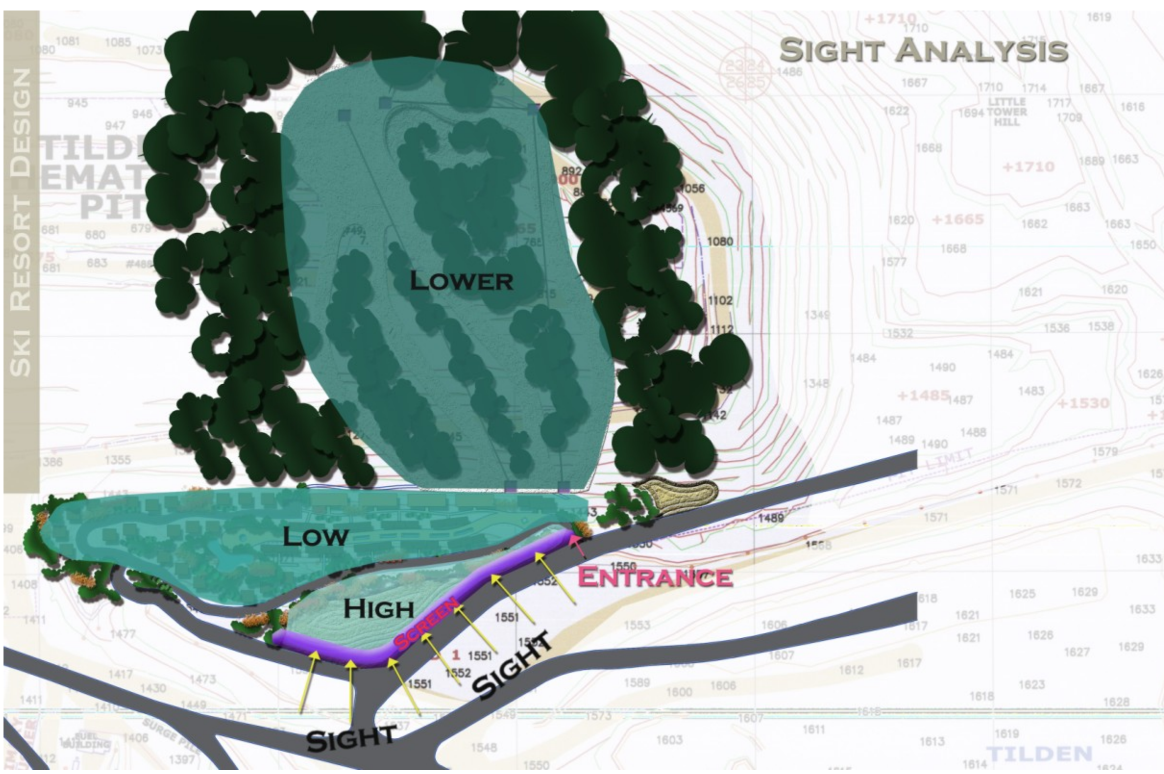


Figure 16: The visual analysis for ski resort.

Visual quality and the experiential quality of the site are the other two considerations for this project. Inspired from traditional Chinese landscape architecture theory about visual and route design, I utilized the different elevations in existing topography, using the high elevation hill as the sight barrier, hiding the ski resort behind it, so that travelers will not see the beautiful scenic in ski resort until they drive behind the hill (Figure 16). For one thing, it can retain some natural characters in the surface mine and combine it with some new features. This unique route can provide distinctive experience for visitors. To enhance the experience, a variety of spatial textures can be considered (Figure 17). "In addition to introducing with constructed facilities, like lifts and buildings, winter sports developments also can alter the natural texture of the landscape by removing vegetation for these sites and the ski runs" (Mittman, H. J., 1984)

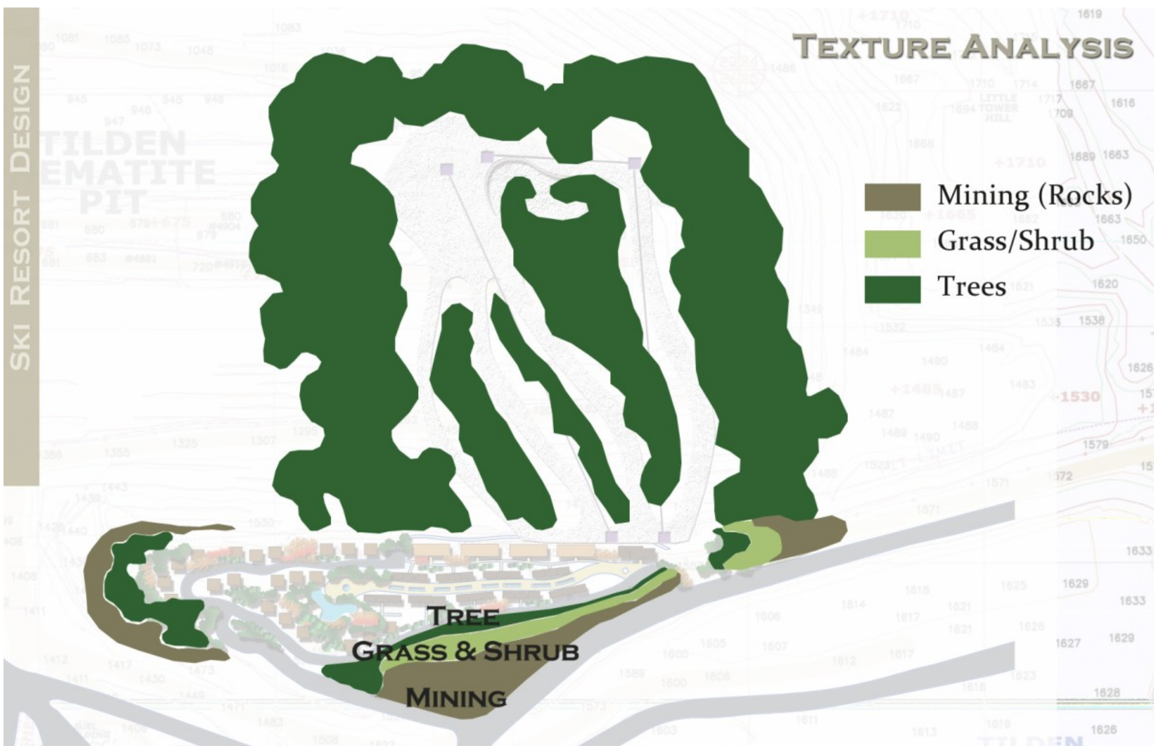
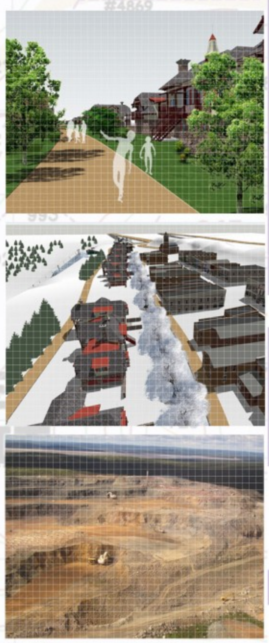


Figure 17: The text analysis for ski resort.

In the evaluation part, there are five assessment methods (visual, pine warbler, hairy woodpecker, vegetation diversity, and water runoff). For Visual Quality (Figure 18), I choose three images to apply the equation. No.1 presents a scene outside the hotel in summer; No.2

presents a bird's-eye view of whole ski resort in winter; No.3 presents a scene of existing mining surface. The score for No.1 is 52.23, for No.2 is 56.28 and No.3 is 61.77. The Habitat Suitability results for wildlife ranged from 0 to 1, 1 is considered very good habitat. In the model, the score for pine warbler is 0.17 and 0.56 for hairy woodpecker. In Simpson's Diversity Index (Figure 19), the vegetation is chosen randomly in the range I picked for ski resort, 0 represents the initiative diversity and 1 represents no diversity; the value of the equation is 0.14 which is very close to 0. In Rational Method Equation for water management (Figure 20), different ground cover has the different coefficient; the value for this design is 16.59.



	Environmental quality index	Image 1	Image2	Image3
	Health	10	9	1
X1	perimeter of immediate vegetation	72	0	0
X2	perimeter of immediate non-vegetation	27	0	0
X3	perimeter of distant vegetation	4	25	86
X4	area of intermediate vegetation	296	202	15
X5	area of any kind of water	0	0	0
X6	area of distant non-vegetation	9	47	54
X7	area of pavement	188	58	0
X8	area of building	104	389	0
X9	area of vehicle	0	0	6
X10	area of humans	37	0	0
X14	area of wildflowers in foreground	0	0	0
X20	smoothness: scale 1 to 5			
X30	open landscapes=X2+X4+[2*(X3+X6)]	331	509	295
X31	closed landscapes=X2+X4+[2*(X1+X17)]	405	417	15
X32	openness X30-X31	-74	92	280
X34	mystery=X30*X1*X7/1140	3930	0	0
X44	complexity			
X46	sum			
X51	wetness			
X52	noosphericness=X7+X8+X9+X15+X16	292	447	6
X53	greenness			
X63	Shafer Index			
X80	X63*X52			
Y		52.22928	56.28027	61.77188

Figure 18: The assessment images and scores of Visual Quality for ski resort.

Evaluation-Vegetation Diversity

Species	Number (n)	n(n-1)
Red Pine	1	0
Sweet Fern	3	6
Switch Grass	3	6
Bladder Sedge	2	2
Yellow Marsh Marigold	4	12
Creeping Juniper	1	0
Total (N)	14	26

Simpson's Index

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

$$= 0.14$$

Simpson's Index of Diversity 1-D = 0.86

Simpson's Reciprocal Index 1/D = 7.14

Figure 19: The Simpson's Diversity result for Ski Resort.

Evaluation-Water Management

$$Q = ciA$$

$$= 0.07 * 3 * 79$$

$$=16.59$$

The Rational equation requires the following units:

Q = Peak discharge, cfs

c = Rational method runoff coefficient

i = Rainfall intensity, inch/hour

A = Drainage area, acre

Figure 20: The Rational Method Equation result for Ski Resort.

3.2. The Housing Unit

Residential housing plays a very important role in architecture history, and as the basic need for human well being, it is affected greatly by social processes and social economy. Low density residents are very normal in United States; high density residents are more popular in a big city for saving space and sharing energy. Le Corbusier advocated the concept of a vertical city and he pointed out that the mass production came out because of economic needs (Le Corbusier, 1986, p. 269). The Marseille Block represents all the theories of Le Corbusier about architecture, town planning and dwelling, and also it is a remarkable work in twentieth century. This housing unit is 165 meter long, 24 meter wide and 17 stories high, contains 337 apartments which are divided into 23 types of flat for different families. The Marseille Block also has the inner street including movie theater, restaurant, post office, hotel, laundry, pharmacy, kindergarten, gymnasium and swimming poor (Choay, 1960, p. 25).

Figure 21: The bird's-eye view for Housing Unit.

In this project, I adopted the Marseille Block as an example, utilized five principles of Le Corbusier to design a housing unit in selected mining area. The unit is 101 meters long, 27.6 meters wide and 11 stories high (Figure 21), 9 levels over ground and 2 levels underground; contains 84 apartments which are divided into 4 types for different families (Figure 22). One of the arrangement styles follows the Marseille Block (Figure 23), this type of design combines by overlaps two-story apartments; each of them is a small villa with three balconies in the huge unit. This design can saving more traffic area and creates extensible interior space.

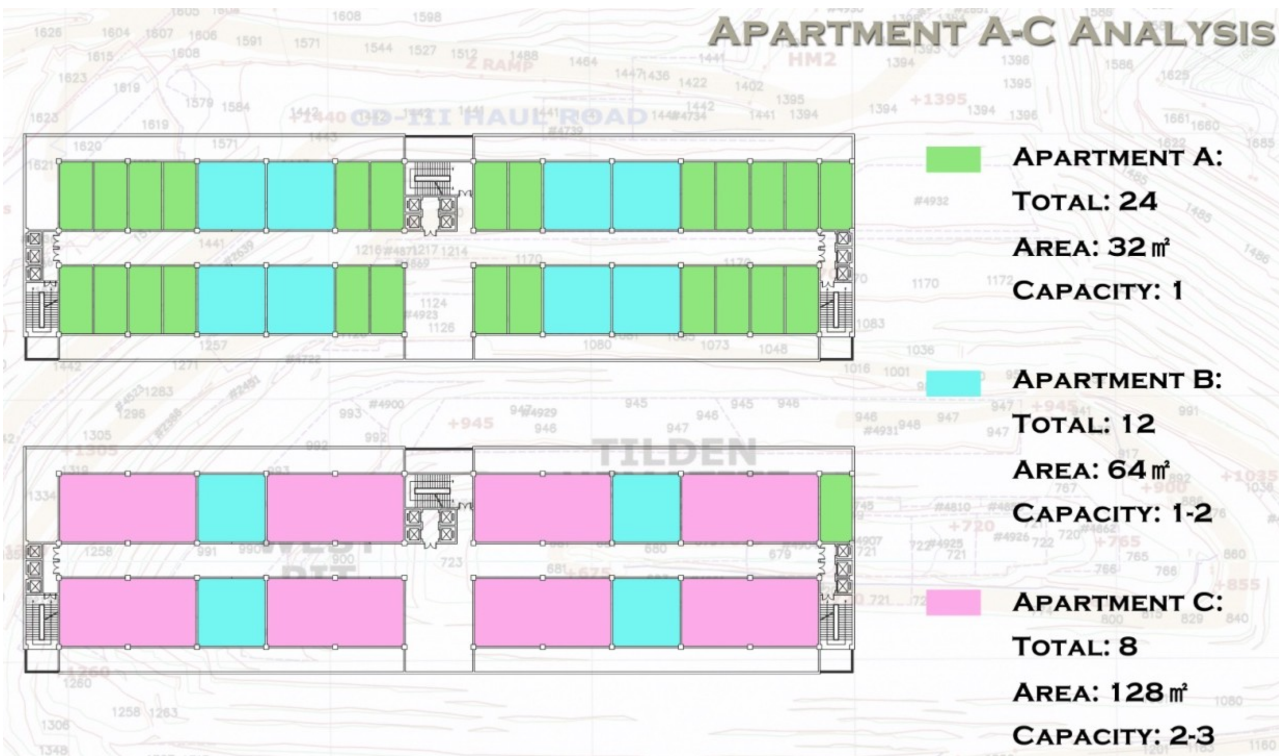


Figure 22: The site plan and spatial analysis for Apartment A-C.

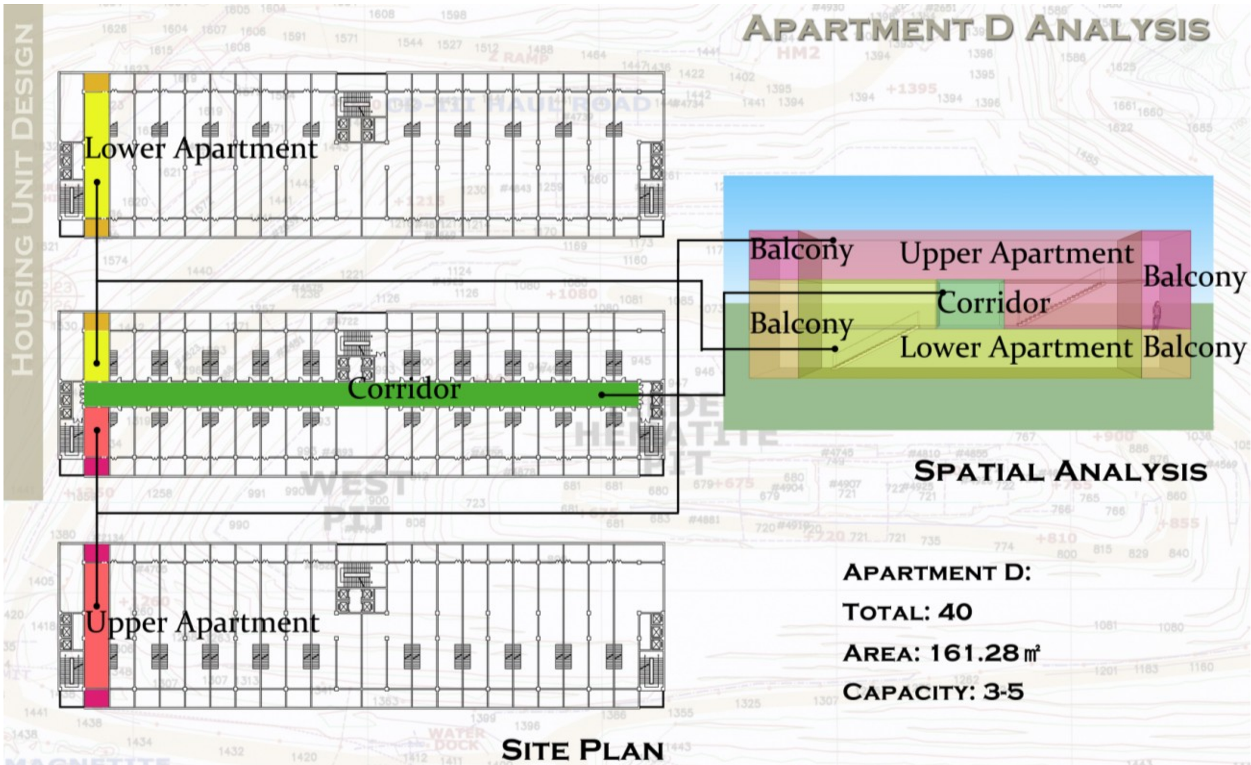


Figure 23: The site plan and spatial analysis for Apartment D.

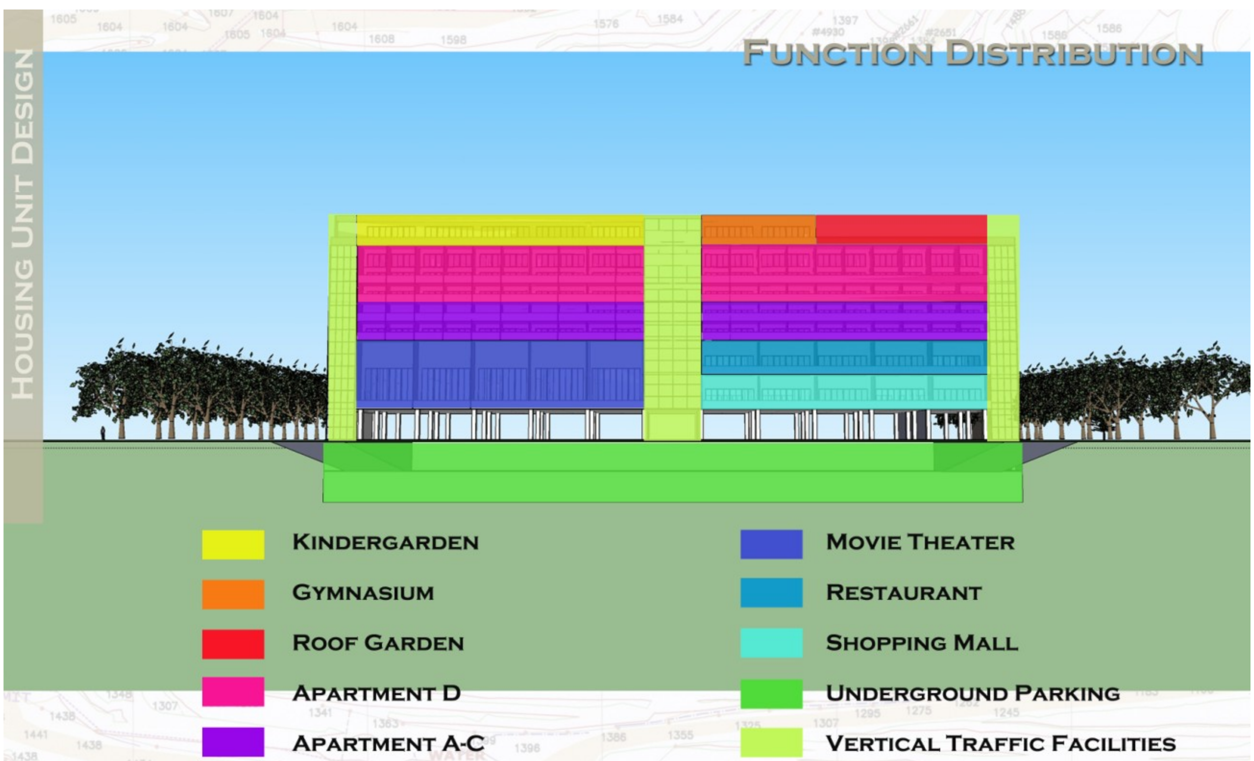


Figure 24: The function distribution for Housing Unit.

This housing unit is also a multifunction building which includes a movie theater, restaurants, shopping mall, kindergartens, gymnasium and roof garden to meet the different needs (Figure 24). The unit can provides everything for residents in daily life, and meanwhile, promotes the communication and relation between neighbors.

The whole structure is raised above ground level as other works of Le Corbusier. All of the ground floor and surrounding natural environment is reserved for residents. No cars are allowed in at the ground level (Figure 25). The two levels of underground are designed for parking, the first level is for services and visitors, and second level is for residents. Service vehicles and visitor/ residents vehicles use a different entrance and exit.

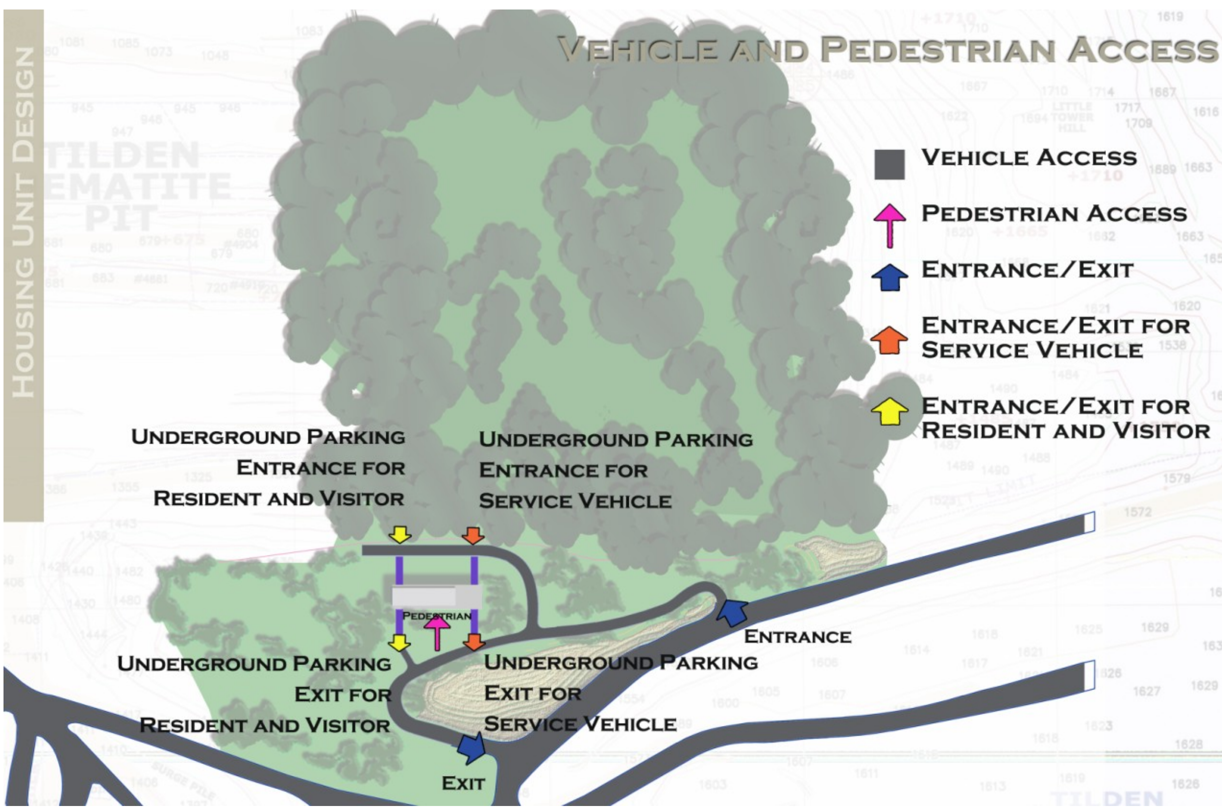
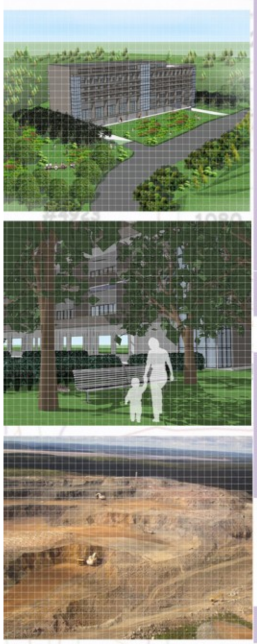


Figure 25: The vehicles and pedestrian access analysis for Housing Unit.

Due to the similar site plan and spatial arrangement, the results of assessment methods for Ski Resort and Housing Unit are very close. For Visual Quality (Figure 26), there are three images are selected: No.1 presents a bird's-eye view of the resident area in summer; No.2 presents a view from outside landscape; No.3 is the same in Ski Resort and conducted as a control group. The score for No.1 is 51.19, for No.2 is 52.50. In Habitat Suitability Index, the score for pine warbler is 0.14, for hairy woodpecker is 0.55. In Simpson's Diversity Index (Figure 27), the vegetation are selected as the same in Ski Resort for better comparison, the result is 0.13. In water management evaluation (Figure 28), the result for Rational Method Equation is 21.33.



	Environmental quality index	Image 1	Image2	Image3
	Health	10	10	1
X1	perimeter of immediate vegetation	47	54	0
X2	perimeter of immediate non-vegetatic	24	0	0
X3	perimeter of distant vegetation	54	24	86
X4	area of intermediate vegetation	234	636	15
X5	area of any kind of water	0	0	0
X6	area of distant non-vegetation	0	0	54
X7	area of pavement	106	0	0
X8	area of building	181	211	0
X9	area of vehicle	0	0	6
X10	area of humans	10	54	0
X14	area of wildflowers in foreground	43	0	0
X20	smoothness: scale 1 to 5			
X30	open landscapes=X2+X4+[2*(X3+X6)]	366	684	295
X31	closed landscapes=X2+X4+[2*(X1+X17)]	352	744	15
X32	openness X30-X31	14	-60	280
X34	mystery=X30*X1*X7/1140	1599	0	0
X44	complexity			
X46	sum			
X51	wetness			
X52	noosphericness=X7+X8+X9+X15+X16	287	211	6
X53	greenness			
X63	Shafer Index			
X80	X63*X52			
Y		51.19241	52.49917	61.77188

Figure 26: The assessment images and scores of Visual Quality for Housing Unit.

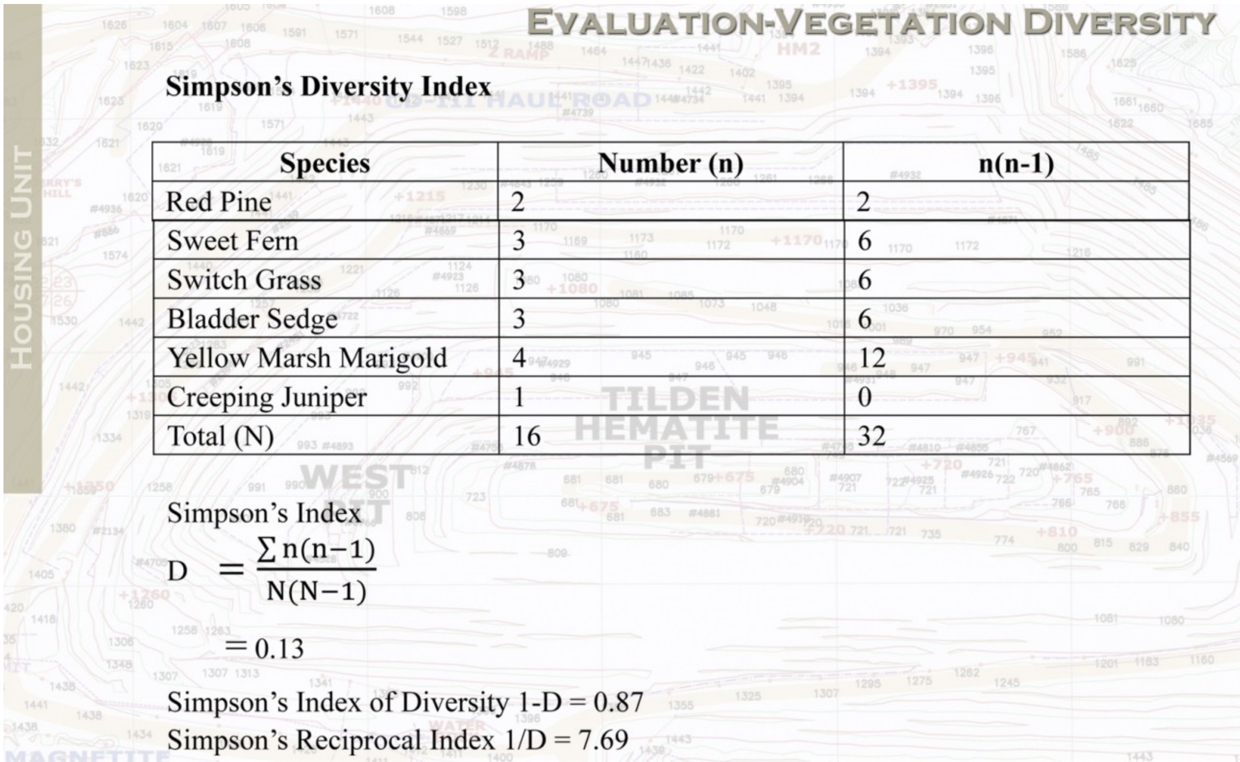


Figure 27: The Simpson's Diversity result for Housing Unit.

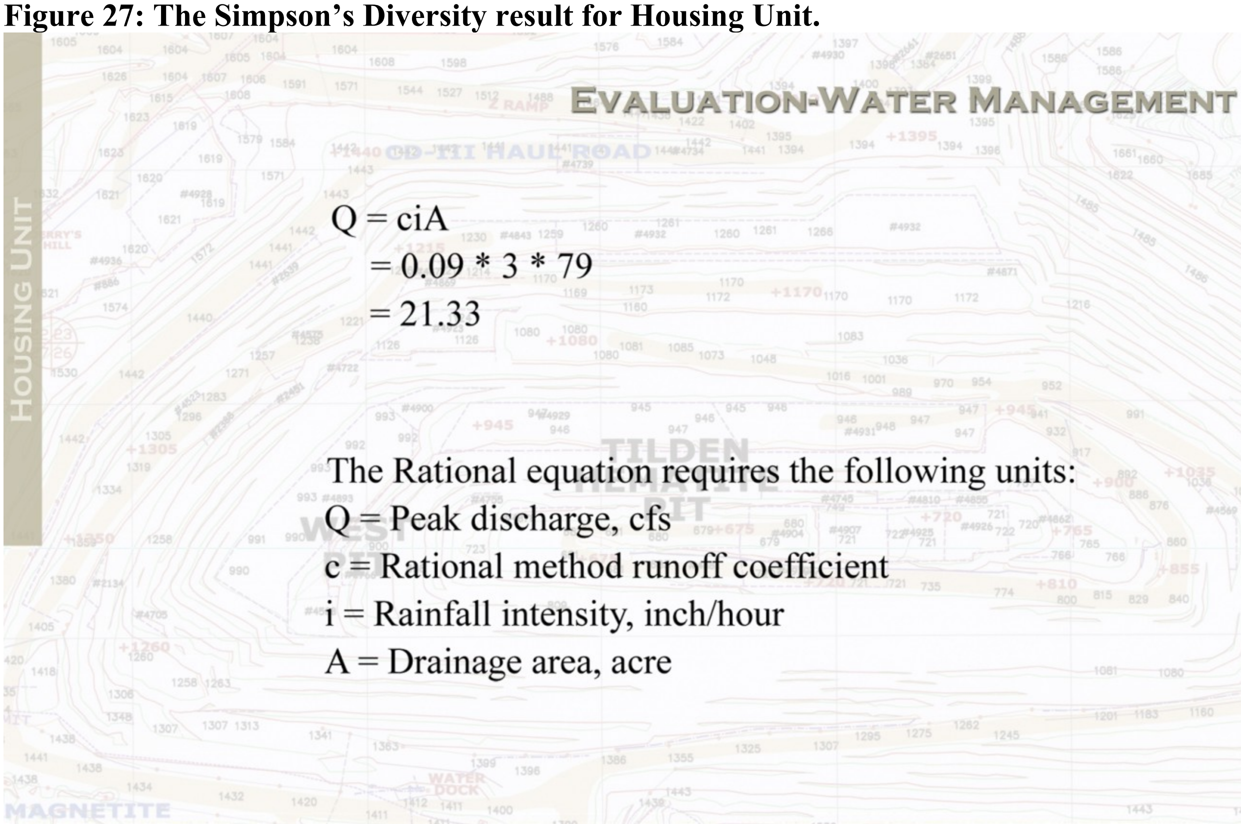


Figure 28: The Rational Method Equation result for Housing Unit.

3.3. The Forest Community

Reclaiming the mining area into a forest land is a common treatment. The benefits include: soil stabilization, watershed management, greenhouse effect reduction, improved visual quality, wildlife habitat, shelterbelts, climate amelioration and it can provide natruals recourses such as fiber (Burley, 2001, p. 191-192).

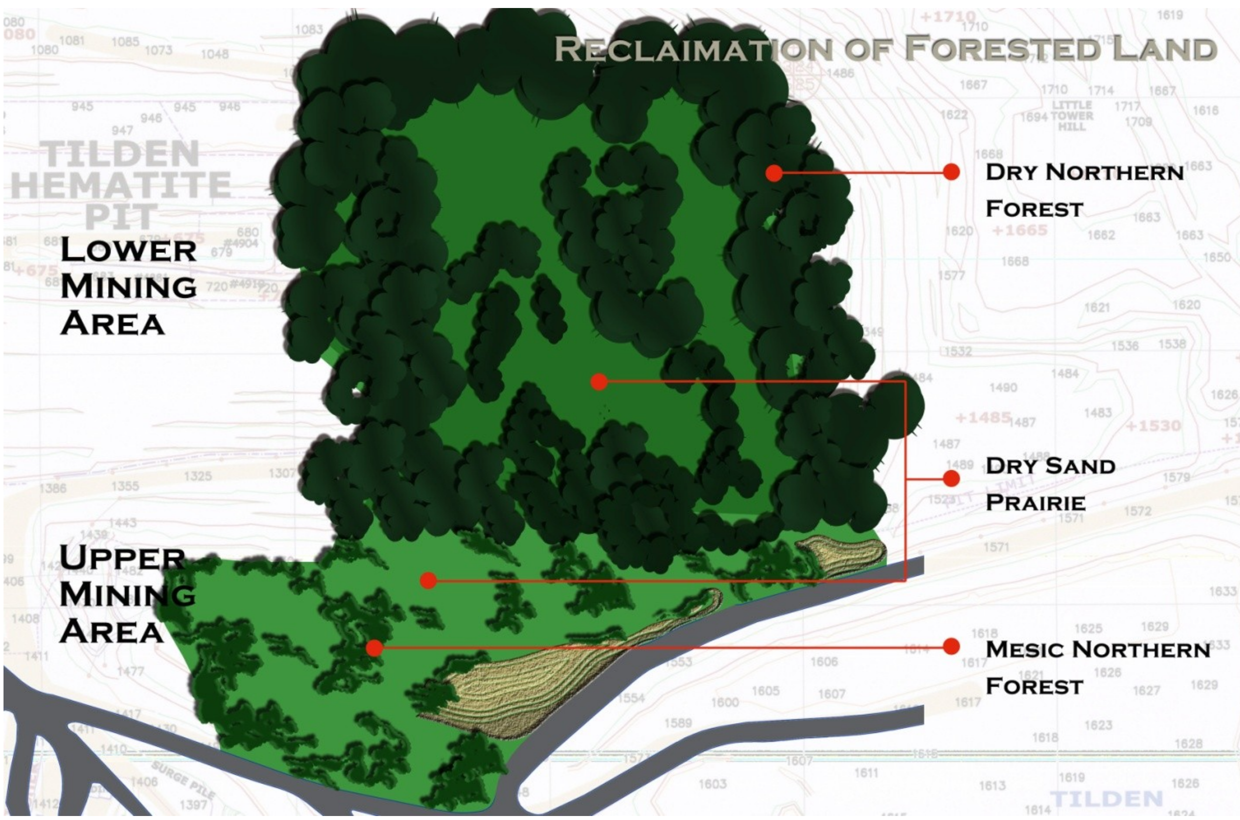


Figure 29: The distribution for three natural communities.

Based on the natural features such as soil type, water table, temperature and precipitation characteristics of Marquette County and considering the classifications of Michigan Natural Feature Inventory, there are three natural communities selected for reclamation (Figure 29). The first one is Dry Northern Forest which is a pine or pine hardwood dominated forest, mainly located on the north of the climate tension zone. Soils are coarse, well excessively drained dry sands, acid to very strongly acid with low nutrient. The overstory of dry northern forest is mainly dominated by jack pine (*Pinus banksiana,* Lambert, 1850) or red pine (*P. resinosa,* Solander, 1786). This natural community is located in the lower mining pit; the pine dominated forest is an ideal habitat for pine warbler. The second community is Mesic Northern Forest, dominated by northern hardwoods, such as sugar maple (*Acer saccharum,* Marshall, 1785) and American beech (*Fagus grandifolia*, Ehrhart, 1788); conifers include hemlock (*Tsuga Canadensis,* Linnaeus, 1766) and white pine (*Pinus strobes,* Linnaeus, 1766) which is important canopy associates. Variety soil types are support this community but it mainly occurs on loamy sand to sandy loam. This community is located on the top of mining pit; it can provide a suitable natural environment for hairy woodpecker. The last community is Dry Sand Prairie, it is a native grassland community, dominated by little bluestem (*Andropogon scoparius*, Michaux, 1803), big bluestem (*Andropogon gerardii,*Vitman, 1792), and Pennsylvania sedge (*Carex pensylvanica,* Lamarck, 1972). Soils are loamy sands, well drainage to excessively drainage. This community is scattered in Dry Northern Forest and Mesic Northern Forest to create open space and connect those two different communities (Kost et al., 2007).

The forest land treatment was selected as an approach to contrast with the two treatments that contain building. For Visual Quality (Figure 30), the selected image presents a view of forest in summer, the score is 45.79. For wildlife assessment, the score of Habitat Suitability for pine warbler is 0.63, for hairy woodpecker is 0.60. In Simpson's Diversity Index (Figure 31), the score for this group is 0.12. For water management (Figure 32), the score of Rational Equation Method is 11.85.

	Environmental quality index	Image 1	Image2
	Health	10	1
X1	perimeter of immediate vegetation	38	0
X2	perimeter of immediate non-vegetatic	0	0
X3	perimeter of distant vegetation	30	86
X4	area of intermediate vegetation	844	15
X5	area of any kind of water	0	0
X6	area of distant non-vegetation	0	54
X7	area of pavement	0	0
X8	area of building	0	0
X9	area of vehicle	0	6
X10	area of humans	0	0
X14	area of wildflowers in foreground	0	0
X20	smoothness: scale 1 to 5		
X30	open landscapes=X2+X4+[2*(X3+X6)]	904	295
X31	closed landscapes=X2+X4+[2*(X1+X17)]	920	15
X32	openness X30-X31	-16	280
X34	mystery=X30*X1*X7/1140	0	0
X44	complexity		
X46	sum		
X51	wetness		
X52	noosphericness=X7+X8+X9+X15+X16	0	6
X53	greenness		
X63	Shafer Index		
X80	X63*X52		
Y		45.7932	61.77188

Figure 30: The assessment images and scores of Visual Quality for Forest Community and Abandoned Mining Surface.

FOREST COMMUNITY

Simpson's Diversity Index

EVALUATION-VEGETATION DIVERSITY

Species	Number (n)	n(n-1)
Red Pine	3	6
Sweet Fern	4	12
Switch Grass	6	30
Bladder Sedge	8	56
Yellow Marsh Marigold	2	2
Creeping Juniper	4	12
Canadian Wildginger	5	20
Longhair Sedge	3	6
Total (N)	35	144

Simpson's Index

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

$$= 0.12$$

Simpson's Index of Diversity 1-D = 0.88

Simpson's Reciprocal Index 1/D = 8.33

Figure 31: The Simpson's Diversity result for Forest Community.

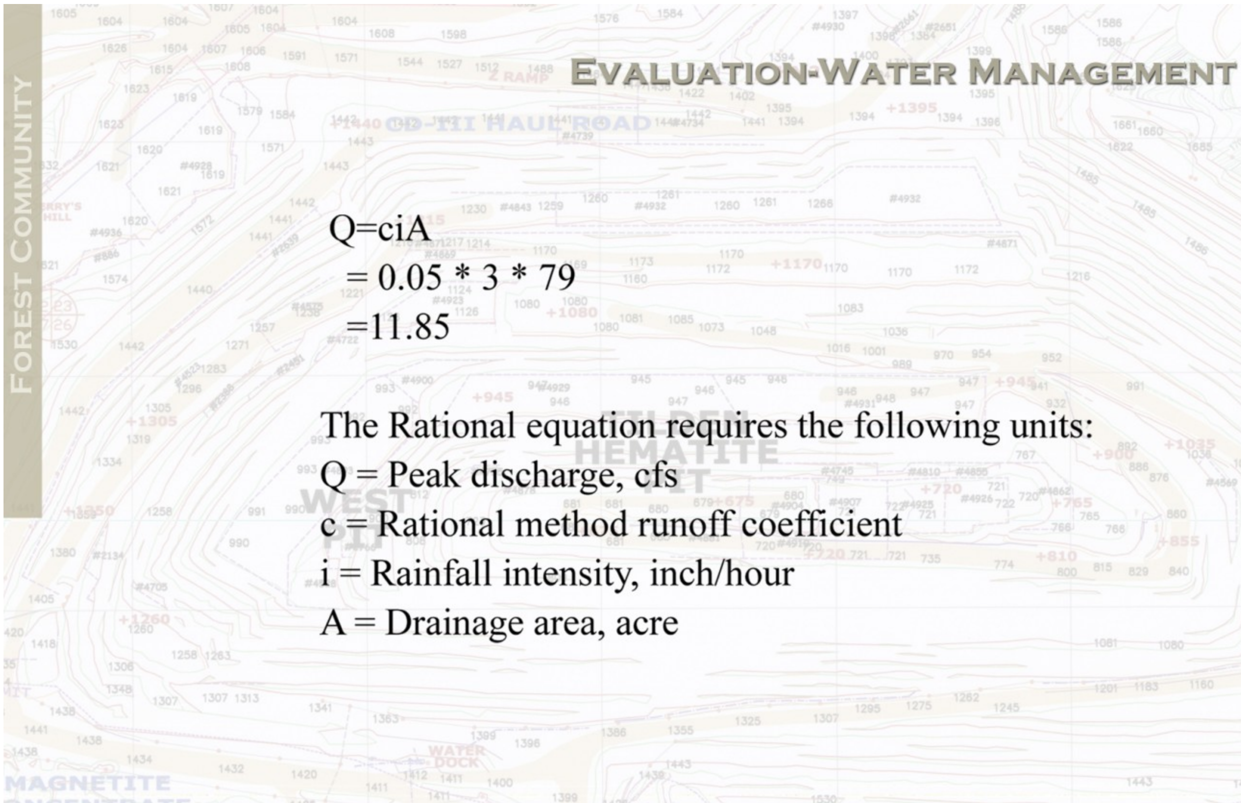


Figure 32: The Rational Method Equation result for Forest Community.

3.4. The Abandoned Mining Surface

The abandoned mine is a control treatment for contrast to the other three treatments. Due to human activities, the natural environment including vegetation, wildlife, and soil are disturbed.

In these assessment methods, for Visual Quality (Figure 30), the selected image presents a view of the existing mining surface, the score is 61.77. For wildlife assessment, there is no suitable habitat for wildlife, so the scores of Habitat Suitability for pine warbler and hairy woodpecker are all 0. In Simpson’s Diversity Index (Figure 33), the score for this group is 0, which represents there is no diversity in this area. For water management (Figure 34), the score of Rational Equation Method is 71.10.

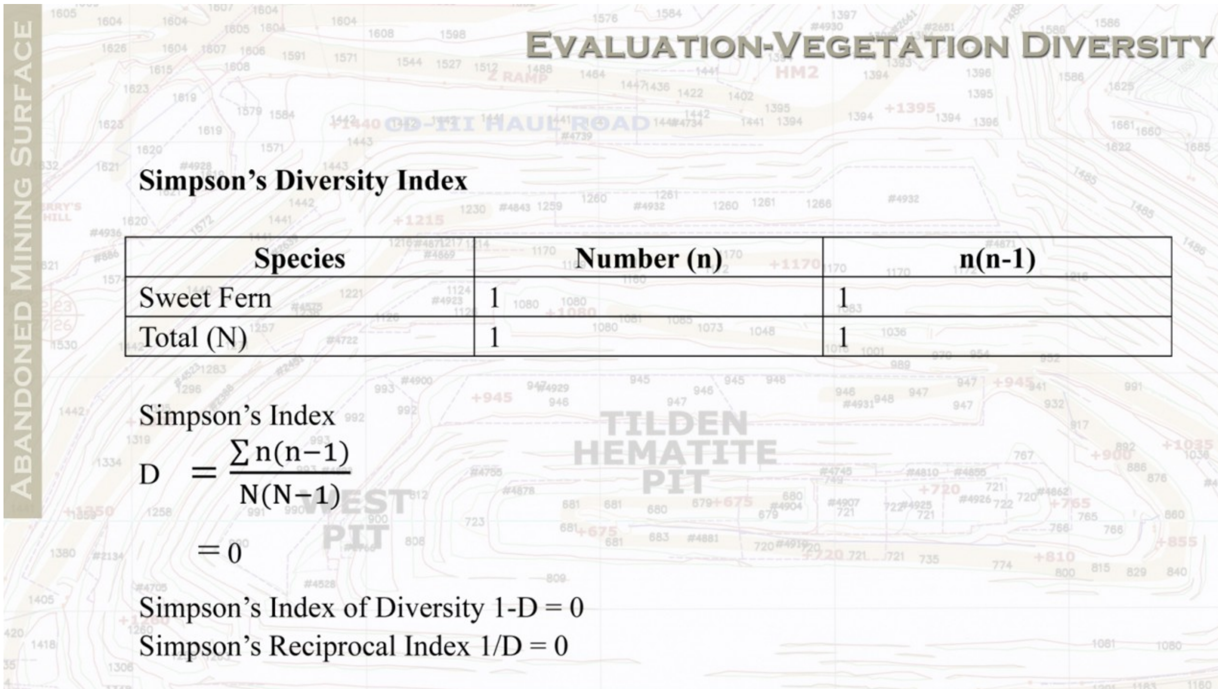


Figure 33: The Simpson's Diversity result for Abandoned Mining Surface.

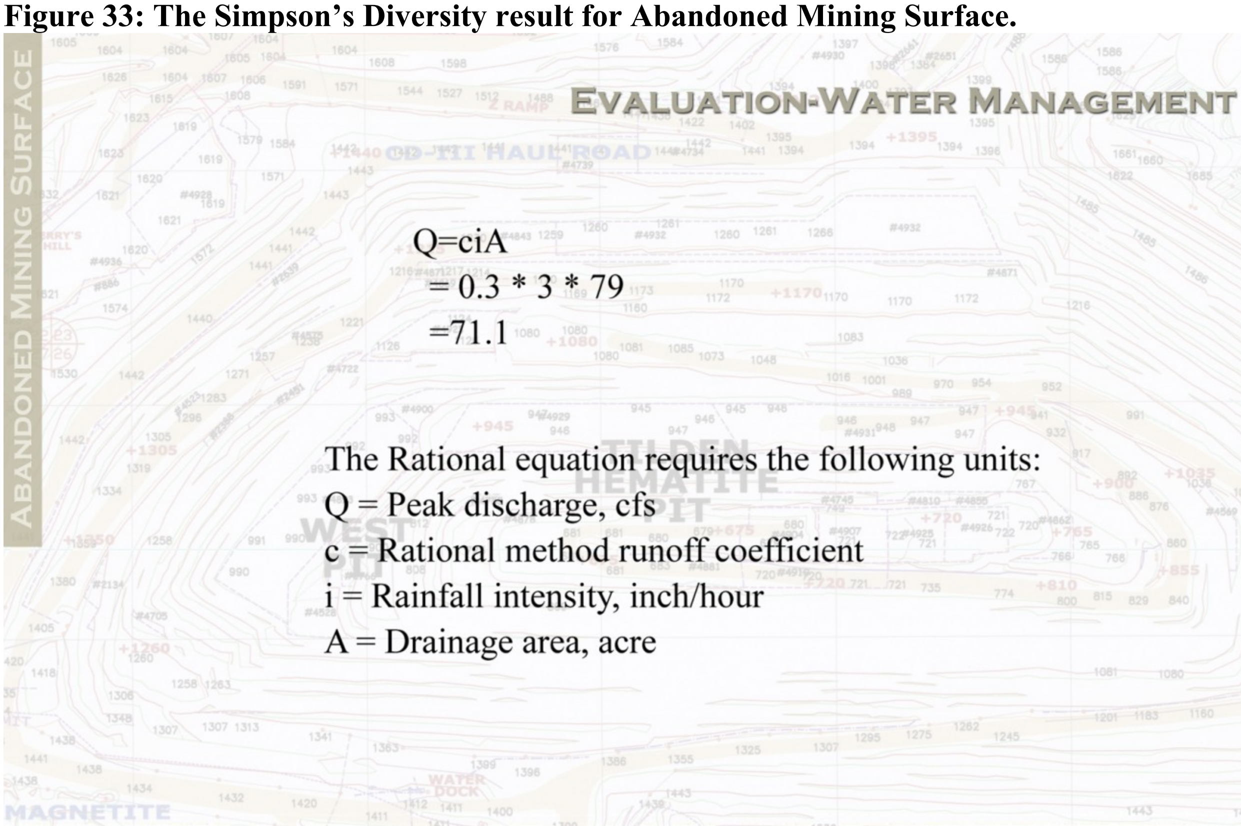


Figure 34: The Rational Method Equation result for Abandoned Mining Surface.

3.5. The Results for Friedman Analysis of Variance Statistic

According to Friedman analysis (Daniel, 1978), the original observations (Table 7) need be converted to ranks (Table 8). The hypotheses for Friedman two-way analysis of variance by ranks are:

H_0 : The four treatment yield identical results.

H_1 : At least one treatment tends to yield larger values than at least one other treatment.

Table 7: The assessment values for each treatment.

Score	Ski Resort	Housing Unit	Forest Community	Abandoned Mining
Visual Quality	54.31	51.85	45.79	61.77
Pine Warbler	0.17	0.14	0.63	0
Hairy Woodpecker	0.56	0.55	0.6	0
Simpson's Diversity	0.14	0.13	0.12	1
Water Management	16.59	21.33	11.85	71.1

Table 8: The ranks according to Friedman analysis.

Rank	Ski Resort(A)	Housing Unit(B)	Forest community(C)	Abandoned Mining(D)
Visual Quality	3	2	1	4
Pine Warbler	2	3	1	4
Hairy Woodpecker	2	3	1	4
Simpson's Diversity	3	2	1	4
Water Management	2	3	1	4
sum of ranks (R_j)	12	13	5	20

By equation 8, the result for this study is:

$$X_r^2 = \left(\frac{12}{bk(k+1)}\sum_{j=1}^{k} R_j^2\right) - 3b(k+1)$$

$$= \frac{12}{5*4*(4+1)}*(12^2+13^2{}_+5^2{}_+20^2)-3*5*(4+1)$$

$$= 13.56$$

Because the computed X_r^2 is not included, it needs to be compared for significance with tabulated values of chi-square with *k-1* degrees of freedom in Daniel (1978, p. 452). The X_r^2 value of 13.56 with 3 degrees of freedom is greater than the chi-square value ($p \leq 0.01$) of 11.35, therefore, the null hypothesis of H_0 is rejected, and we can conclude that the four treatments do not all yield identical results.

Since the hypothesis H_0 is rejected, in order to illustrate the differences between four treatments, the multiple-comparison procedure is needed. In this test, the experiment error is $\alpha = 0.01$, with k = 4, then the z = 2.72 can be found in Daniel (1978, p. 397). By equation 9,

$$|R_j - R_{j'}| \gg z\sqrt{\frac{bk(k+1)}{6}}$$

$$2.72\sqrt{\frac{5*4*(4+1)}{6}}$$

$$=11.10$$

The sum of rank for each column is: R_A =12, R_B = 13, R_C = 5, R_D = 20

Table 9: The difference for sum of ranks between four the treatments.

Difference $\lvert R_j - R_{j'} \rvert$	R_A	R_B	R_C	R_D
R_A	-	1	7	8
R_B	1	-	8	7
R_C	7	8	-	15
R_D	8	7	15	-

Comparing the results, the difference of treatments C and D is greater than 11.10, other groups are not (table 9), and therefore, it can be proved that treatment C and D are significantly different.

Chapter 4: Discussion

In this study, all the four design treatments were evaluated by assessment methods. The result of Freidman Analysis of Variance Statistics indicates the four treatments are not identical and two of them are significantly different. To discuss the study more thoroughly, the outcomes for each assessment should be studied first.

Based on visual quality equation made by Burley (1997), the result for each group is listed in table 10. The excellent visual quality usually contains large area of vegetation, wildlife, sky and water, the score for such image is about 30s to 40s, on the contrast, high score means worse visual quality, the score can reach 80 and above. In this study, the Forest Community has the best score and the abandoned mining surface has the worst. We can infer that the aesthetic quality is improved by using the Forest Community. However, for Ski Resort and Housing Unit, the average score of Ski Resort is lower than the Forest Community. The forested area is replaced by ski facilities. To mitigate these effects, designers could apply roof gardens and other types of greening to amend the visual impact.

Table 10: The Visual Quality results for four groups.

	Image No.1	Image No.2
Ski Resort	52	56
Housing Unit	51	52
Forest Community	46	_
Abandoned Mining Surface	62	_

Wildlife habitat can be an indicator of the success of a reclamation project. From the applications of predictive models which were published by Sousa (1987) and Schroeder (1982), the habitat suitability results for the treatments are presented (Table 11). In final score, the value ranges from 0 to 1. A value of one is considered as very good habitat. The forest community treatment and the treatments with structures scored better than the abandoned mine treatment.

Table 11: Scores of Habitat Suitability for Pine Warbler and Hairy Woodpecker.

SIC	Pine Warbler	Hairy Woodpecker
Ski Resort	0.17	0.56
Housing Unit	0.14	0.55
Forest Community	0.63	0.60
Abandoned Mining Surface	0	0

In this study, vegetation and water management are the other two considerations. In Simpson's Diversity Index, the value D ranges from 0 to 1, 0 represents infinite diversity. In order to make a better comparison, the species are selected as the same, except the dominated species may different for Forest Community type; and all the species are native to avoid invasion. The D value for Ski Resort is 0.14, Housing Unit is 0.13 and for Forest is 0.12, and we can infer that the diversity is improved compares to the mining surface, which the D value is 1. Water management is the last assessment method, ground surface will greatly influence the water runoff, and this is the reason why the score for Abandoned Mining Surface is so bad compares to other groups. Forest and lawns can help to held and infiltrate water and significantly reduce the volume of water runoff, however, pavement, parking lot, roof and concrete streets are not helpful, and on the contrary, these kinds of ground surface will contaminate water and make a bad effect on ground water system. In design project, designers can utilize the bricks with gaps for paving, the gap in between can allow the grass grow, this procedure can reduce water runoff especially for large area of pavement such as parking lot.

The comparison approach used in the study applied a statistical method. The Friedman analysis indicates that the four treatments did not yield the same result, which means that at least one of the designs is different; although there is a slight chance ($p \leq 0.01$) that the four designs are the same. The result for multiple-comparison procedure shows that Forest Community is significantly different from the Abandoned Surface Mine. The individual rank and sum of rank for each assessment can reveal the rank for each design treatment. In a broader and comprehensive scale, the Ski Resort is slightly better than Housing Unit, although some scores for ski are lower than housing. The native natural community scored best. The Abandoned Surface Mine ranked the worst.

There are too much obvious advantages of natural community in this urbanization era. Along with the increasing amount of impervious surface in urban area, forest community can alter the interaction of air, water, soil, sunlight and living beings; enhance community appeal; improve urban environment and human health (Wolf, 2004). Therefore, natural community should be the priority consideration in each design; it is the preference in ecology perspective for sure, and also this is the reason why natural community scored the best.

In this study, the Ski Resort is the only one which applied Context Sensitive Design. Compared with the Abandoned Surface Mine, all the environmental indicators are improved. The results suggest that CSD can not only be used in highway transportation, but also in architecture, landscape architecture, or on the broader scale, in city planning. CSD has been developed in transportation area and applied for a decade. The achievements are impressive. This philosophy will be very feasible if it is applied in other area planning and design settings, especially in developing country. In places like China, there is no such comprehensive or systematic approach to integrate every involved factor, if CSD can be introduced, it could be very helpful and beneficial.

Housing Unit and Ski Resort are utilized two different design philosophies, their design intents, space configuration, structure area, building density, functions and users are all quite distinct from each other. However, the results of assessment methods for those two treatments are similar; this may be because the performances in ecology aspects are similar, and all the assessment methods are related to biosphere perspective, so there is no significantly different between Housing Unit and Ski Resort. In future study, it should be more helpful to make the comprehensive evaluation for taking other factors into account.

Limitation and Future Research

There are five principles of Context Sensitive Design. Although I applied five assessment variables, the variables are related aesthetic, ecological environment, and function. Two of the principles were not assess: culture and economics. Of the two, culture seems to be a difficult area to quantify. Culture is an important factor; it can be abstract and also detailed; and it may be easy to follow in design but it is hard to examine or evaluate, this is a limitation in this study.

Except those limitations, errors may also occur during in this study. In assessment evaluation, all the scores may not be the accurate value, and in order to better understand and revise the design, some of the variables are assumed in the best condition, this can cause discrepancy with actual condition. There are also other factors may affect the result of assessment.

Future studies should include the study of economics, expand the assessment methods to the make the results more accurate, and use different designs to study the applicability in other land use project.

Conclusion

The assessment and statistical analysis in this study identified the differences between each treatment. Ranks for design treatments show the improvement and progress in every aspect. These findings can suggest that Context Sensitive Design is a sustainable approach for designers and planners beyond transportation. However it has not been demonstrated the CSD is substantially better than other possible, thoughtful design philosophies and approaches. The exits many more opportunities to study and compare various design approaches.

BIBLIOGRAPHY

BIBLIOGRAPHY

Albert, D. A., & North Central Forest Experiment Station (Saint Paul, Minn.). (1995). *Regional landscape ecosystems of Michigan, Minnesota, and Wisconsin: A working map and classification*. St. Paul, Minn: North Central Forest Experiment Station, Forest Service, U.S. Dept. of Agriculture.

Burley, J. B. (2001). *Environmental design for reclaiming surface mines*. Lewiston, N.Y: Edwin Mellen Press.

Burley, J. B. (1997). Visual and ecological environmental quality model for transportation planning and design. *Transportation Research Record*, *1549.*

Center for Transportation and the Environment North Carolina State University. (2007). *Results of Joint AASHTO/FHWA Context Sensitive Solutions Strategic Planning Process.* North Carolina:United State Department of Transportation-Federal Highway Administration.

Choay, F. (1960). *Le Corbusier*. New York, NY: G. Braziller.

Daniel, W.W. (1978). *Applied nonparametric statistics*. Houghton Mifflin Company.

Dorward, S. (1990). *Design for mountain communities: A landscape and architectural guide*. New York, NY: Van Nostrand Reinhold.

D'Ignazio, J., Day, M., Maguire, M., Lane, L., Toth, G., & Venner, M. (2011). *NCHRP Web-Only Document 184: Going the Distance Together: A Citizen's Guide to Context Sensitive Solutions for Better Transportation*. National Academy of Sciences. Retrieved from http://www.trb.org/Main/Blurbs/166933.aspx

Federal Highway Administration. (1998).*Thinking Beyond the Pavement*. Maryland

Ferguson, B. K. (1998). *Introduction to stormwater: Concept, purpose, design.* New York, NY: Wiley.

Georgia Department of Transportation. (2006). *Context Sensitive Design Manual*. Forest Park, GA: Author. Retrieved from: http://www.dot.state.ga.us/doingbusiness/policiesmanuals/roads/contextsensitivedesign/gdot_csd_manual.pdf

Hill, M. O. (1973). Diversity and Evenness: A Unifying Notation and Its Consequences. *Ecology*, *54*, 427–432.

Hunt, M., & Hunt, D. (2001). *Hunt's guide to Michigan's Upper Peninsula: The celebrated places and hidden treasures of a wild and historic region*. Albion, Mich: Midwestern Guides.

Hunter, P. R. & Gaston, M. A. Numerical Index of the Discriminatory Ability of Typing Systems: an Application of Simpson's Index of Diversity. *Journal of Clinical Microbiology, 26*, 2465-2466.

Kaufman, M. A. (2002). *Context Sensitive Design: How to Build Success into Highway Projects from the Start*. Context Sensitive Sustainable Solutions & Design: An Online Resource Guide. Retrieved from: http://www.cssforum.org/context_sensitive_design.htm

Kost, M.A., Albert, D.A. Cohen, J.G. Slaughter, B.S. Schillo, R.K. Weber,C.R. & Chapman, K.A. (2007). Natural Communities of Michigan: Classification and Description. *Michigan Natural Features Inventory*, Report No. 2007-21, Lansing, MI.

Kuichling, E. (1889). The Relation Between the Rainfall and the Discharge of Sewers in Populous District. *Transactions of the American Society of Civil Engineers,Vol. 20*, January, p. 1-60.

Lane, L. B. (2007). *NCHRP Synthesis 373: Multi-Disciplinary Teams in Context-Sensitive Solutions.* Washington, DC: Transportation Research Board.

Le Corbusier. (1986). *Towards a new architecture*. New York, NY: Dover Publications.

Loures, L., & Panagopoulos, T. (2007). Sustainable reclamation of industrial areas in urban landscapes. *Transactions on Ecology and the Environment, 102*, 791-800. doi:10.2495/SDP070752

Lynch, K., & Hack, G. (1984). *Site planning*. Cambridge, Mass: MIT Press.

Marquette County Clerk. (2011). *2011 Directory of Marquette County and Rules of Order of the Board of Commissioners*. Marquette, MI: Author. Retrieved from http://www.co.marquette.mi.us/county_government/county_directory.htm

Meyer, M.D., Campbell, S., Leach, D., & Coogan, M. (2005). Collaboration: The Key to Success in Transportation. *Transportation Research Record: Journal of the Transportation Research Board*, *1924*, 153-162.

Michigan Department of Natural Resources. (n.d.). *Western Upper Peninsula.* Newberry, MI: Author. Retrieved from Government Printing Office website: http://www.michigan.gov/dnr/0,1607,7-153-10370_30909_31053-153468--,00.html#context

Michigan Department of Transportation. (2006). *Drainage Manual*. Paw Paw, MI: Author. Retrieved from http://www.michigan.gov/stormwatermgt/0,1607,7-205--93193--,00.html

Michigan Department of Transportation. (n.d.). *Context Sensitive Solutions: Paving the way for better transportation.* Paw Paw, MI: Author. Retrieved from http://www.michigan.gov/documents/MDOT_CSS_articlel_159512_7.pdf

Michigan Department of Transportation. (2006). *Fundamentals of Context Sensitive Solutions*. Paw Paw, MI: Author. Retrieved from http://www.michigan.gov/mdot/0,4616,7-151-9621_41446---,00.html

Millennium Ecosystem Assessment (Program). (2005). *Ecosystems and human well-being: Health Synthesis.* Washington, DC: Island Press.

Minnesota Department of Transportation. (n.d.). *MnDOT Visual Quality Management Program*. Saint Paul, MN: Author. Retrieved from http://contextsensitivesolutions.org/content/case_studies/mndot_visual_quality_management/

Mittman, H. J. (1984). *National forest landscape management: Volume 2, chapter 7.* Washington, D.C: U.S. Dept. of Agriculture, Forest Service.

Neuman, T. R., Schwartz, M., Clark, L., & Bednar, J. (2002). *NCHRP Report 480: A Guide to Best Practices for Achieving Context Sensitive Solution.* Washington, DC: Transportation Research Board.

Norberg-Schulz, C., & Norberg-Schulz, C. (2000). *Principles of modern architecture.* London: A. Papadakis.

Oregon Department of Transportation. (2007). *Context Sensitive and Sustainable Solutions.* Salem, OR: Oregon Government. Retrieved from http://www.obdp.org/partner/cs3/

Oregon Department of Transportation. (2005). *Hydraulics Manual.* Salem, OR: Oregon Government. Retrieved from http://cms.oregon.gov/ODOT/HWY/GEOENVIRONMENTAL/Pages/hyd_manual_info.aspx

Pérez, G. A. (1983). *Architecture and the crisis of modern science*. Cambridge, Mass: MIT Press.

Ramroth, W. G. (2006). *Pragmatism and modern architecture.* Jefferson, N.C: McFarland & Co., Publishers.

Schoenbach, L. M. (2012). *Pragmatic Modernism*. New York, NY: Oxford University Press.

Schroeder, R. L., Western Energy and Land Use Team., & Biological Services Program (U.S.). (1982). *Habitat suitability index models: Pine warbler*. Washington, DC: Western Energy and Land Use Team, Office of Biological Services, Fish and Wildlife Service, U.S. Dept. of the Interior.

Simpson, E. H. (1949). *Measurement of diversity.* Nature 163*:* 688.

Sousa, P. J., & U.S. Fish and Wildlife Service. (1987). *Habitat suitability index models: Hairy woodpecker.* Washington, DC: U.S. Dept. of the Interior, Fish and Wildlife Service, Research and Development.

Stamatiadis, N., Kirk, A., Hartman, D., Hopwood, T., & Pigman, J. (2009). *NCHRP Report 642: Quantifying the Benefits of Context Sensitive Solutions.* Washington, DC: Transportation Research Board.

Stephenson, D. (1981). *Stormwater hydrology and drainage*. Amsterdam: Elsevier Scientific Pub. Co.

Strauch, P. (1994). *A wildlife habitat, maintenance, water runoff, and fertilizer comparison between links, target, woodland, and traditional golf course designs at Moonlight Basin, Montana.* Master of Landscape Architecture Thesis*,* University of Michigan.

Transportation Research Board. (2004). *Context Sensitive Design Around the Country: Some Examples*. Washington, DC: National Academy of Sciences.

Transportation Research Board. (2004). *NCHRP Web-Only Document 69: Performance Measures for Context Sensitive Solutions- A Guidebook for State DOTs*. Washington, DC: National Academy of Sciences. Retrieved from http://www.trb.org/Main/Blurbs/155207.aspx

Turner, T. (1996). *City as landscape: A post-postmodern view of design and planning.* London: E & FN Spon.

University of Minnesota. (2000). *Context Sensitive Design—Executive Summary*. Minneapolis, MN: Author. Retrieved from http://www.cts.umn.edu/contextsensitive/workshops/

United Nations General Assembly. (1987). *Report of the World Commission on Environment and Development: Our Common Future. Transmitted to the General Assembly as an Annex to document A/42/427 - Development and International Co-operation: Environment.* New York, NY: United Nations. Retrieved from http://www.un-documents.net/wced-ocf.htm

United Nations Human Settlements Programme. (2010). *Land, environment, and climate change: challenges, responses, and tools.* New York, NY: United Nations. Retrieved from http://www.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3022

Wolf, K. L. (2004). *Trees, Parking and Green Law: Strategies for Sustainability*. Stone Mountain, GA: Georgia Forestry Commission, Urban and Community Forestry.