Sustained Flight

Ecological Disc Golf Course Design: A Guide

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approval

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abstract

Disc golf is a rapidly growing sport all over the world; it is played like traditional golf, throwing a small frisbee, or disc, instead of hitting a ball, and playing a course which weaves through forested and other natural areas instead of across a manicured lawn. The attraction to the sport is attributed to its accessibility, the low-impact exercise opportunity it offers, time spent in nature, and its family friendly factor. During the last 10-15 years disc golf has experienced exponential growth, and course installation has grown alongside this increase in popularity. However, lack of official guidelines and regulation have led to poor course design decisions in terms of ecological preservation, leading to habitat degradation and other environmental damage. This project explores disc golf course design through the lens of environmental preservation. A merging of the fields of science and design will be at the forefront of the methodology developed, with the aim of demonstrating the importance and practicality of using scientific data to inform design in ecologically sensitive areas, where disc golf courses are often located. This project documents incidences of observed environmental degradation occurring on disc golf courses and then uses a landscape analysis methodology to develop a set of course design principles which aim to mitigate said degradation. Those principles are then merged with existing design principles to produce a new course plan in Oakridge, Oregon.

acknowledgements

The sport of Disc Golf and many of the courses on which it is played would not exist without the continued contributions of the many local Disc Golf Clubs, volunteer groups, and course stewards throughout the world. A massive thanks goes out to all those who have made the sport what it is and given me and my friends a place to play for so many years.

A huge thanks goes out to my family for all the support they have shown throughout this process. To my husband, for giving me the idea for this project, to my two-year-old son Eldon, for always reminding me to get outside and play a little bit every day, and to my unborn daughter Evelyn, for it is your generation we design for and therefore where we get the motivation to do our best to make the world a better place.

They say raising a child takes a village, but raising a child during graduate school took a small city, and I am so grateful for my parents, friends, and the wonderful staff at Moss Street Children's Center for making it possible for me to complete this work while becoming a mother.

Finally I want to express my deepest appreciation and gratitude to Chris Enright, my project adviser, for the unwavering support during the last year. Thank you not just for the editing, the project guidance, and the software turorials, but also for the friendship, the compassion you showed, and the intellectual conversations we shared each week, a welcome relief from my babbling toddler. Your dedication and committment to your students is something all professors should aspire to, and I feel eternally lucky to have had such a close working relationship with you throughout the program. Thank you for all that you do.

table of contents

list of figures

key terms

Basket: A disc-catching basket under a deflection assembly generally made out of chain.

Tee Pad: The designated area from which the first throw of each hole takes place. Tee pads are often made of concrete, though some feature rubber, turf, grass, asphalt, or gravel, and are 4' wide x 10' long.

Disc: A smaller than usual frisbee measuring 8.3–11.8 in in diameter, made out of polypropylene plastic, designed and shaped for control, speed, and accuracy.

Hole: The composition of a tee pad and basket, and the space in between them, averaging 150-1000' in length.

Course: The composition of all holes, typically 9, 12, 18, or 24 holes make up a course.

"Tree love": Term used to exclaim that a tree has assissted or aided your throw.

"Inside the circle" : Term used to describe being in scoring distance to the basket.

"Rotational play" : Term used to describe the order in which players throw off the tee pad.

Degradation: The process in which the beauty or quality of something is destroyed or spoiled; the process by which something is made worse, especially the quality of land.

Compaction: When soil particles are pressed together, reducing pore space between them, as well as water infiltration and drainage.

Erosion: The process by which the surface of the earth is worn away by the action of water, glaciers, winds, waves, etc.

Vegetation Damage: The removal of bark and other injury to trees and large woody shrubs.

Desire Line: An unplanned path that is used in the absence of a designated alternative.

Slope: Rise divided by run, represented by a percent.

Aspect: The position of a hillside in a specified direction.

Soil Type: The final classification of soil series description on a site, e.g. clay loam.

Vegetative Cover: Dominant species and density type in an area on a site, e.g. Ash Woodland.

chapter 1: Introduction

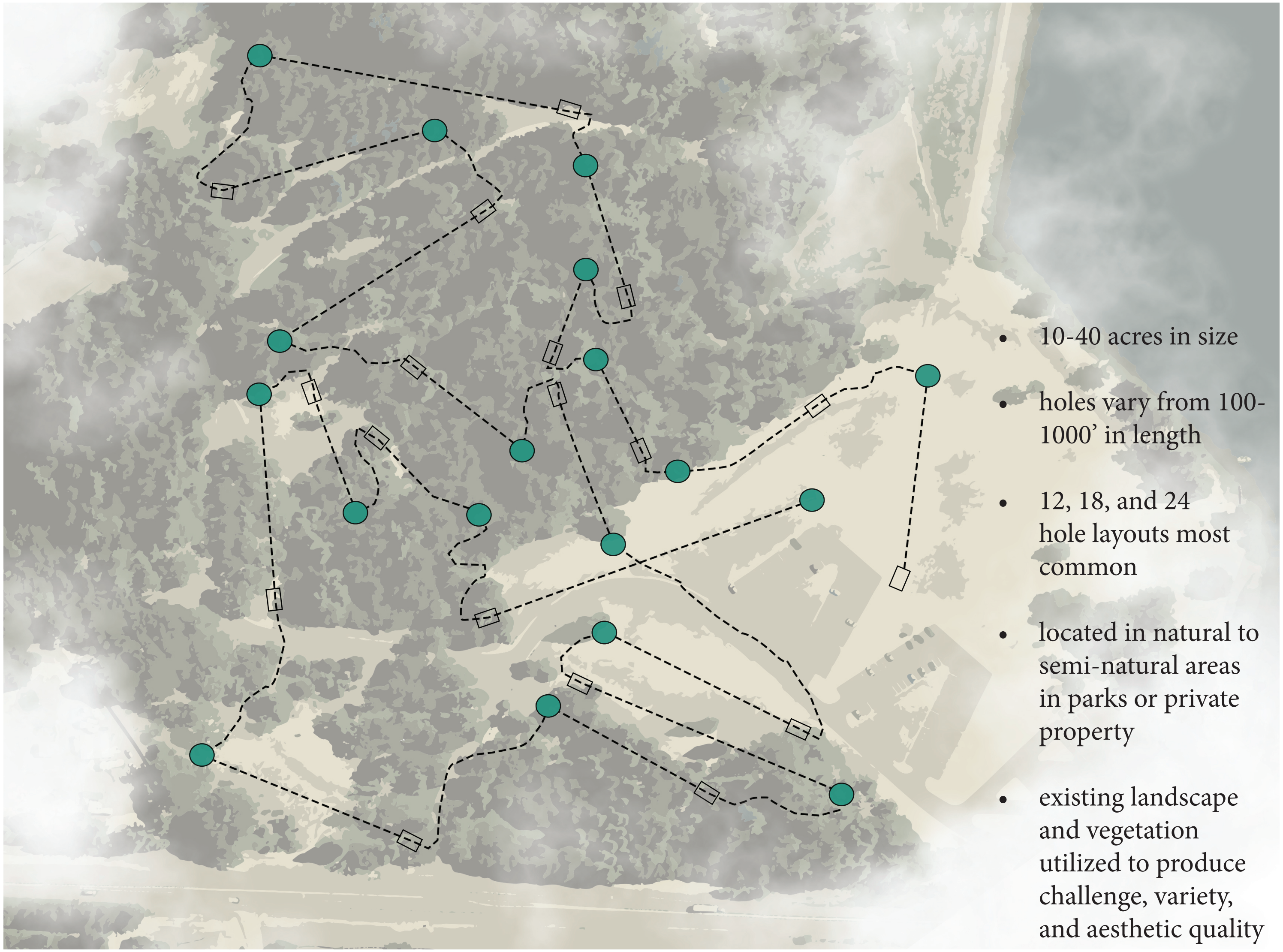
It is a blistering summer day and you and a couple friends are wanting to get out of the house. An air-conditioned movie theatre? Nope, not an option. The public pool? Closed. The park down the street? Probably too close for comfort. A hike in the woods? Those trails are not 6 feet wide. The year is 2020, and the global pandemic caused by Covid-19 has put a stopper on most activities we have come to depend on for entertainment. Luckily, there is an emerging sport that checks a lot of boxes for a lot of people and can even be done during the most restrictive period any of us has ever experienced. You and your friends agree to meet up at one of the local disc golf courses nearby; it is not a big deal to drive separately, as 98.5% of disc golfers live within a half hour drive of at least 2 courses, according to one survey (Infinite Discs Blog, 2019). You spend the afternoon wandering through the woods with a couple close friends, escaping the news and playing a fun and challenging game while getting fresh air and even a little exercise. Maybe tomorrow you will play again and get a better score or perhaps go explore a brand-new course nearby.

Disc Golf Popularity

Over the last few decades an increase in outdoor recreation has been observed, and projections indicate this trend will continue (White, 2016). During the coronavirus pandemic, people have flocked to the outdoors for activities and social interaction due to the perceived safety and reduced chances of contracting the virus in an outdoor setting (Outdoor Industry Association, 2020). Participation in disc golf has increased parallel to other forms of outdoor recreation during the pandemic, on top of its already exponential growth in popularity (Sports Planning Guide, 2013). Most people have thrown a frisbee at least once in their life, but fewer have played disc golf, or even heard of it. As popularity of the sport explodes however, that gap is closing.

Disc Golf Overview

Disc Golf is played very much like traditional golf in that it adopts the same basic set of rules and principles. There are typically 18 'holes' on a course, and the aim of the game is to finish the course in as few throws as possible. (fig. 1.1) However, instead of hitting a ball into a hole in the ground, one throws a compact frisbee, called a disc. Each hole starts at a tee-pad, and the goal is to get the disc into a basket made from steel rings and chains. (figs 1.2-1.3). One hole can be anywhere from 100-1000 feet in length, and each is assigned a 'par', like traditional golf, which is the number of throws it should take to get from tee-pad to basket. The fewer throws it takes over the entire course, the better the score. The greatest disparity between disc golf and traditional golf is the landscape on which each occurs. Traditional golf courses feature open, highly designed stretches of manicured lawn, with paved walks for carts that escort players from hole to hole. Disc golf, in stark contrast, most frequently takes place in a wooded setting with very little alteration of the grounds. The only design that goes into a disc golf course is the placement of the tee-pads and baskets, working with existing natural features, topography, and vegetation to create an interesting and challenging course.



- 10-40 acres in size
- holes vary from 100-1000’ in length
- 12, 18, and 24 hole layouts most common
- located in natural to semi-natural areas in parks or private property
- existing landscape and vegetation utilized to produce challenge, variety, and aesthetic quality

fig. 1.1: the landscape of disc golf

Current Course Design Principles

While people have likely been throwing frisbees at targets for much longer, disc golf officially became a sport with the establishment of the Professional Disc Golf Association (PDGA) in 1976, founded by the designer of the modern disc, Ed Headrick, also known as 'the Father of Disc Golf' (14ideas, 2019). The PDGA is the hub of the ever-expanding community of disc golfers in the U.S. and internationally. The PDGA provides official rules and guidelines for sanctioned tournament events, promotes the sport and provides basic guidelines for new course design. The guidelines they have adopted were developed by the Disc Golf Course Designers (DGCD), a loosely organized group of people who have some level of experience in designing successful disc golf courses (Professional Disc Golf Association-a, 2008). It is encouraged by the PDGA, but not required, to enlist the help of an experienced designer when installing a new course, and the DGCD provides a list of contacts for this purpose. The guidelines they provide are centered around designing courses from an anthropocentric view, as the factors considered are player skill level, fun factor, and challenge. (fig. 1.4). At present there is no officially recognized guidance that outlines course design principles from an environmental protection perspective. This project proposes adding a fourth factor to mitigate or avoid environmental damage and degredation. (fig. 1.5).

The above-mentioned popularity of the sport of disc golf can be measured in the demand for new courses. According to an article published by the Sports Planning

fig. 1.2: Innova brand disc golf basket & Disc


fig. 1.3: paver and wood frame disc golf tee pad

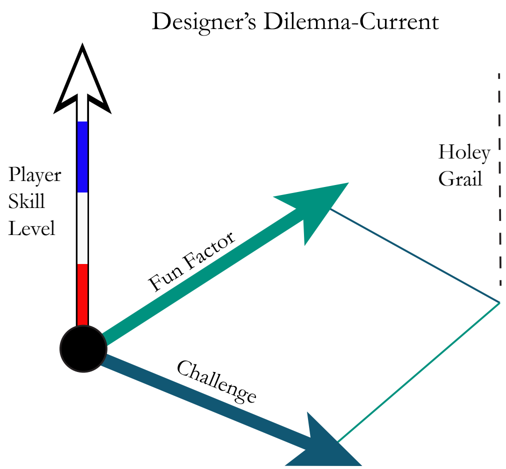


fig. 1.4: Disc Golf Course Designer's 'Designers Dilemna'

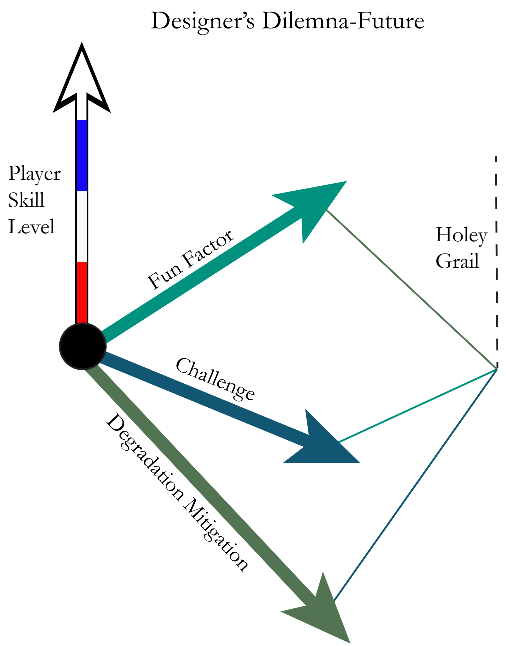


fig. 1.5: Future DGCD 'Designer's Dilemna'

Guide, by 2007 it had taken 30 years for 1,861 courses to be installed in the U.S., but between 2007 and 2013 an additional 1,319 courses were added to that number (Sports Planning Guide, 2013). That number continued to increase, and in 2020 there were 3,147 courses listed for the U.S. in the official directory of the PDGA (Professional Disc Golf Association-b, 2020) with some websites listing over 10,000 worldwide (UDisc-a, 2020). The growth of this sport and the accompaniment of course installations has begun to garner attention from the public, and it isn't all positive. Community opposition and even protests have prohibited some courses from being built or shut down existing courses due to environmental concerns (Parked, 2018). If the increase in popularity of this sport is sustained, these concerns will need to be addressed so that course installations can continue to provide access to all those who wish to begin to play disc golf.

Research on the negative environmental impacts of disc golf has begun to develop, and the primary issues identified thus far are tree damage, soil compaction, soil erosion, and wildlife disturbance (Leung, et al., 2013). Damage to trees and other woody vegetation is incurred by contact made by discs travelling at very high speeds, up to 80 mph (Disc Golf Course Review-a, 2020). Repeated impacts can cut through tree bark, snap branches, and weaken the tree making it susceptible to pests and disease. Soil compaction occurs throughout the course, but is concentrated at the basket, or target on each hole. This is caused by disc golfers and sometimes their accompanying carts (to carry their discs and other gear) moving across the course. Soil erosion is observed most often on sloped areas or adjacent to a stream moving through a course. Most courses do not have formal trails to guide players from one hole to the next, therefore groups will move freely down steep slopes and trample vegetation that would otherwise maintain the soil or cause direct erosion by trampling. These issues have been widely acknowledged by the disc golf community, and some efforts have been made to mitigate them on a case-by-case basis (PDGA Discussion Board, 2020). However, it is due time for a formal guide to course design that takes these concerns into consideration and addresses them prior to a course being installed.

Issues & Signifigance

There is no certification, license, or accreditation required for someone to design a course and they are often designed, funded, and installed by local disc golf groups or clubs. It has been acknowledged that the closest relevant degree for disc golf course design would be landscape architecture, but there is no known program that address disc golf course design explicitly (DGCDwiki, 2020). Therefore it has become apparent that there is a need to bridge this gap between known negative effects disc golf has on the environment and accepted principles of course design and provide a new set of principles that can be referenced in order to produce more ecologically sound courses in the future.

This project explores disc golf course design through the lens of environmental preservation and evaluates the potential for course design to mitigate its negative effects. A merging of the fields of science and design is at the forefront of the set of principles developed. (fig. 1.6). The goal of the methodology used is to demonstrate the importance and practicality of using scientific data to inform design in ecologically sensitive areas, where disc golf courses are most often located.

Incidents of environmental degradation occurring on disc golf courses are documented and then a McHargian landscape analysis methodology is used to determine how to mitigate them or prevent them from occurring while designing a new course. “"McHarg's Method" describes how, (through) thorough and multidisciplinary analysis of a region's ecological sensitivity, different information can be layered and combined geographically to identify suitability for different types of development and use.” (URISA, 2020). This technique will merge principles developed through a methodical, scientific approach with existing design principles to produce a course plan that will avoid or mitigate the known negative environmental impacts of disc golf.

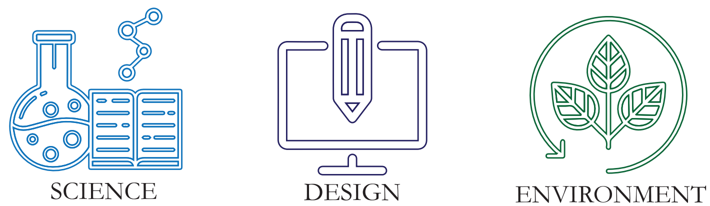


fig. 1.6: Merging science and design for environment

‘This project explores disc golf course design through the lens of environmental preservation and evaluates the potential for course design to mitigate its negative effects. A merging of the fields of science and design is at the forefront of the set of principles developed. The goal of the methodology used is to demonstrate the importance and practicality of using scientific data to inform design in ecologically sensitive areas, where disc golf courses are most often located.’

Project Objectives:

- Evaluate a set of existing courses and determine common incidents of environmental degradation on existing disc golf courses
- Develop a set of principles for disc golf course design that can be applied to achieve courses that minimize ecological degradation while providing human benefit
- Apply the principles by selecting a site and producing an example course design (fig. 1.7)

This project utilized a sequenced methodology that was then developed into a set of principles for future course design based on findings from a set of existing case study sites. A mixture of on-site documentation (including photography and measurement where appropriate) and computer-based land analysis including GIS and LiDAR modeling were used to establish the principles of course design outcome of this project. Those principles were then applied to a site in Oakridge, OR to design a new course demonstrating the application of the established principles.

The aim of this work is to address arising concerns regarding damage incurred by disc golf and integrate this knowledge into future course design by observing and documenting the impacts disc golf play is having on the ecosystems in the three case study sites. To ensure continued growth in a sustainable manner for the sport, a firm set of principles should be established, to be made available for reference for those who wish to design and build a new course in their community. If adapted and accredited by the PDGA, this work could be developed into a process required for new course installation to guarantee that some level of environmental protection has been implemented during the design process. This will aid in alleviating conflict between environmental groups who express concern over disc golf courses in their area, as well as promote ecological mindfulness throughout disc golf culture and produce healthy, functional courses to be enjoyed by both human and non-human beings.

The brief history and rapid development of disc golf as a sport has led to a lack of diligence during the process of course design and installation. As the popularity of the sport continues to expand and shows no sign of slowing, it is due time for a more refined procedure for course design that utilizes land analysis appropriate for the scale on which disc golf courses occur. The type of landscapes on which disc golf courses are built calls for the consideration of habitat protection, as most are in natural areas. If a positive relationship is to be maintained between the disc golf community and other user and interest groups of these natural areas, an effort needs to be put forth to demonstrate that habitat protection and ecosystem health are considered during the course design process. This project aims to develop such a process that would utilize appropriate and scientific landscape analysis tools and literature to inform course design, which will culminate in a prototypical design that could then be tested for future playability and enjoyment.

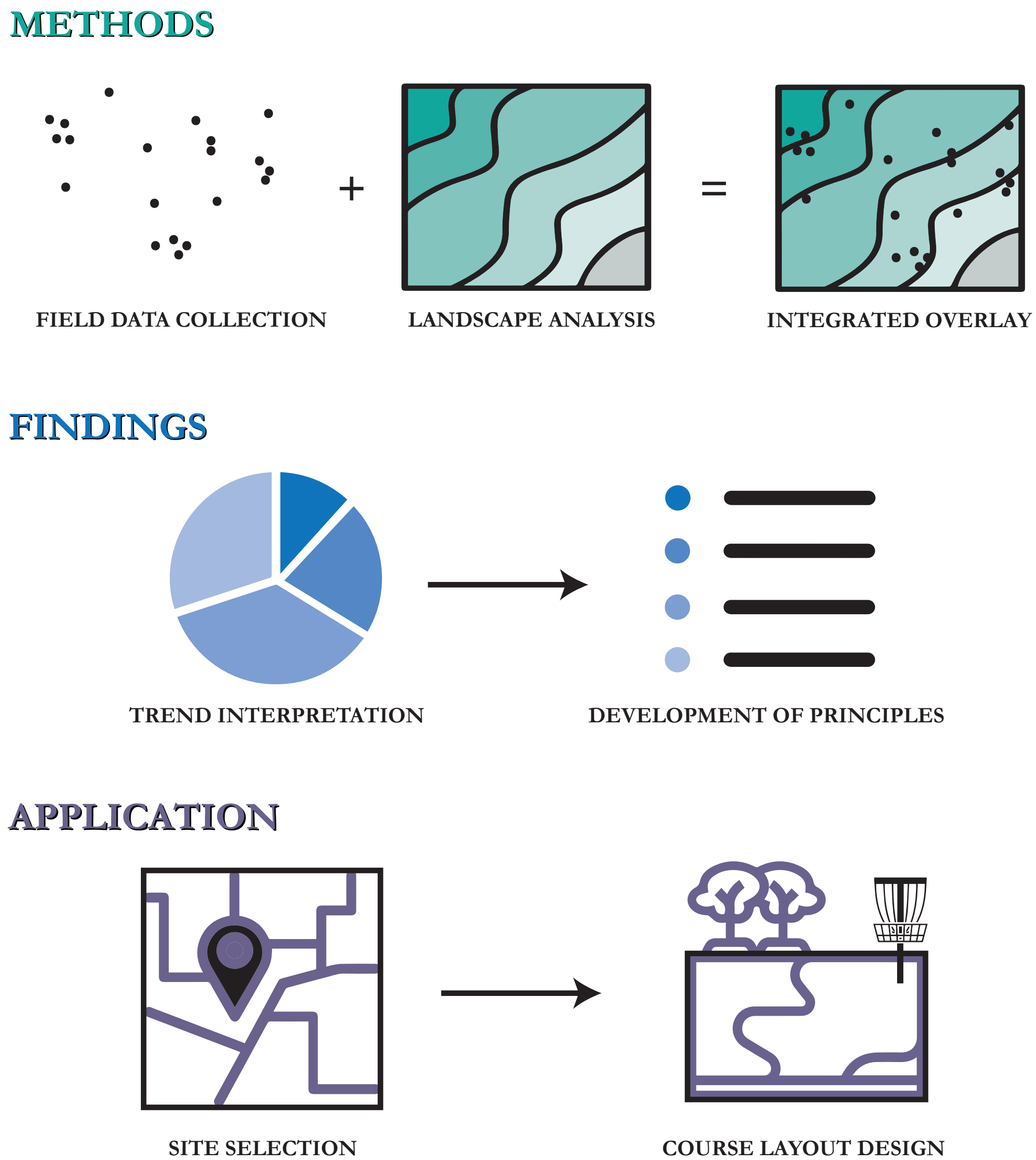
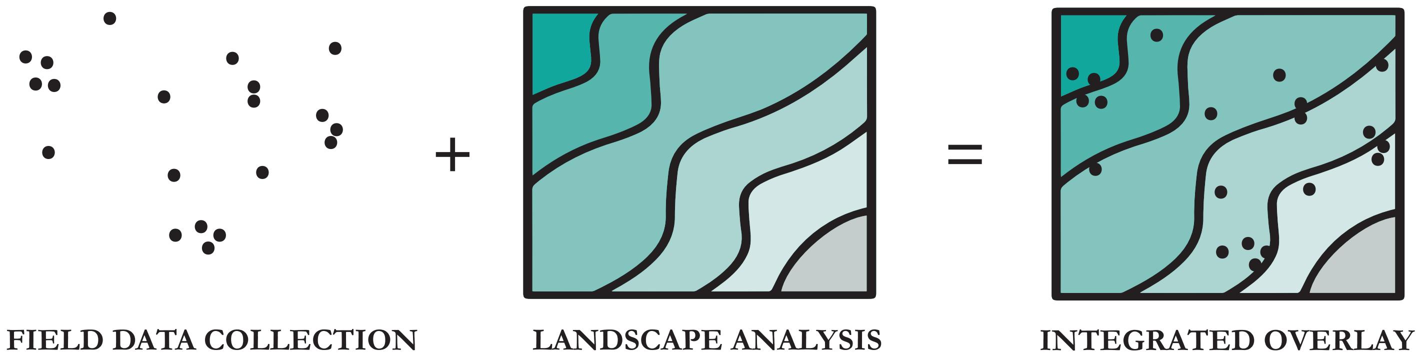


fig. 1.7: project concept diagram

chapter 2: Methodology

Site Documentation: Geo-tagged photography
Case Study Evaluation Sites
    Stewart Ponds
    Dexter
    Camp Serene
GIS Analysis


FIELD DATA COLLECTION
+
LANDSCAPE ANALYSIS
=
INTEGRATED OVERLAY

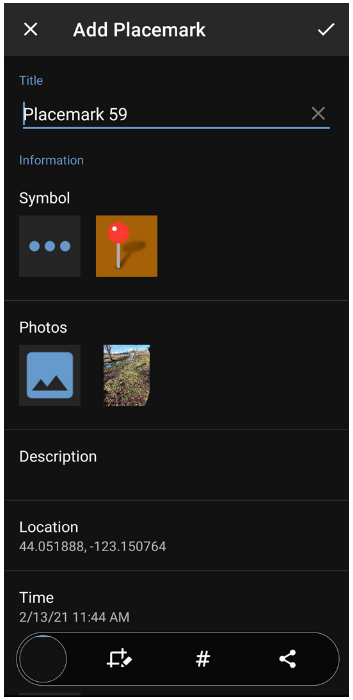


fig. 2.1: adding a placemark in Avenza

fig. 2.2: placemark population at Stewart Ponds Disc Golf Course

Site Documentation: geo-tagged photography

At the core of this project lies the joining of systematic site observation, experience, and documentation with the objective process of computer-generated landscape analysis techniques. The interpretation of observed incidents of degradation as well as well-functioning landscape interventions on existing disc golf courses are key principles in this methodology. That interpretation began with time spent on each case study site to record incidents of environmental degradation.

The project began by utilizing a standardized method to document the environmental degradation I had been observing during my visits to each site. Initially I had planned to walk pre-determined transects for each hole, taking photos of observed environmental degradation along my path. However, I discovered that if I played the course during my observation visits, I was exposed to areas outside of the planned transect. Therefore, I decided to play the course and document observed incidents of degradation (soil compaction, erosion, extensive vegetative damage, and desire lines) (figs. 2.3a-d) up to 50’ on either side of my disc flight path. When an occurrence of degradation was observed within my line of sight I moved to that location and photographed the occurrence.


fig. 2.3a: observed compaction


fig. 2.3b: observed erosion


fig. 2.3c: observed vegetation damage


fig. 2.3d: observed desire line

I used the application Avenza (Avenza Maps, 2021), downloaded to my Samsung S20 Galaxy smartphone to record data points at each site. I downloaded two maps within the Avenza application (two of my sites were located on one map): Oregon Wildlife Management Area 19, and Oregon Wildlife Management Area 20, both sourced from 'Map the Xperience'. At each site I used Avenza to locate myself on the appropriate map and recorded locations of tee pads and baskets using the placemark function. I also recorded photographs of my site observations and their geographic locations in Avenza by using the placemark function and attaching a photo to the placeholder (fig. 2.1). At the end of each course, I had thus mapped the current layout for the course and populated the study site with geo-tagged photographic observations (fig. 2.2).

Case Study Evaluation Sites

Being an avid disc golfer residing in the Southern Willamette Valley, I had been to many of the courses in my local area on numerous occasions prior to the onset of this project. The observations I made during play are what drove me to pursue this work. I chose three existing disc golf courses in the Southern Willamette Valley as case study sites for this project based on their distinct ecosystems and land ownership types. They are located within Lane County, Oregon (fig. 2.4). These were the sites for observation and documentation of environmental degradation occurring on disc golf courses. The following pages offer a brief overview of each course.

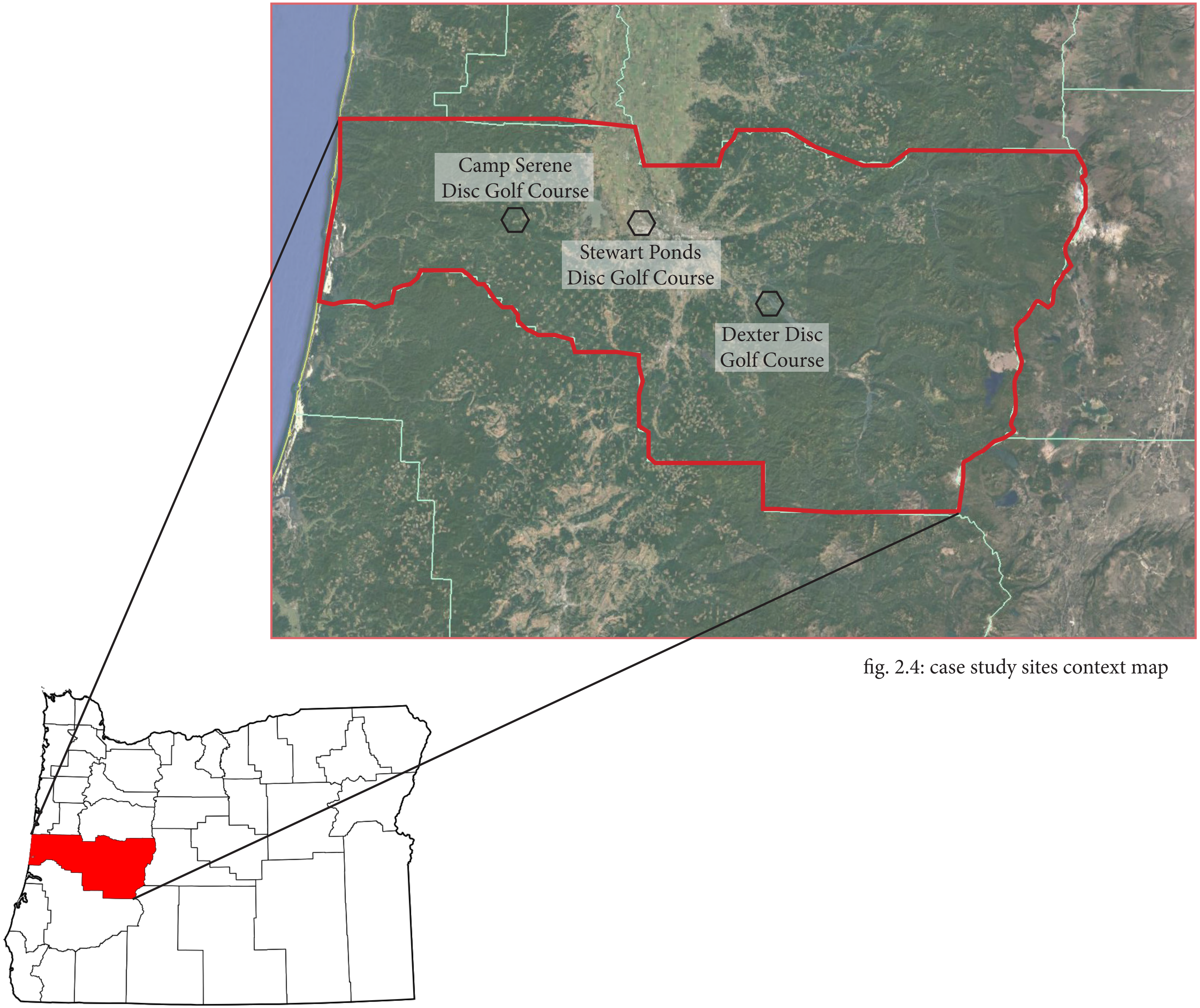
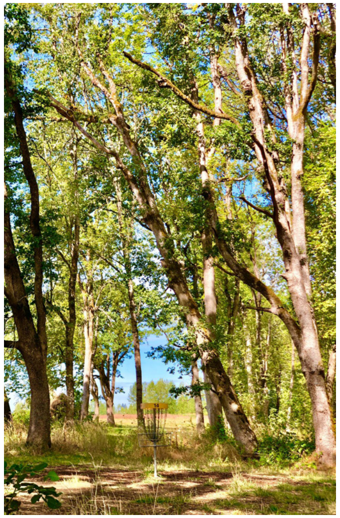


fig. 2.4: case study sites context map

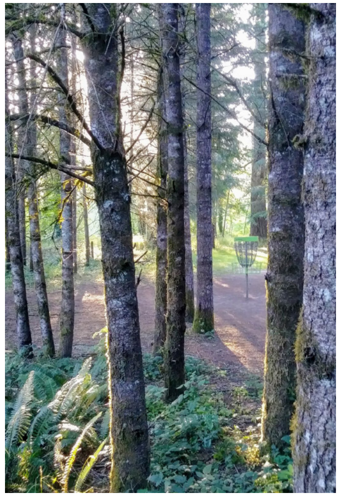
Stewart Ponds Disc Golf Course

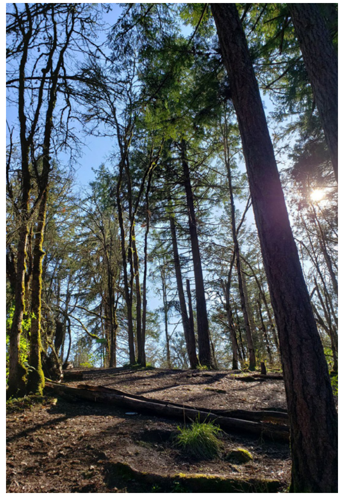


Located within the city limits of Eugene, OR, Stewart Ponds Disc Golf Course is located in West Eugene in the Stewart Ponds Natural Area managed by the Bureau of Land Management. The course was established in 2015. The site is a seasonal mixed wetland/upland savannah with Oregon White Oak and Oregon Ash as the dominant tree cover. Existing management of the site includes regular mowing and brush clearing to reduce illegal camping and maintain the oak savannah ecotype. It is open year-round, with winter play (Dec. – Mar.) being restricted to 12 holes instead of the regular 18 holes open during the rest of the year. The course features multiple water hazards, some established trails with boardwalks, and 1-3 holes with notable elevation gain or drop, though most of the course occurs on level topography (Disc Golf Course Review-a, 2020). This course has an elevation range of 390-460' above sea level, and gets an average of 46" of precipitation annually.

Dexter Park Disc Golf Course

This course is sited within Dexter State Park, on Hwy. 58 about 15 miles east of Eugene, OR. Established in 2001, Dexter Disc Golf Course is known to be a challenging course with varied topography and vegetative cover. The course is laid out adjacent to Dexter Resevoir, but does not feature any water hazards. Tree composition is primarily Oregon White Oak and Douglas Fir. There are 18 permanent holes, and the full course is open year-round (Disc Golf Course Review-b, 2020). The course has an elevation range of 650-720' above sea level and gets an annual average precipitation of 46".





Camp Serene Disc Golf Course

Camp Serene Disc Golf Course is privately owned and is a 'pay to play' course. Cost of play is $3 per person per round. It is in the coastal foothills, about 15 miles west of Eugene, OR. The property owners developed the course in 2014 as part of the Camp Serene Lutheran Summer camp they operate on their property, but it has recently become open to the public. The course weaves through second-growth Douglas Fir and Western Hemlock Forest, alongside the Long Tom River (Disc Golf Course Review-c, 2020). This course has an elevation range of 520-550', and experiences and average of 63" of precipitation.

GIS Analysis

After site visits were complete, a base map was created in a separate GIS project for each case study site. To create each base map, LiDAR data tiles were downloaded from the Oregon Department of Geology and Mineral Industries – Oregon LiDAR consortium (DOGAMI LiDAR Viewer, 2020). A topographic map of Lane County as well as a 1' resolution aerial photo were used to identify the extents of each of the three study sites. The LiDAR data were clipped to each site extent. Slope, aspect, and 1' contours were created from the LiDAR data for each site. Soils data were downloaded from the Web Soil Survey (Web Soil Survey, 2021). Using the aerial photo and observations from site visits, vegetation mapping was performed for each site by creating a new shapefile with polygons to identify the vegetative communities on site. The level of specificity for the vegetative communities included cover class (prairie, savanna, woodland, forest, etc.), dominant species (oak, fir/hemlock, ash, etc.) and ground moisture (wet, dry).

Once all the relevant data were imported or produced in ArcMap, the data sets were standardized across each study site. Slope was classified (layer properties, symbology, classified) into 5 classes using the Jenks (natural breaks) method, and then reclassified using the reclassify tool to assign each category a number (1-5) Aspect was classified into 4 classes designating North (292.5-67.5), East (67.5-112.5), South (112.5-247.5), and West (247.5-292.5), and then reclassified to assign each category a number 1-4. The soils shapefiles were classified from the full series description to a simpler soil typology (sandy loam, silty clay, etc.) and were then converted to raster data and reclassified to assign each soil type a number. The vegetation shapefiles were also converted to raster and reclassified to assign each cover type a number. The standardized analysis data sets were then imported and formatted to run cross-analysis and identify trends to develop a set of design principles. (figs. 2.6-2.8).

The field data I collected in geo-tagged photographic form with Avenza were downloaded as a kmz file and then processed for import into ArcMap as a shapefile for each site. In ArcMap, I manually edited the attribute tables for each shapefile, adding a field designating the type of degradation associated with each placemark. This was done by cross referencing the kmz file open in Google Earth, viewing each photo, and then choosing the most appropriate degradation type (fig. 2.5). The type of degradation was identified as either erosion, compaction, vegetation damage, or desire line (figs. 2.3a-d). Erosion was identified as complete removal of ground vegetation and notable loss of soil from an area. Compaction was chosen for images containing partial eradication of ground vegetation and notably sunken areas from concentrated foot traffic. Vegetation damage was called out for instances of trees suffering from loss of bark due to repeated impact from discs. An image was classified as a desire line when an informal trail had been established on the course. Placemarks showing locations of baskets and tee pads were labeled either basket or pad, and were then separated into their own shapefile and associated attribute table within the GIS project.

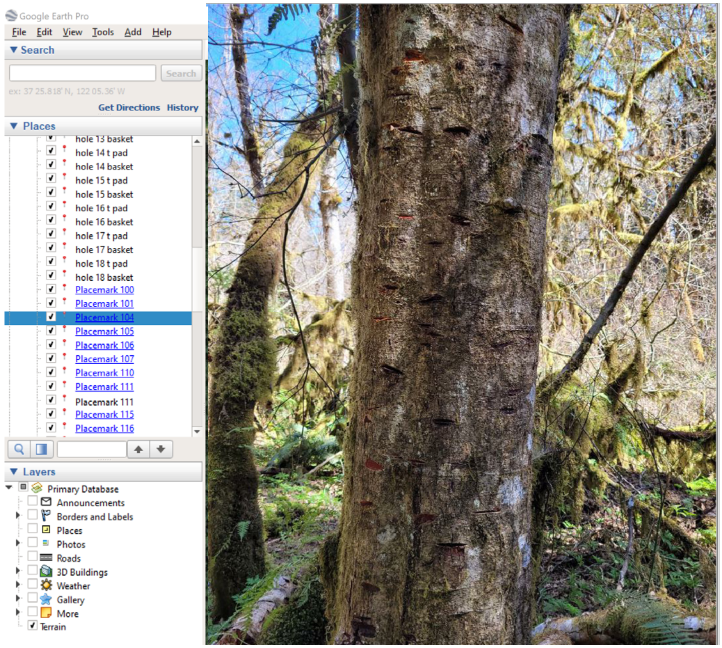


fig. 2.5: viewing placemark #114 image for Camp Serene Disc Golf Course in Google Earth, identified as vegetation damage

To perform the analysis the degradation point data were converted to a raster file (point to raster) and reclassified using prime numbers 7-17. Incidents of compaction were assigned 7, erosion 11, vegetation damage 13, and desire lines 17. The use of prime numbers allowed me to identify outcomes from the raster calculations with the other datasets (slope, aspect, soil, and vegetative cover). Additionally, none of the other data sets had been reclassified using numbers above 7, therefore a duplicate outcome would not occur. Raster calculations were then performed using the reclassed degradation data: [degradation*aspect], [degradation *slope], [degradation*soil], and [degradation*vegetative cover], where * indicates multiplication. Each result was saved into the ArcMap project and then exported as a Dbase table. This was done for each site and then each table was opened in Microsoft Excel to produce visual charts displaying the findings.

In addition to landscape feature analysis, degradation was cross referenced with proximity to both the tee pad and basket locations on each study site. To perform this, the ArcGIS buffer wizard was used to generate circular polygons at 20, 40, and 60-foot radii from all the tee pads and baskets. These polygons were then converted to raster and reclassified to assign the 20’ radius as 1, 40’ as 2, and 60’ as 3. Next a raster calculation was performed [(degradation*baskets] and [degradation*pads]) to identify occurrences of each degradation within each buffer ring. Tables for these results were then exported into Microsoft Excel and translated into visual graphs to display the results.

Stewart Ponds Disc Golf Course GIS Analysis Maps

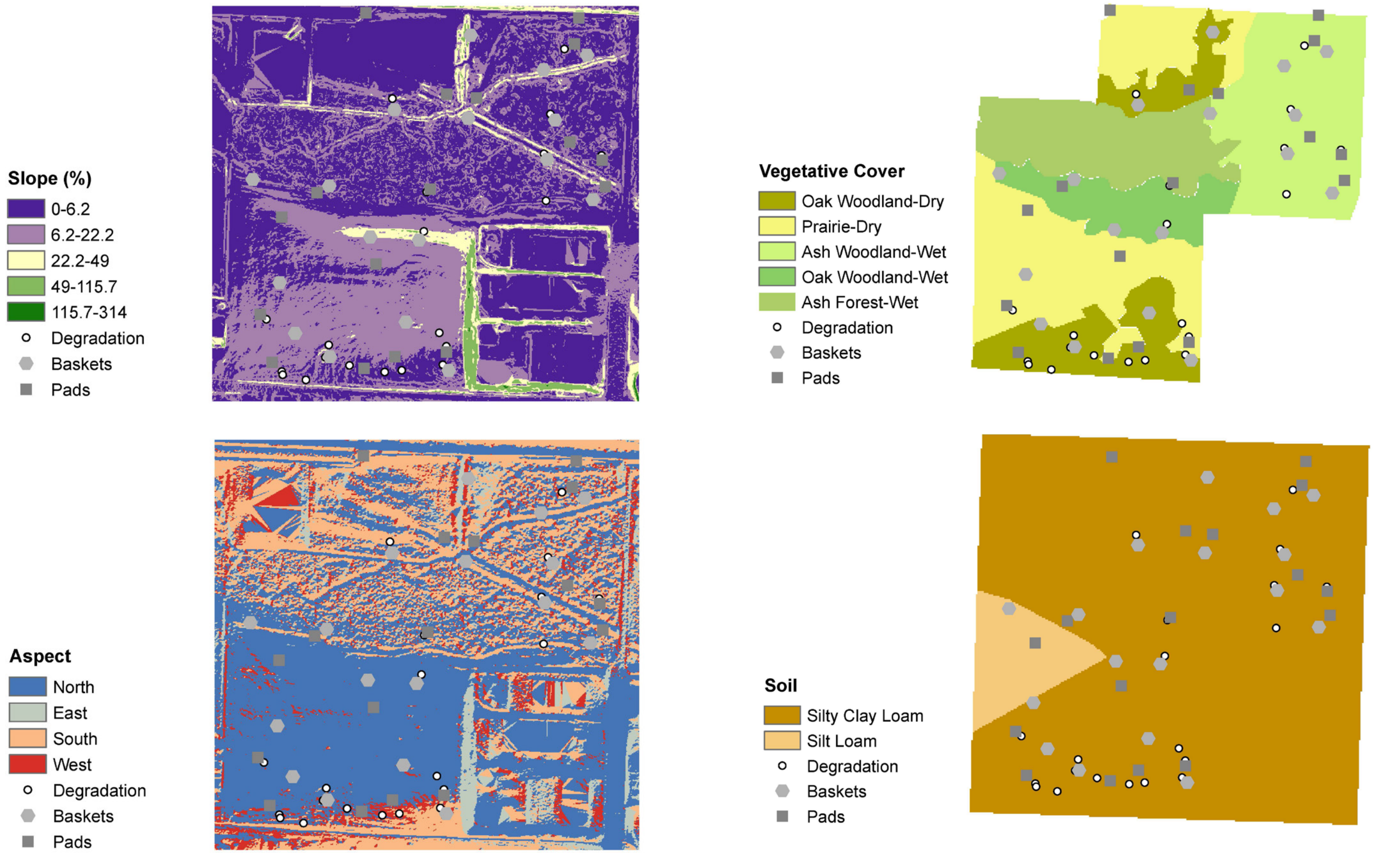


fig. 2.6a-d: Stewart Ponds Disc Golf Course GIS analysis with obserevd degradation points, tee pads, and baskets

Dexter Disc Golf Course GIS Analysis Maps

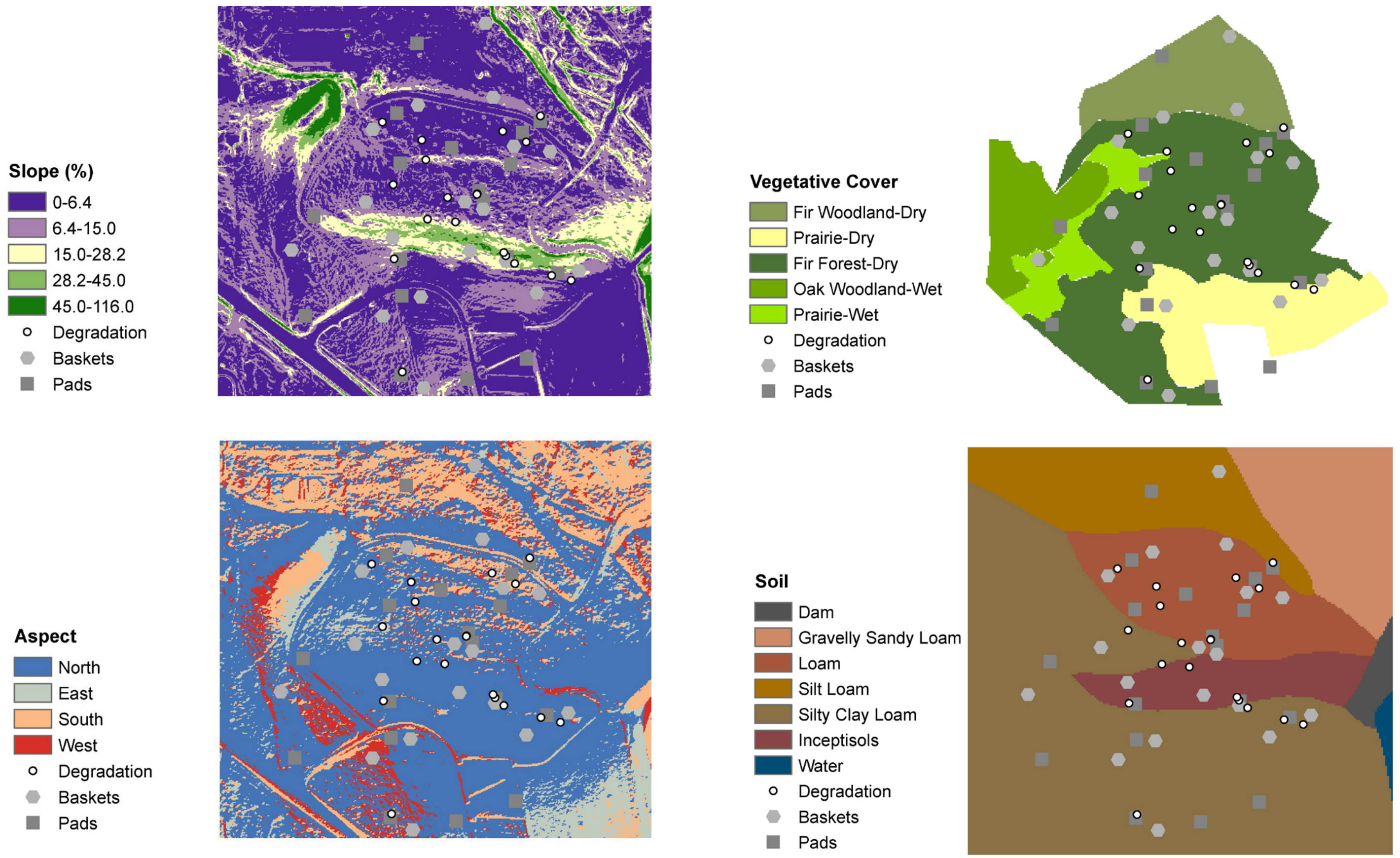


fig. 2.7a-d: Dexter Disc Golf Course GIS analysis with obserevd degradation points, tee pads, and baskets

Camp Serene Golf Course GIS Analysis Maps

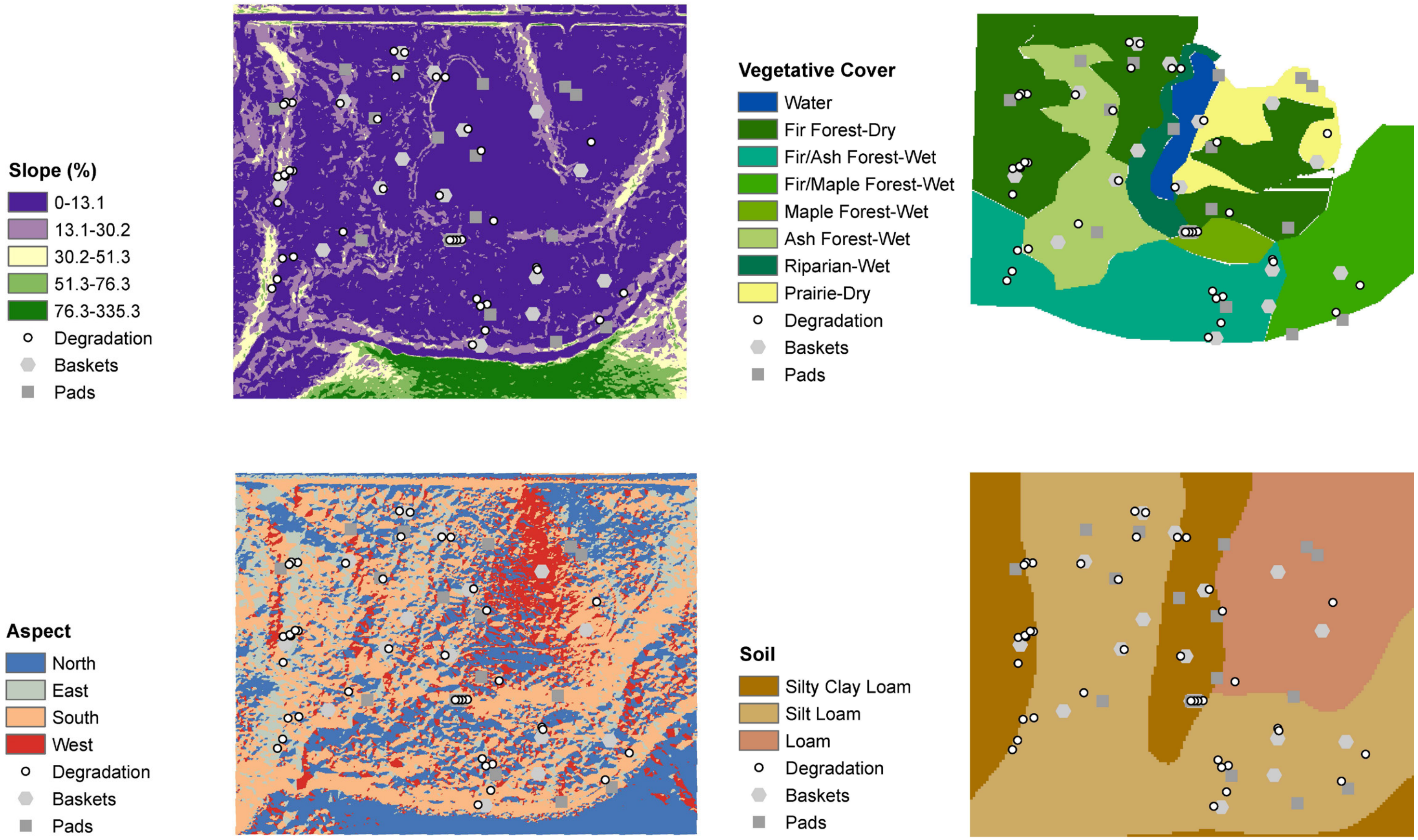
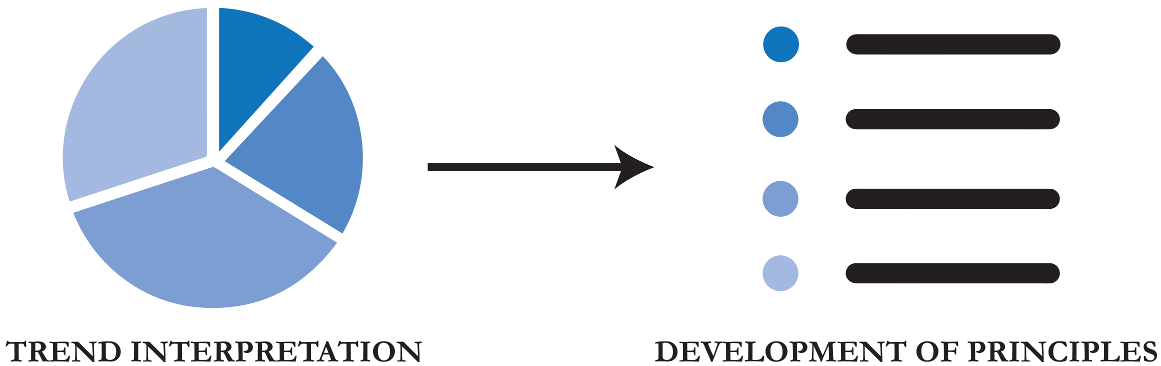


fig. 2.8a-d: Camp Serene Disc Golf Course GIS analysis with obserevd degradation points, tee pads, and baskets

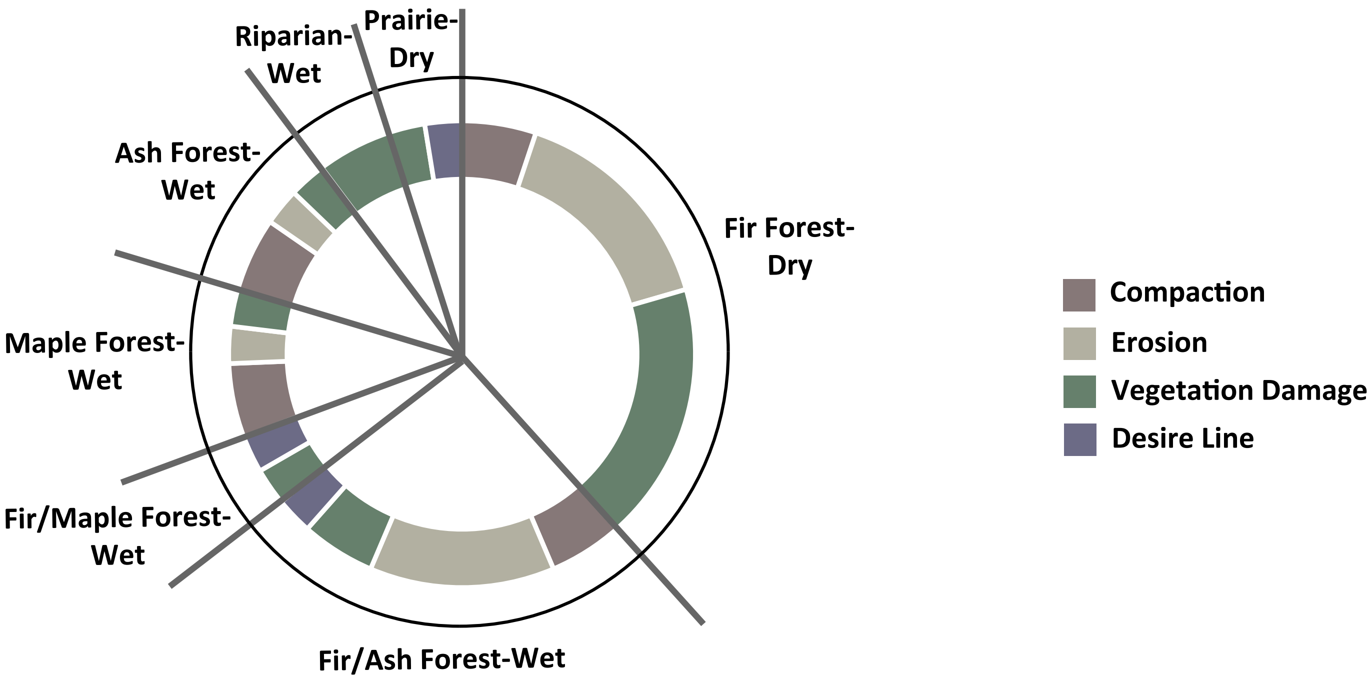
chapter 3: Findings


TREND INTERPRETATION
DEVELOPMENT OF PRINCIPLES

Individual Site Results

Each of the three case study sites occur on unique landscapes across a spectrum of elevations and precipitation regimes in Oregon. Landscape feature analysis was standardized across the sites when possible, but due to the unique nature of each site this was not always the case. The findings below show the distribution of observed degradation within each category of landscape analysis for each site: aspect, slope, vegetative cover, and soil type. (figs. 3.1-3.3a-d). Also included are observed degradation incidents occurring within 20, 40, and 60 feet of the tee pads and baskets on each course. (figs 3.1-3.3e-f).

Raster calculation outcomes were ranked by cell count and identified by the prime number denominator to be one of the 4 degradation types. This produced a chart showing the percentages of occurrence of each degradation type within each class of the relevant analysis category. For example, the chart on the facing page shows degradation associated with vegetative cover at Camp Serene, and it was determined for the Camp Serene Disc Golf Course site that degradation most often occurred in Fir Forest-Dry, and within those areas, the most common types of degradation were vegetation damage, followed by erosion. This allowed for identification of the most likely problem areas on each case study site and on which geophysical features incidents of landscape degradation due to disc golf play most often occur.



Camp Serene degradation associated with vegetation cover (from fig. 3.3c)

Stewart Ponds Disc Golf Course:

Data collection occurred during the fall at the onset of the wet season, and this course is partially located on a seasonal wetland. This drew particular attention to incidents of compaction as standing water was occurring in multiple areas during my site visit. Much of the course is in a semi-open canopy composed of hardwood species, which resulted in less frequent incidents of vegetation damage. The course is also mostly flat and therefore the incidents of observed erosion were minimal. The site had been recently mowed, and a visit during a time when vegetation was not freshly mowed could lead to a greater number of observed incidents of vegetation damage to woody shrubs or reveal a greater number of desire lines.

Aspect - The top two combinations of observed degradation and aspect were

1. Erosion on north aspects (25%), and
2. Compaction on south aspects (17%). (fig 3.1a)

Slope - The top two combinations of observed degradation and slope were

1. Compaction on slopes 0-6.2%, and
2. Erosion on slopes 6.2-22.2%. (fig 3.1b)

Vegetative Cover - The top two combinations of observed degradation and vegetative cover were

1. Compaction in Oak Woodland-Dry (27%), and
2. A tie between vegetation damage in Oak Woodland-Dry (14%) and compaction in Ash Woodland-Wet (14%). (fig 3.1c)

Soil - The top two combinations of observed degradation and soil type were

1. Compaction on Silty Clay Loam (34%), and
2. Erosion on Silty Clay Loam (33%). (fig 3.1d)

Tee Pads - The top two combinations of observed degradation and proximity to the tee pad were

1. Compaction between 0-20 feet and
2. Veg. damage between 40-60 feet. (fig. 3.1e)

Baskets - The top two combinations of observed degradation and proximity to the basket were

1. Erosion between 20-40 feet and
2. A tie between erosion between 0-20 feet and compaction between 40-60 feet. (fig. 3.1f)

Stewart Ponds Disc Golf Course GIS Analysis Findings

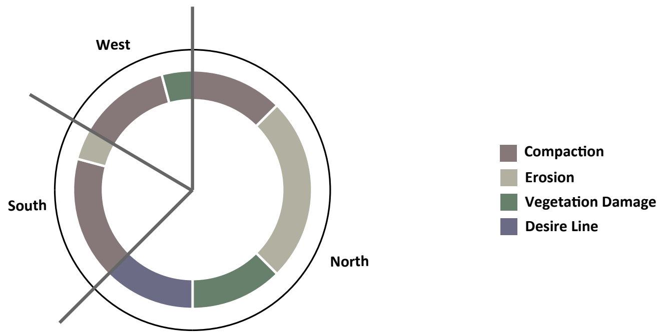


fig. 3.1a: degradation*aspect

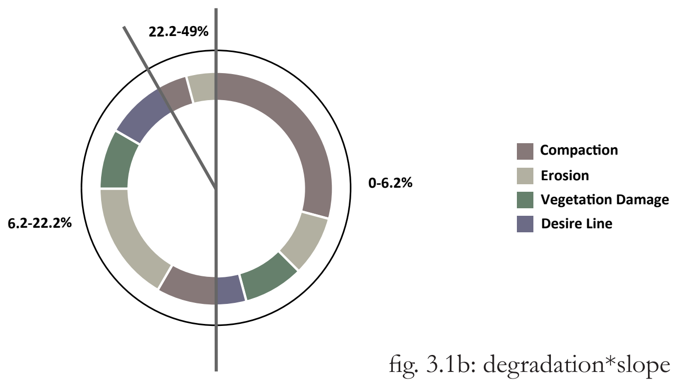


fig. 3.1b: degradation*slope

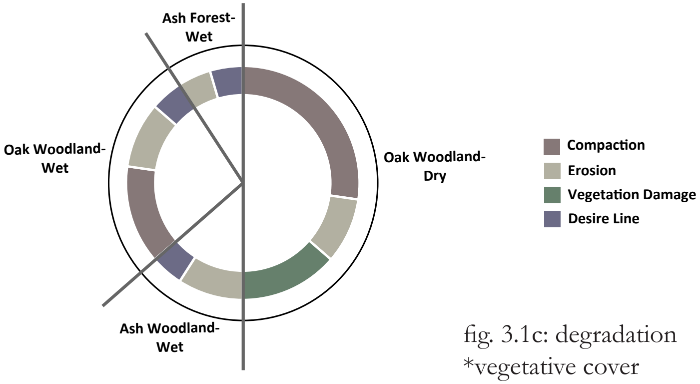


fig. 3.1c: degradation *vegetative cover

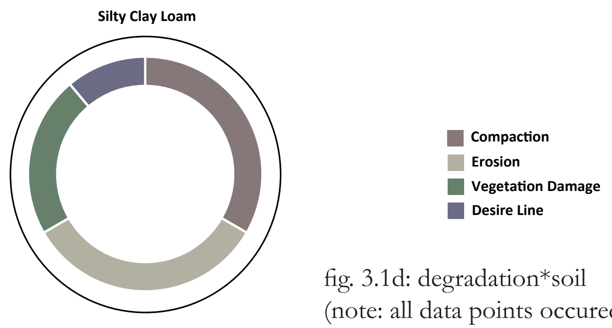


fig. 3.1d: degradation*soil (note: all data points occured on Silty Clay Loam)

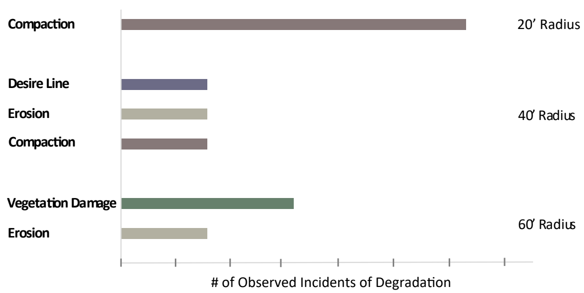


fig. 3.1e: degradation at the tee pad

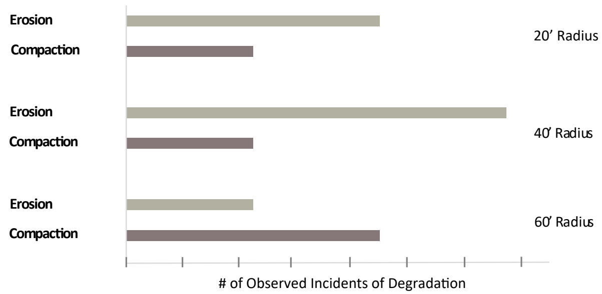


fig. 3.1f: degradation at the basket

Dexter Disc Golf Course:

The course at Dexter State Park features a near equal balance between open and closed canopy cover, which gave contrast to the frequency of degradation occurring on each cover type. Degradation was notably more frequent within the closed canopy areas and less frequent in the open/prairie areas. The most degraded section of the course occurred on a transition between open and closed canopy, the steepest slopes on site, and the area designated as an inceptisol soil. Several desire lines were noted on this course within the semi-closed canopy areas. Data collection on this site also occurred during the fall, but during other visits outside the project a population of Camas (a sensitive native wildflower) has been observed on one of the holes. Future research on this topic would include seasonal vegetation and wildlife protection that this project did not allow time for.

Aspect - The top two combinations of observed degradation and aspect were

1. Erosion on north aspects (33%), and
2. compaction on north aspects (22%). (fig 3.2a)

Slope - The top two combinations of observed degradation and slope were

1. A tie between compaction on slopes 0-6.4% and erosion on slopes 15-28.2% (17%), and
2. A three-way tie between vegetation damage on slopes 0-6.4% (11%), compaction on slopes 6.4-15% (11%), and desire lines on slopes 0-6.4% (11%). (fig 3.2b)

Vegetative Cover - The top two combinations of observed degradation and vegetative cover were

1. Erosion in Fir Forest-Dry (38%), and
2. Compaction in Fir Forest-Dry (37%). (fig 3.2c)

Soil - The top two combinations of observed degradation and soil type were

1. Erosion on Inceptisols (soils that are still becoming established) (43%), and
2. Compaction on Loam (15%). (fig 3.2d)

Tee Pads - The top two combinations of observed degradation and proximity to the tee pads were

1. Erosion between 20-40 feet and
2. Compaction between 40-60 feet. (fig 3.2e)

Baskets - The top two combinations of observed degradation and proximity to the baskets were

1. A 4-way tie between erosion 0-20 feet, and desire line, erosion, and compaction between 20-40 feet.
2. A 2-way tie between compaction between 0-20 feet and compaction between 40-60 feet. (fig 3.2f)

Dexter Park Disc Golf Course GIS Analysis Findings

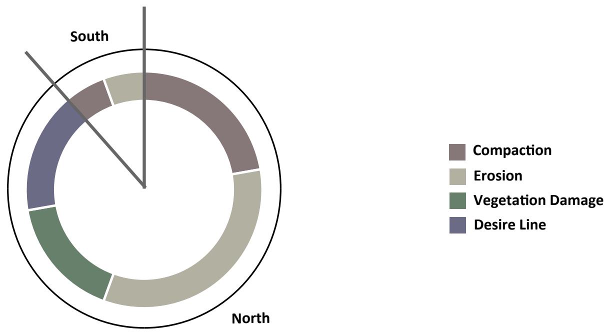


fig. 3.2a: degradation*aspect

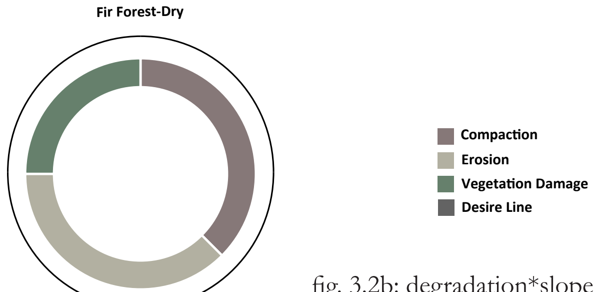


fig. 3.2b: degradation*slope (note: all data points ocurred in Fir Forest-Dry)

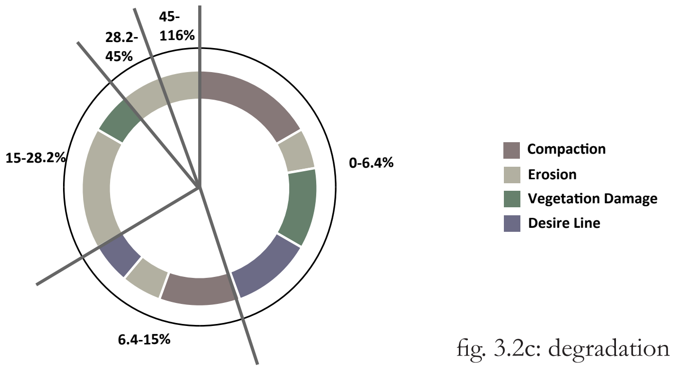


fig. 3.2c: degradation *vegetative cover

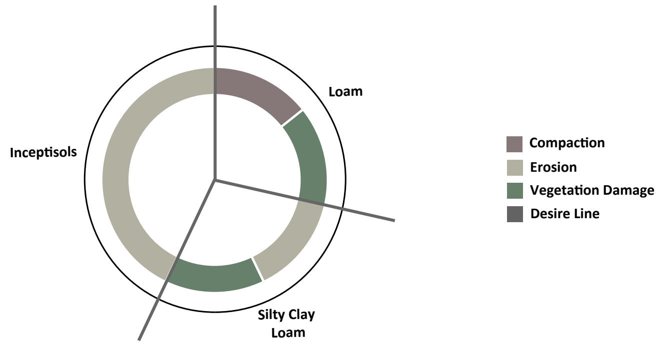


fig. 3.2d: degradation*soil

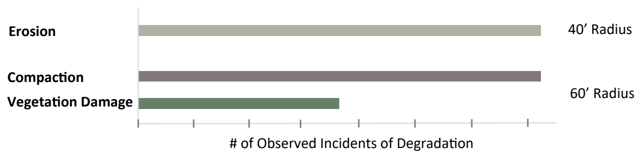


fig. 3.2e: degradation at the tee pad

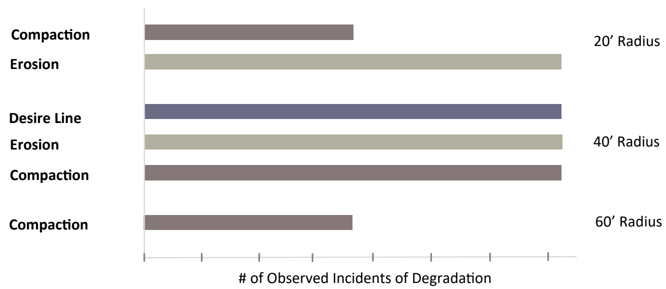


fig. 3.2f: degradation at the basket

Camp Serene Disc Golf Course:

Camp Serene experiences greater annual precipitation than the other two sites, and it is almost entirely occurring in closed canopy vegetative cover. This resulted in the most frequently observed degradation type being vegetation damage. This course is also unique to the study because it is bordered by a river and has tributary creeks flowing through it. Several incidents of severe erosion were observed in these riparian areas. The site has an elevation range of just 30' and therefore does not feature many notably steep slopes, and the number of observed incidents of erosion reflected this, resulting in fewer than other sites. At the time of my site documentation visit, the course owner and volunteer crews had completed an impressive amount of work on the course, mostly laying wood chips to establish trails and adding signage to guide players through the course, which greatly reduced the presence of widespread compaction on the course.

Aspect - The top two combinations of observed degradation and aspect were

1. Vegetation damage on south aspects (25%), and
2. A tie between compaction on south aspects (15%) and erosion on east aspects (15%). (fig. 3.3a)

Slope - The top two combinations of observed degradation and slope were

1. Vegetation damage on slopes 0-13.1% (22%), and
2. A tie between erosion on slopes 0-13.1% (20%) and vegetation damage on slopes 0-13.1% (20%). (fig. 3.3b)

Vegetative Cover - The top two combinations of observed degradation and vegetative cover were

1. Vegetation damage in Fir Forest-Dry (18%), and
2. Erosion in Fir Forest-Dry (15%) (fig. 3.3c).

Soil - The top two combinations of observed degradation and soil type were

1. A tie between compaction on Silty Clay Loam (20%) and erosion on Silty Clay Loam (20%), and
2. A 4-way tie between vegetation damage on Silty Clay Loam (10%), erosion on Silt Loam (10%), vegetation damage on Silt Loam (10%), and desire lines on Silt Loam (10%). (fig. 3.3d)

Tee pads - The top two combinations of observed degradation and proximity to the tee pads were

1. Vegetation damage between 0-20 feet and
2. Vegetation damage between 20-40 feet. (fig 3.3e)

Baskets- The top two combinations of observed degradation and proximity to the basket were

1. Erosion between 20-40 feet and
2. Compaction between 0-20 feet. (fig. 3.3f)

Camp Serene Disc Golf Course GIS Analysis Findings

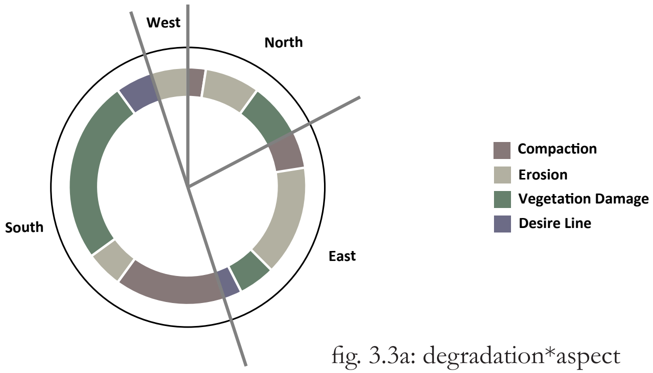


fig. 3.3a: degradation*aspect

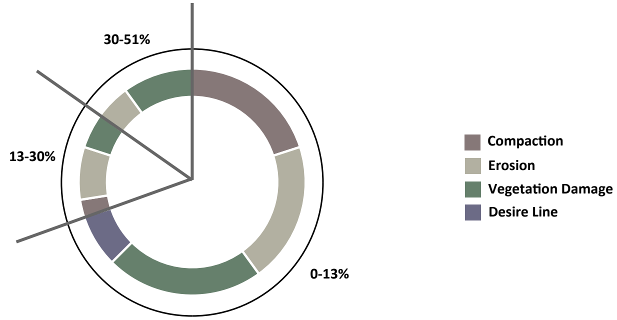


fig. 3.3b: degradation*slope

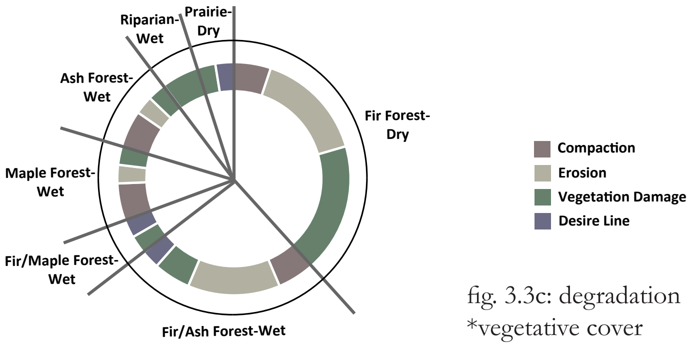


fig. 3.3c: degradation *vegetative cover

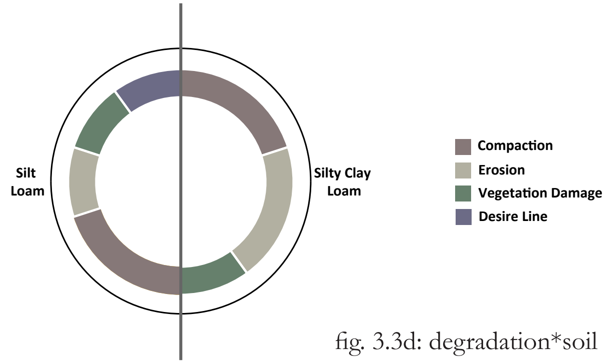


fig. 3.3d: degradation*soil

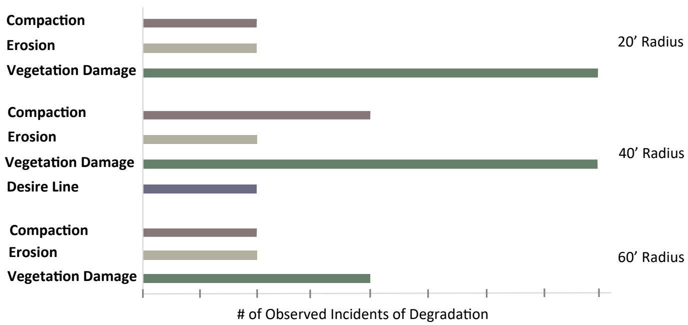


fig. 3.3e: degradation at the tee pad

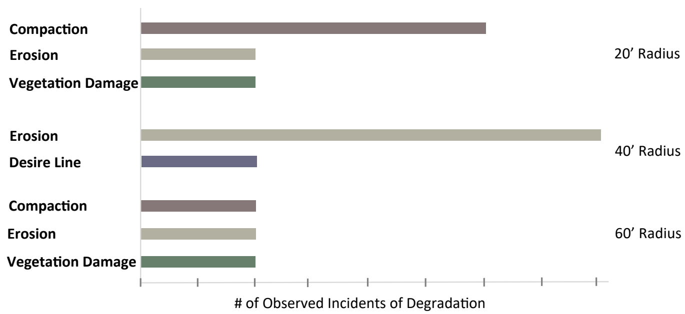


fig. 3.3f: degradation at the basket

Trends Across Sites

Due to the variance in landscape features and geophysical location between the three case study sites, consistent trends across all three were not common, but were present. Commonalities amongst the sites will be discussed according to each landscape feature that was analyzed and the relationships discovered between those features and the degradation types discussed previously.

Aspect:
In two of the three study sites, most degradation incidents occurred overwhelmingly on north aspects. The most common type of degradation occurring on north aspects on those sites was erosion, followed by compaction. This trend was true for all three sites.

Slope:
All three sites had observed incidents of erosion on slopes up to 30%, and on two of the sites greater than 6% and 15%. It was also found on two of the sites that compaction occurred most frequently on slopes between 0-7%.

Vegetative Cover:
Two of the sites were found to display a high frequency of vegetation damage and erosion in Fir Forest-Dry vegetative cover. It should be noted that a very small fraction of observed degradation occurred in prairie or savannah vegetative cover types.

Soil:
Two sites demonstrated degradation occurring almost entirely on Silty Clay Loam, however one site displayed a notably high concentration of erosion on inceptisols.

Tee Pads:
Two of the sites had high occurrences of vegetation damage within 60 feet of the tee pad, particularly on the Camp Serene site which is located almost entirely in a forested vegetative cover. Compaction was also noted in close proximity to the tee pad in two of the sites.

Baskets:
Compaction as well as erosion in close proximity to the baskets were the most frequent occurrences of degradation in this category on all three of the sites.

Design Principles

The trends observed across these three case study sites was then translated into two hierarchies of design principles:

Site selection within a given area/region

These principles provide guidance to select a site that provides the basic requirements or recommended features to accommodate a disc golf course. They are partially influenced by guidelines set forth by the Professional Disc Golf Association and by the research done within this project. In order of priority, they are:

<u>1. Land under Government/public ownership, i.e. USDA or BLM:</u>

Currently in the United states just 99 out of 7,028 disc golf courses have been established on National Forest or BLM land use types. As demand for new courses increases, Forest Service and BLM land presents a huge opportunity for new course development. That is if the course design proposal can provide assurance that extensive ecological damage will not occur on the chosen site. In a potential future application of disc golf courses as land management tools to be discussed later, the USFS (United States Forest Service) or BLM (Bureau of Land Management) could benefit from reduced maintenance such as tree thinning or invasive species control. The research done within this project, in conjunction with the benefit provided to the local community in which a course is installed should validate the request for a course to be installed on State or Federal Lands and make available another recreational use on these properties. As it stands, "You hike, bike, ride horses and drive off-highway vehicles. You picnic, camp, hunt, fish, and navigate waterways. You view wildlife and scenery and explore historic places. You glide though powder at world class alpine resorts and challenge yourselves on primitive cross-country ski or snowmobile routes." (U.S. Forest Service, 2021). Disc Golf could be added to that list to maximize enjoyment of these lands for a broader group of individuals and to generate tourist attraction to areas that could benefit from a course being installed nearby.

<u>2. An adequate amount of acreage needed for a disc golf course within selected site (minimum 80 acres):</u>

The PDGA Course Design Acreage Guide recommends allocating 39 acres for an 18-hole, Gold Tee, Championship level course, which is the highest level of difficulty and therefore length and size a course can achieve. Selecting a site with at least double the recommended maximum acreage allows for a more selective process during course layout design to accommodate the layout principles developed through the research of this project.

3. Slopes less than 20%, and Aspects other than North:

Initial site selection should seek out parcels of land with the maximum amount of land with slopes less than 20%. This will allow for the most freedom while designing the course layout utilizing the layout principles developed through the research done in this project. One of the design goals outlined by the PDGA is to "Utilize elevation changes…as well as possible." Therefore it is assumed that some level of elevation change is desirable to create a variety of holes in terms of difficulty and enjoyment. Within the areas of less than 20% slopes on a selected site, a course layout with more refined slope standards can be established to adhere to course layout principles and mitigate incidents of degradation.

Course design/layout within the chosen site

This set of principles uses the same set of landscape analyses applied to the three case study sites on the chosen site for a new course. Within these categories of landscape features, a course is laid out using these principles, not necessarily prioritized in the order presented:

1. Aspect – Avoid north aspects whenever possible, and avoid locating baskets on south aspects:

Case study research concluded that a disproportional number of incidents of observed degradation occurred on north aspects within the course. Specifically, it was found that an increased amount of erosion and soil compaction occurred on north aspects. To prevent erosion and compaction across the course it is recommended that holes occurring on north aspects be kept to a minimum. Additionally, a large portion of observed compaction occurred on south aspects and at basket sites. Therefore, it is recommended to avoid locating baskets on south aspects to minimize compaction.

2. Slope – Plan the course layout within slopes of less than 15%:

Trends identified across the case study sites revealed that the greatest concentration of incidents of erosion occurred on slopes between 6%-22% on one site and between 15-28% on another. The average between these two sites is 15%, and so it is recommended that course layouts be planned along a route that features slopes of less than 15% to minimize occurrences of erosion. The third site, Camp Serene, occurred entirely on slopes less than 15% and therefore did not fit in with this trend.

3. Vegetative Cover – Locate the course layout within an equal or near equal ratio of closed and open canopy cover. If possible, locate holes within closed canopy cover in areas dominated by hardwood species.:

A strong trend across sites was the presence of degradation in Forest/closed canopy cover types, particularly in Dry Fir Forests. A high ratio of these degradation occurrences were vegetation damage which is unsurprising because the denser the trees are, the more likely a disc in flight will come into contact with them and cause damage. The second most frequent type of degradation in closed canopy vegetative covers was erosion, likely due to reduced understory vegetation leaving more bare soil susceptible to erosion. The PDGA course design elements state that, "Ideally, a well-balanced course has a mixture of holes that go completely through the woods, partially through woods and mostly in the open." So although the case study research suggests avoiding closed canopy vegetative cover, to satisfy recommendations for course difficulty, interest and player enjoyment, an equal ratio of open and closed cover is suggested. However, it would be desirable to choose the portion of the course that occupies a closed canopy to do so in a hardwood species dominated forest or woodland.

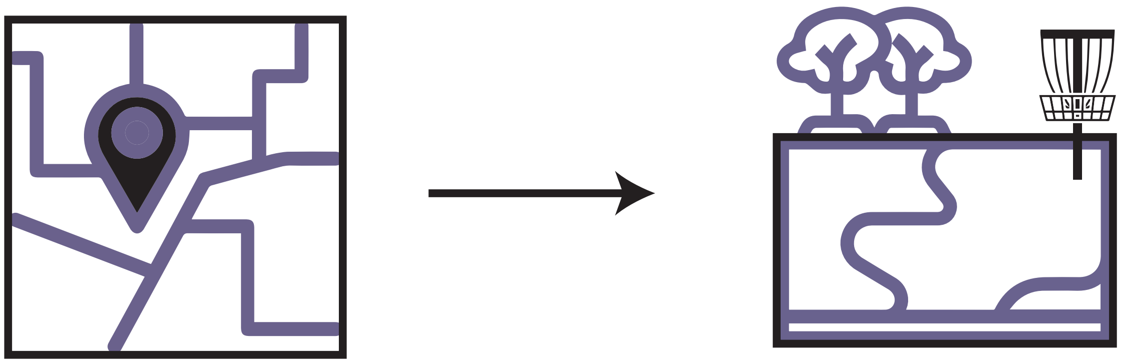
These categories were found to experience much less degradation than softwood (Fir) dominated forests or woodlands, particularly in terms of vegetation damage, likely due to the durability of the trees experiencing impact from flying discs.

4. Soils – Avoid soil types featuring high silt content or high clay content. Avoid Inceptisol or similar (Entisol) soils:

Analysis between observed degradation and soil type also revealed a strong trend between study sites, revealing that nearly all occurrences of degradation (of all types) occurred on silty clay loam. The Dexter Park Disc Golf Course featured an area of the course that was occupied by Inceptisol soil types, which are under-developed soils, and this area experienced the greatest amount of erosion by a wide margin. As noted previously, all incidents of degradation on the course at Stewart Ponds occurred on silty clay loam, as nearly the entire site was made up of this soil type. More research would be required on this topic, but from these study sites it can be recommended that soils containing a high concentration of silt should be avoided during future course layout designs. Additionally, it was made very clear in the research that Inceptisol soils are poorly suited for disc golf courses and should be avoided. It can also be assumed that Entisol soils should be avoided as well, as they share many properties of instability that Inceptisols have.

chapter 4: Application

Exploratory Course Design, Oakridge, OR
Site Context
GIS Analysis
Course Site Selection & Layout
Ground Truthing for Playability
Design Intervention Applications



SITE SELECTION **COURSE LAYOUT DESIGN**

Exploratory Course Design: Oakridge, Oregon

The principles developed through interpretation of the case study site research and analysis were then applied to select a tax parcel, identify an area within the chosen parcel, and design an 18-hole disc golf course. Principles and goals set forth by the PDGA were also applied to create a course layout offering challenge, user enjoyment, and aesthetic quality to produce a positive and desirable disc golf experience. To begin this process, an area of interest needed to be chosen from which to select a site, and I decided to search in the area around Oakridge, OR.

Site Context

Oakridge is a small town with a population of roughly 3000, located about 45 miles east of Eugene, OR. (fig. 4.1). It has been called "the ultimate basecamp for outdoor adventurers. Above the fog and below the snow line, these communities offer a year-round paradise of outdoor thrills. This mountain town is the perfect getaway for adventurers looking for a rugged adventure in the pristine Cascades." (Hit the Dirt!, 2021). Like many small Oregon towns, the economy of Oakridge was previously built on timber extraction and processing, and "Oakridge was a prosperous timber town for nearly 80 years until the Pope & Talbot mill closed in 1989. Struggling for the better part of the last 25 years, Oakridge is beginning to come to life again, this time as a premiere destination for mountain biking." But, "With the knowledge mountain bikers are bringing their families for the weekend, additional activities focused towards families should be developed. Furthermore, since mountain bikers don't typically bike for the entire day, additional amenities would encourage day visitors to spend the night, or destination visitors to spend more time, and more money, in Oakridge." (Meltzer, 2014). Disc golf is a family friendly, outdoor-based activity that could continue to draw visitors to or through Oakridge, which would further aid in the recovery of their economy. Additionally, the research from this project would be applicable to the Oakridge area as it shares latitudinal, precipitation, vegetation and soils traits with the case study sites.

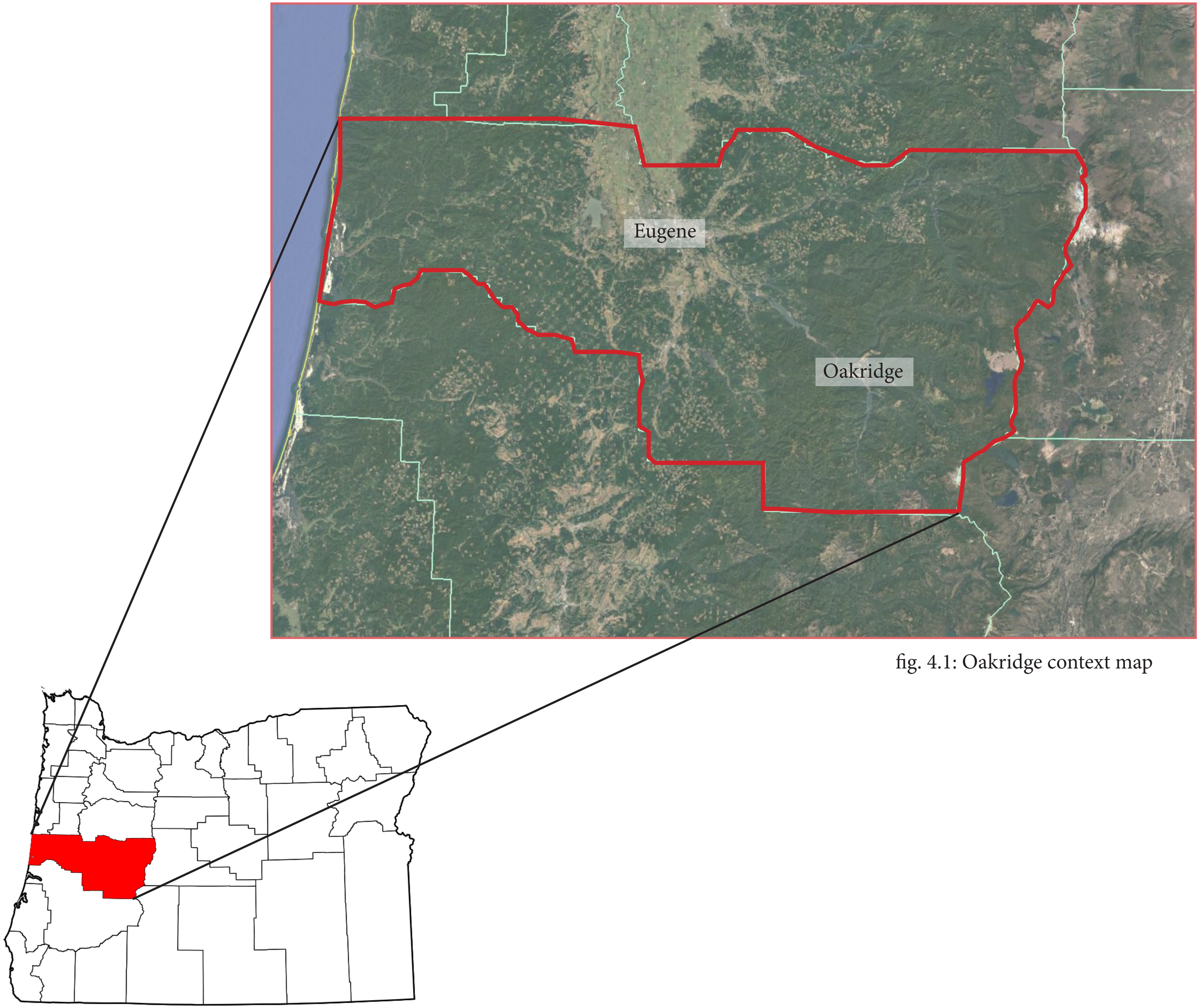


fig. 4.1: Oakridge context map

GIS Analysis

Initial site selection using the first set of principles developed previously (Site selection within a given area/region) began using ArcMap. An Oregon Urban Growth Boundary (UGB) file was imported and the UGB for Oakridge was identified and clipped. Using the ArcMap Buffer Wizard, a 1-mile buffer was generated around the UGB of Oakridge. (fig. 4.2) A 1-mile distance was chosen to keep the selected taxlot within walking or biking distance to town to increase accessibility for users. LiDAR data and Lane County Taxlot data were then downloaded for the applicable area and imported into ArcMap. The LiDAR and taxlot data were clipped to the 1-mile UGB buffer and the LiDAR data were analyzed to produce files representing slope and aspect. Within the attribute table for the Lane County Taxlot file, tax parcels owned by the public/government, suited for recreational use and larger than 80 acres in size were selected using 'select by attribute' (forest land highest and best use/recreation/vacant AND acres > 80). This produced a selection set that satisfied the first two principles outlined (public ownership and parcels greater than 80 acres). (fig. 4.3) This selection was then added to the project as a new layer for further analysis.

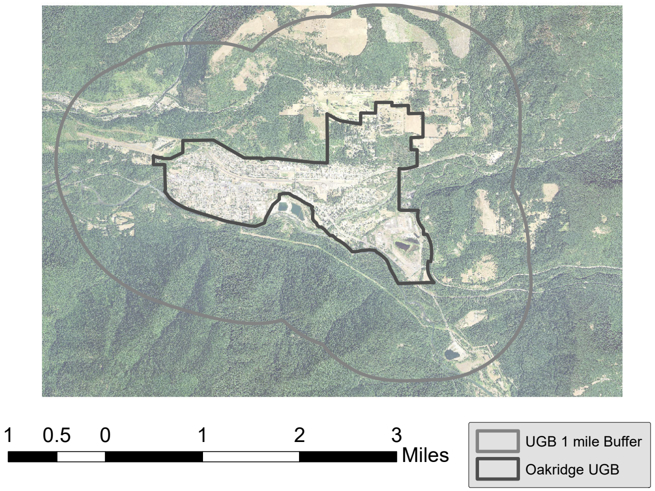


fig. 4.2: Oakridge Urban Growth Boundary with 1 mile buffer

First and Second Site Selection Design Principles: Public Ownership & Greater than 80 Acres

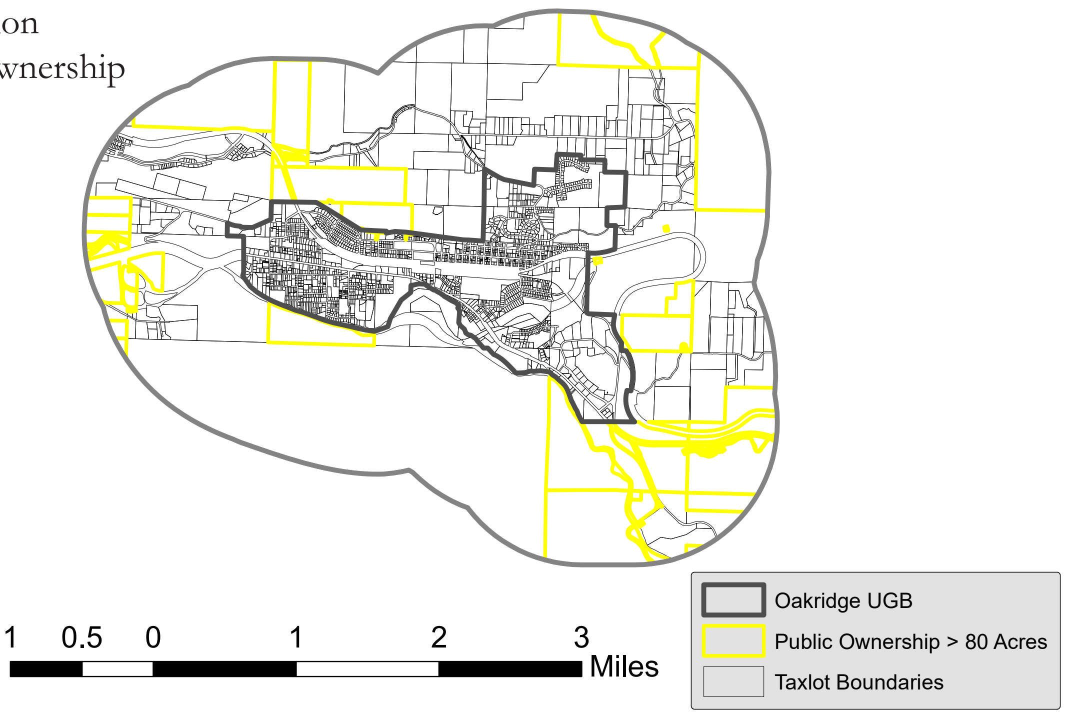


fig. 4.3: Taxlot parcels under public ownership and over 80 acres within the 1 mile Oakridge UGB buffer

The next criteria for initial site selection were to find parcels featuring the most amount of land with slopes less than 20%, and to maximize land area with aspects other than North. This was done by clipping the files created from the LiDAR data showing both slope and aspect to the new selection set of publicly owned parcels over 80 acres. Slope was then reclassified to represent slopes above 20% as 0, and slopes under 20% as 1. (fig. 4.4a) The same process was repeated for aspect, with North aspects reclassified as 0, and all other aspects as 1. (fig. 4.4b) These files were then combined using the raster calculator to produce a file containing the land featuring slopes under 20% and aspects other than north within publicly owned parcels greater than 80 acres in size. (4.4c) By viewing the attribute table for this file and ranking the results by count (land area) the top 5 suitable tax parcels were identified. From this selection, I visually analyzed the options for a desirable ratio of vegetative cover (open and closed canopy) and made a final selection on which to design a course. (fig. 4.5-6)

Third Site Selection Design Principle: Slope Less Than 20% & Aspect Other Than North

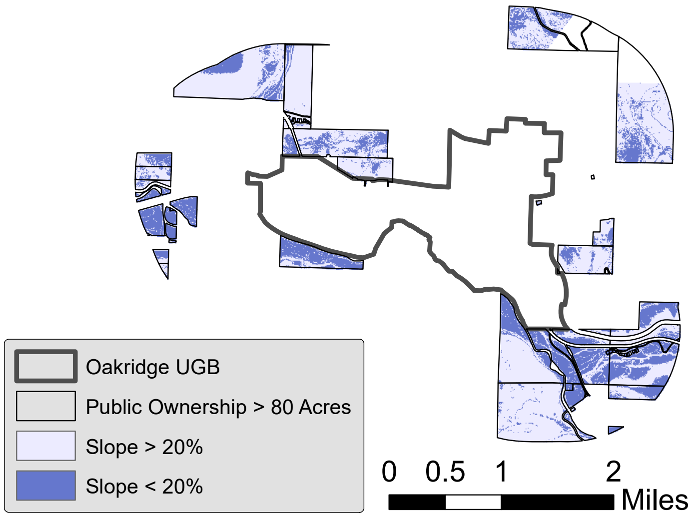


fig. 4.4a: slope analysis within initially selected parcels

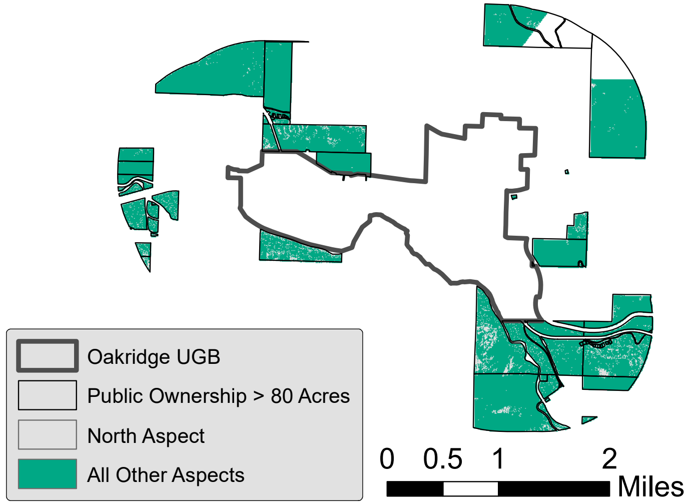


fig. 4.4b: aspect analysis within initially selected parcels

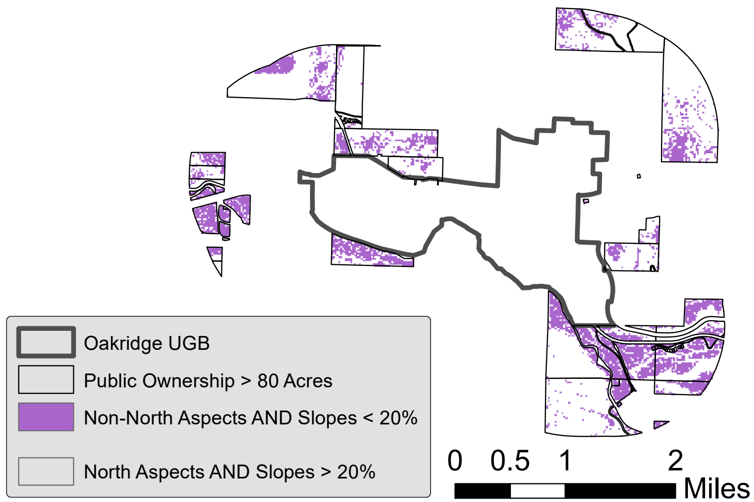


fig. 4.4c: combined slope and aspect analysis within initially selected parcels

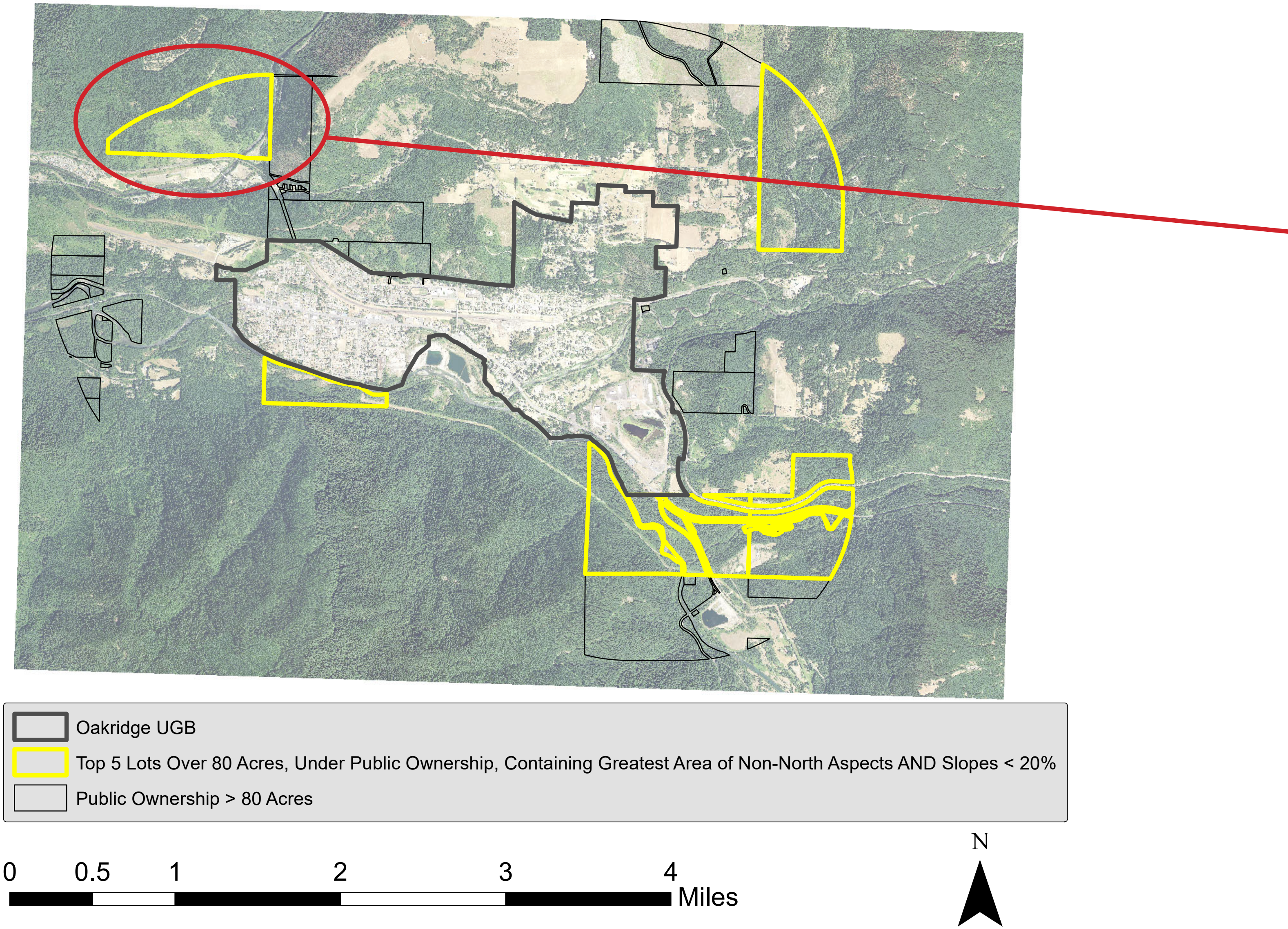


fig. 4.5: final site selection from top 5 publicly owned taxlots over 80 acres, containing greatest amount of land with <20% slopes and non-north aspects, based on visual assessment of vegetative cover ratio

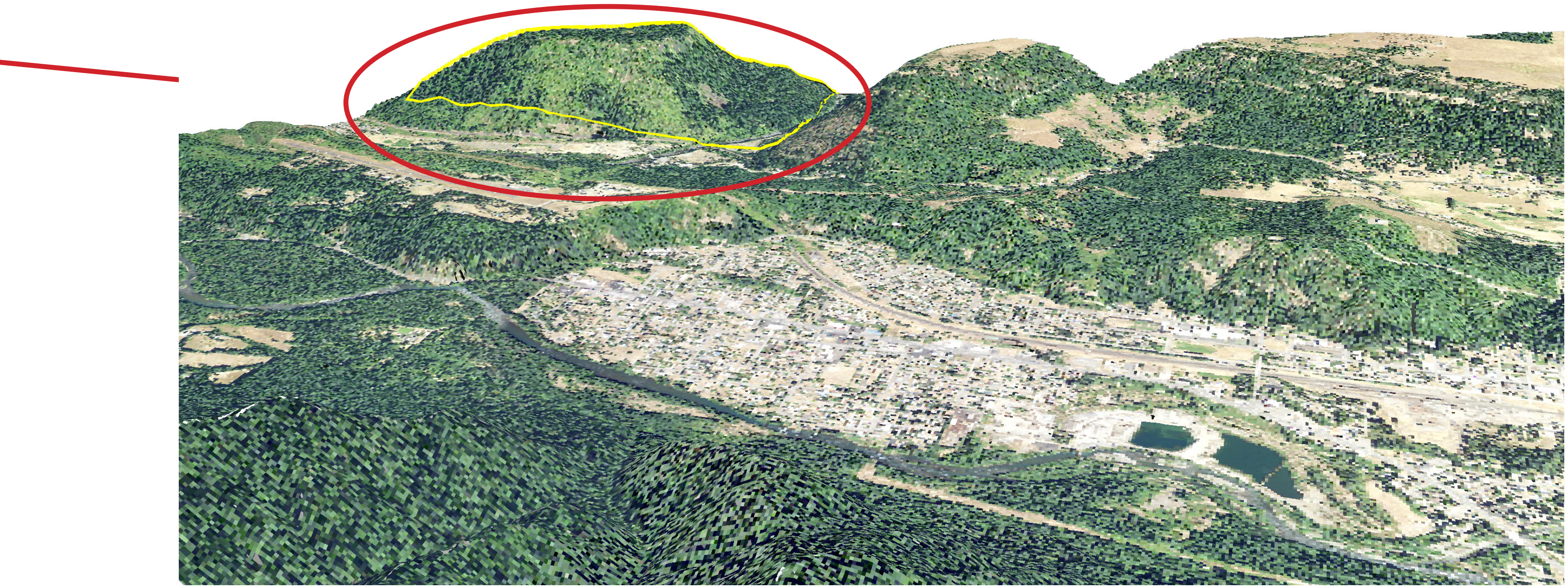


fig. 4.6: ArcScene capture of final site selection

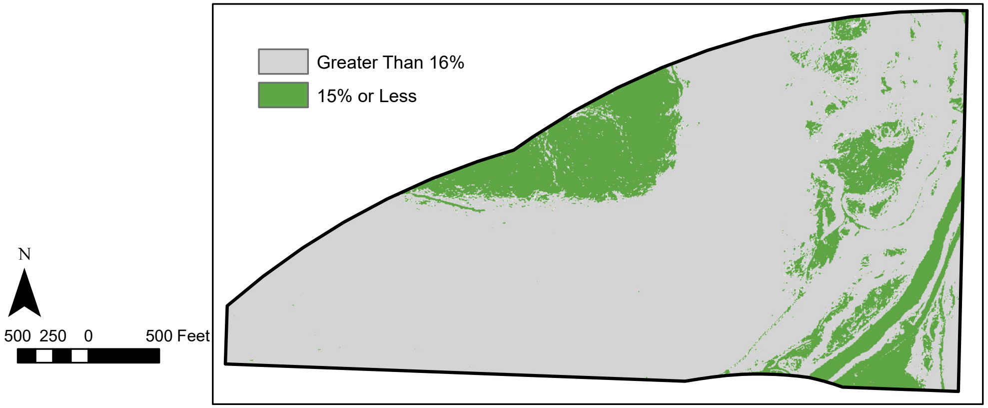


fig. 4.7a: slope analysis on selected site

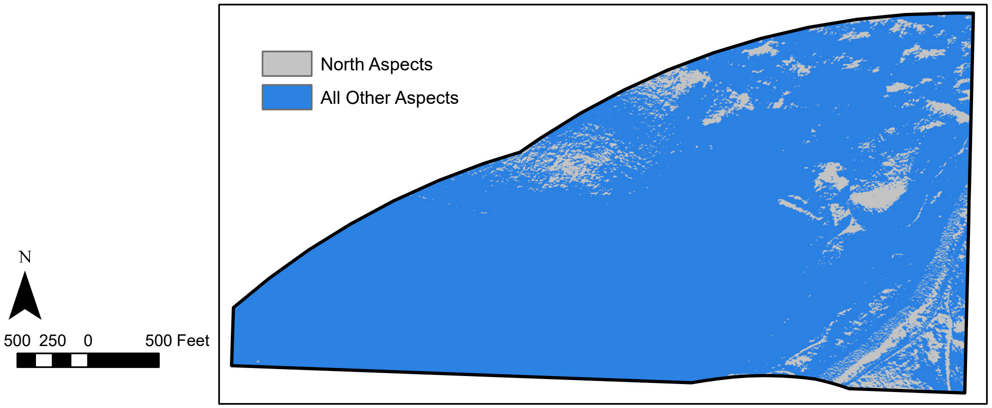


fig. 4.7b: aspect analysis on selected site

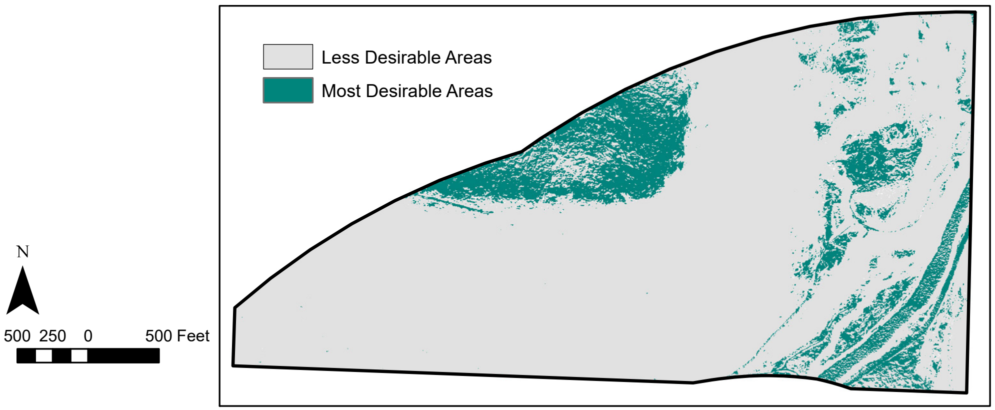


fig. 4.7c: combined slope and aspect raster analysis on selected site

Course Site Selection

The final site selected through the raster analysis ended up being a 900-acre parcel, therefore further analysis had to be done to narrow the scope of the area chosen for the course layout. For this, the second set of principles were applied to determine the most suitable area of land within the site on which to design a course.

In ArcMap the selected parcel and its associated LiDAR data were clipped to the taxlot boundary and added to the project as a new layer. Slope and aspect files were produced from the LiDAR data, and soils data were downloaded and added to the project. A visual analysis was conducted using the aerial photo for the site to produce a file representing the vegetative cover types featured on the site. Each landscape analysis data set was then reclassified prior to performing raster analysis. Slope was reclassified as 0-15% = 1, and over 15% to 0. (fig. 4.7a) Aspect was reclassified to North aspects = 0 and all other aspects = 1. (fig. 4.7b) Soils data were classified as follows: silty clay loam and water = 0, cobbly loam and clay loam = 1, and cobbly silty clay loam = 2. (4.8b) It should be noted that none of the case study sites featured cobbly loam or cobbly silty clay loam, but it was assumed that these soils would be less susceptible to degradation due to their lower silt contents. Cobbly silty clay loam was assigned 2 for the raster analysis to identify secondary suitable areas, as it does have a silt content but less than that of silty clay loam. Vegetative cover classes identified on site were Fir Forest-Dry, Fir Woodland-Dry, Fir/ Maple Forest-Wet, Water, Riparian-Wet, Road, Rock,

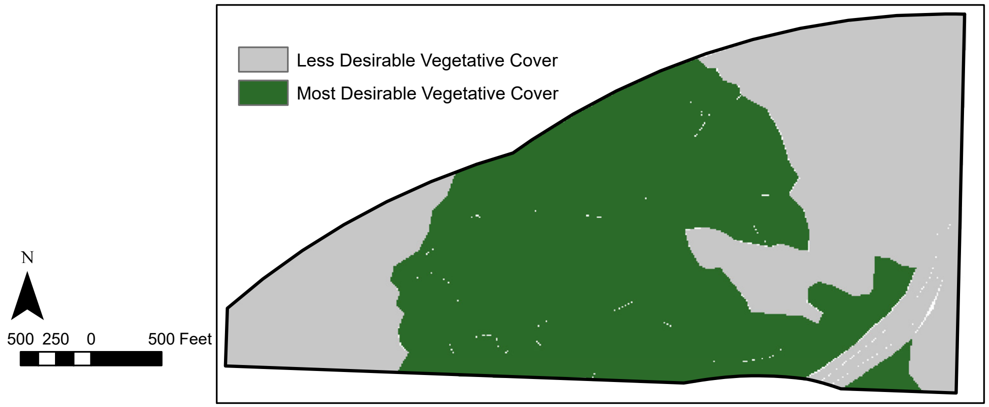


fig. 4.8a: vegetative cover analysis on selected site

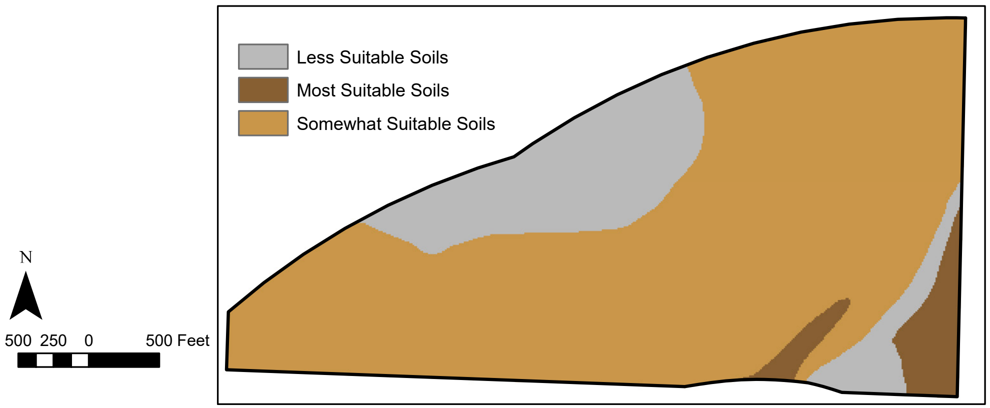


fig. 4.8b: soils analysis on selected site

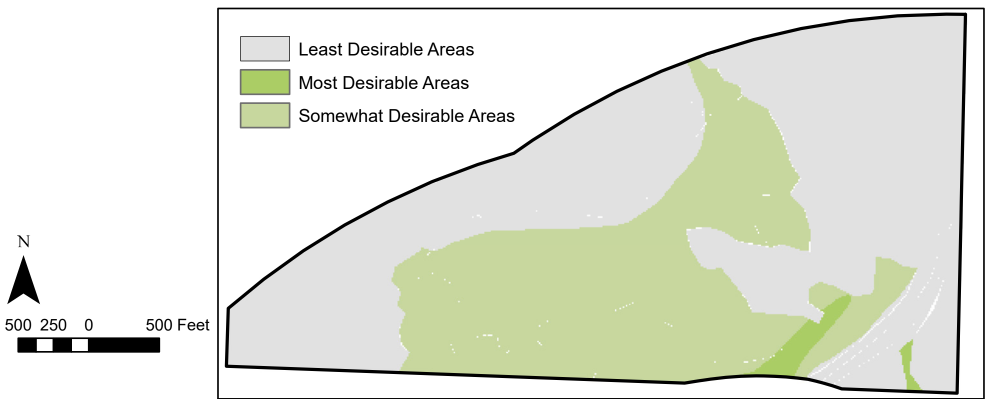


fig. 4.8c: combined vegetative cover and soils raster analysis on selected site

Maple Woodland-Wet, Prairie-Dry, and Fir Forest-Wet. These were identified by aerial photo only and were not verified on the ground at the time of writing, therefore potential adjustments would need to be made after a site visit was made. For raster analysis, these vegetation types were reclassified as follows: Fir Forest-Dry, Water, Riparian-Wet, Road, and Fir-Forest-Wet = 0, and Fir Woodland-Dry, Fir/Maple Forest-Wet, Rock, Maple Woodland-Wet, and Prairie-Dry = 1. (fig. 4.8a) This reassignment was in keeping with the principles developed for vegetative cover based on case study analysis, preferencing hardwood species and prairie or open areas, and woodlands, while avoiding dry or wet forest cover types. Once the landscape analysis data sets had been established and reclassified, a raster analysis was performed to identify the area within the selected parcel to focus in on for course layout design.

Raster calculations were first performed in sets of two and then combined to view the final outcome but also note which overlays were eliminating or including certain areas within the site. The first calculation was between the slope and aspect files [slope*aspect], which produced a map displaying the ideal land areas for a course based on just slope and aspect. (fig. 4.7c). Next, soil and vegetative cover were combined [veg*soil] to produce a map showing the ideal locations based on vegetative cover and soils data (fig. 4.8c). Lastly, the outcomes for the two calculations prior were combined to show the final land area selection which took all four landscape analysis features into account (fig. 4.9).

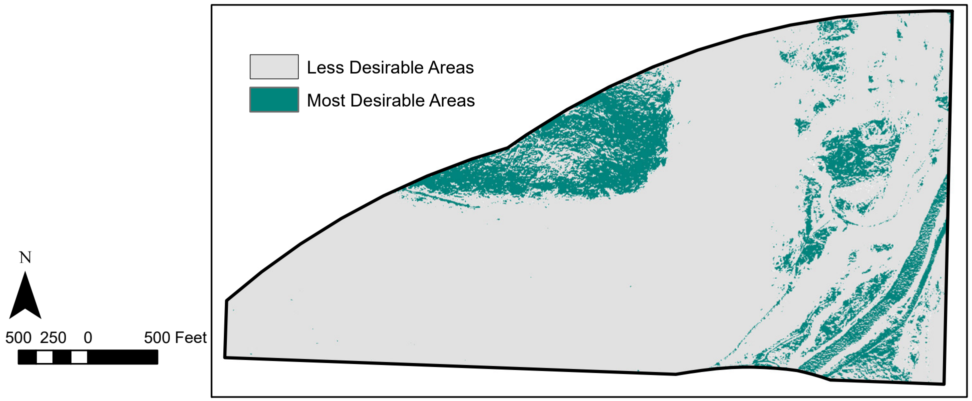


fig. 4.7c: combined slope and aspect raster analysis on selected site

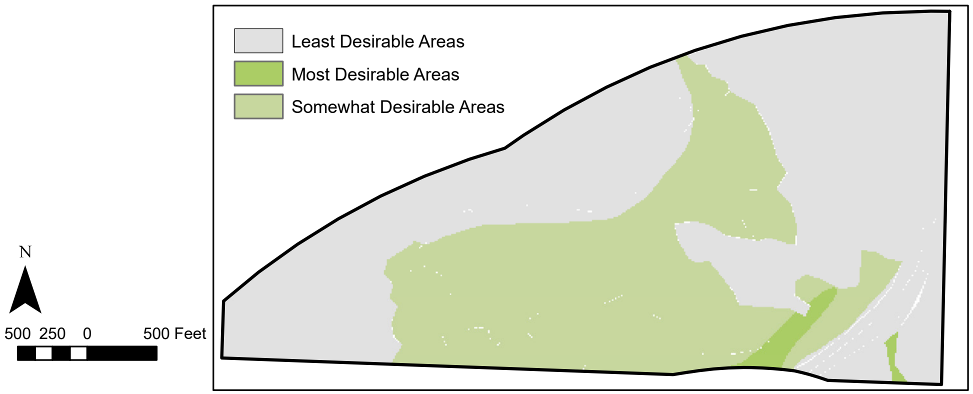


fig. 4.8c: combined vegetative cover and soils raster analysis on selected site

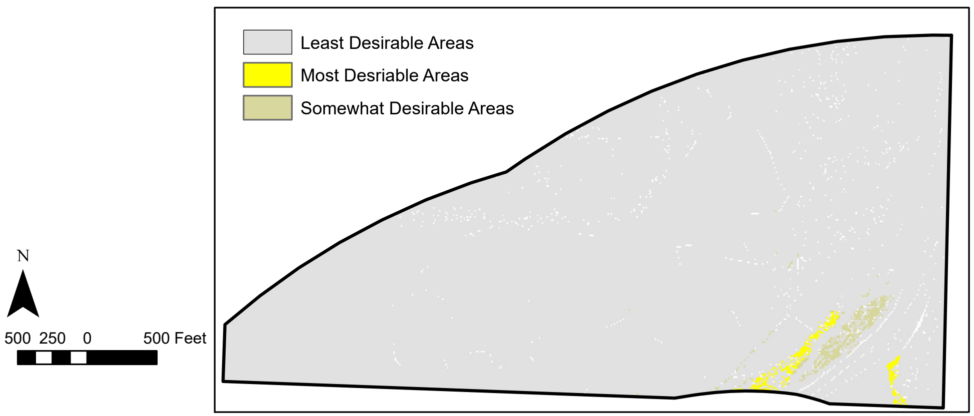


fig. 4.9: combined raster analysis showing overall suitible land area

This resulted in a small area within the site on which to begin course layout that totaled roughly 40 acres in size, (fig. 10) which was a suitable amount of land for a course according to the PDGA as discussed earlier. The chosen area was then enlarged and exported with 5’ contours to begin course layout design outside of ArcMap.

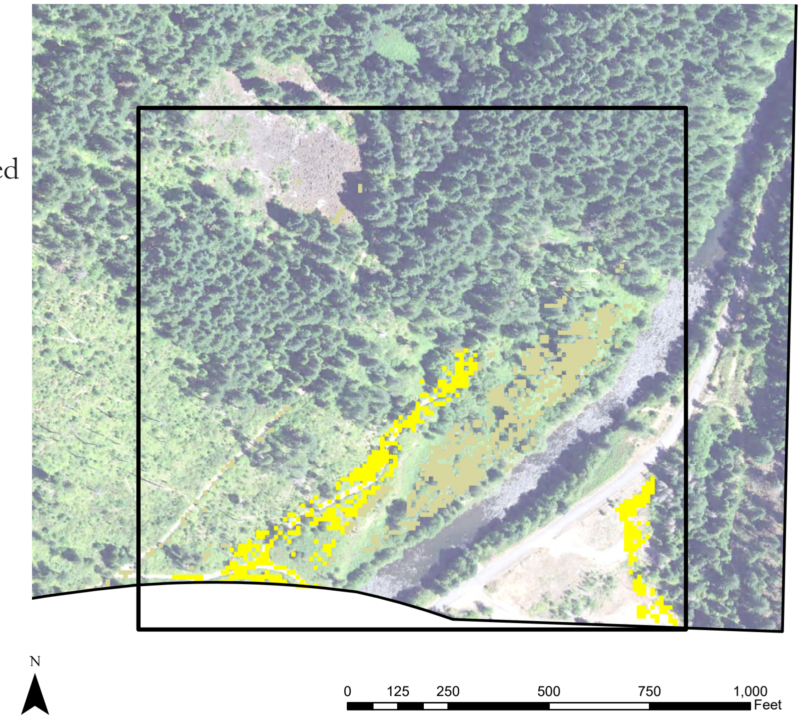


fig. 4.10: enlargement of final analysis suitibility area with aerial underlay

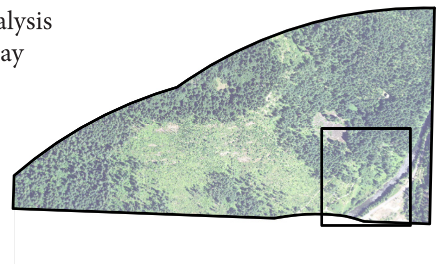


fig. 4.11: course layout on selected site

Course Layout

For the town of Oakridge and for this site I decided to design a full 18-hole course for intermediate to advanced skill levels. Working in Autocad I scaled my exported study site with 5' contours and underlaid an aerial to factor for both grade and vegetative cover while designing the course. I began with an average hole length of 300' which was either shortened or lengthened for each hole depending on additional challenges presented by elevation change or vegetative obstacles. Using past experience as a disc golfer as well as the design goals and guidelines put forth by the PDGA each hole considered the following:

- safety for players (no holes crossing each other)
- a variety of elevation variances between the holes
- aesthetic and scenic quality (utilizing perceived viewpoints for tee pads) and
- an equal ratio of open and closed vegetative cover, which was a principle I confirmed to also reduce degradation through the research in this project

While some holes in the design feature slopes in excess of 15% in the direct flight path of the disc, adjustments on the ground paired with formalized trails throughout the course would account for steeper slopes and reduce incidents of erosion in these areas. The final rendered plan features indicated vegetative cover, 5' contours to indicate grade, and schematic layout of the intended tee pad and basket locations, as well as intended flight paths for each hole. (fig. 4.11)

By coincidence, the final course site selection through the raster analysis happened to feature existing access roads within the site and an adjacent parking area just off-site which provided a graded pathway to the higher elevations within the course, and access to the site for users, respectively. The final site also featured a section of the North Fork Middle Fork Willamette River, offering scenic quality as well as additional recreational opportunity for those visiting the course with family or those opting not to play disc.

Ground Truthing

What began in the fall as a lot of time spent out playing disc at my local courses and making site documentations quickly morphed into hours upon hours of screen time during the winter and spring months. Finally at long last it was time to go to another disc golf course, only this one hadn't been built yet. In order to close the circle of this work I went to Oakridge on a sunny saturday in May to determine whether the site that the GIS analysis sequence developed through this project had indeed provided a decent location for a disc golf course.

The site was very accessible, and as mentioned previously, had existing parking just across a historic covered bridge, established for users of the North Fork Trail, which passed through my final site. I followed the trail from the parking lot underneath the Pacific Union Railroad and, referencing my location on the map on my phone, found myself at the hypothetical hole 18 basket location. What I had pictured in my mind was a lovely riparian meadow spotted with small hardwood tree species. What I encountered was a wall of Himalayen Blackberry roughly ten feet tall, climbing up and strangling young Cedar trees and Cottonwoods seeking out the light. I continued on the trail and it pitched into the thicket which continued along the river's boundary until meeting the forest edge. I continued to note my location on the map on my phone to gauge when I had reached holes 17 and 16, walking along the trailrail and my course layout, albeit backwards. At each intended tee pad location I stopped and tried to imagine the blackberry removed, the understory opened, and the flight path my disc might take. It would take work, that was for certain, but the reward could be a healthier ecosystem and a downright beautiful and fun course.

Once I had reached the extent of my course design boundary along the trail I attempted to bushwhack into the forest to continue to follow the course route. Theh understory was thick with Vine Maple, struggling young Firs, and a number of common native shrubs and ferns. Even during the dry spring we had been experiencing the fuel load was frighteningly robust, and I couldn't help but imagine how it would fair if a fire hit in August once it had all dried to a crisp. I gave up on my venture and returned to the trail and traced back to the beginning of the course layout, where an existing access road marked the tee pad for hole 1.

The first few holes would play through a remnant stand of forest, burned and then salvaged logged, likely no more than 20 years ago. The remaining snags provided excellent habitat for cavity nesting birds, but the hillside was quickly being swallowed by Scotch Broom. It would be a challenging start to the course with a few uphill holes, but the vistas of the surrounding forests and post fire environment would act as reward for the effort. I was able to walk nearly the entire course, save for the thickest sections of forest at the northern extent of the layout boundary, at 5 months pregnant on a 80 degree day, after months at computer, so it passed as accessible.

Whether or not the principles developed through the research conducted during this project had resulted in a course site selection and layout design that would prevent or mitigate the common types of degradation occuring on existing courses remains unknown. The course would need to be installed and played for a full year, then re-evaluated to see what impact had occured on the landscape from playing the course through all seasons. However, as I looked out over the proposed location for hole 16, picturing an open meadow sprawling beneath with a view of the river beyond, I found myself wishing I had brought my discs.

Dense understory near hole 12

Beginning of North Fork Trail, hole 17 basket location

Post-burn hillside at hole 1 tee pad location, becoming overgrown with Scotch Broom and Blackberry

Hole 18 basket location; a field of 10’ high Blackberry where a riparian meadow could be.

Hole 16 tee pad location, overlooking a potential riparian meadow and the North Fork Middle Fork Willamette River

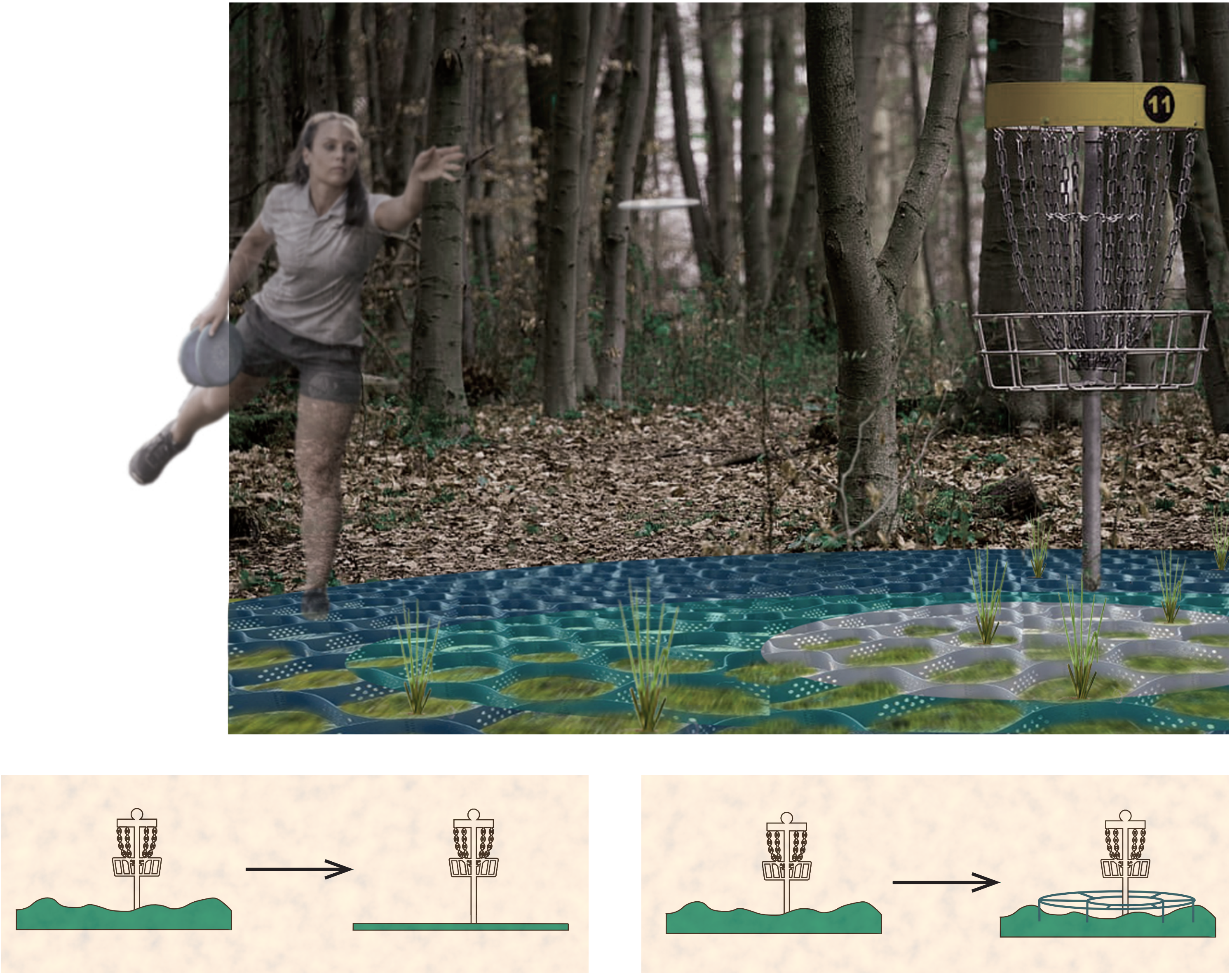


fig. 4.12: “inside the circle”: landscape intervention using HEX-Pave aggregate system at basket sites to reduce soil compaction

Landscape Interventions

In addition to these principles for course layout on the selected site, a number of landscape interventions were developed during this project to implement at the tee pad and basket locations to reduce degradation at these sites. (fig 4.12-4.14) These interventions address a high concentration of incidents of compaction at basket sites and a high concentration of incidents of vegetation damage at tee pad sites. Additionally, an intervention was developed to address occurrences of sensitive vegetation populations, which was not directly addressed in the research but has been observed on one of the study sites.

Thoughtful and informed course design likely cannot prevent or mitigate all incidents of land degradation occurring on disc golf courses, and therefore these landscape interventions were developed to further promote ecologically sound disc golf courses. The following interventions could be adapted or even required as standard details to be included on new course proposals as a part of the formal application process, and could greatly reduce negative impacts of disc golf in the natural areas in which the game is played.

Inside the Circle

Compaction at the basket sites is possibly the most notable occurrence of land degradation on disc golf courses and can lead to excessive erosion. This results from the congregation of all players at the basket site and increased foot traffic due to repeatedly putting (a short throw aiming at getting the disc into the basket) and missing, therefore having to walk back and forth in the basket vicinity. Many courses have attempted to mitigate this damage by providing multiple basket locations for each hole and moving the basket back and forth between them every couple of months to give the area a chance to recover.

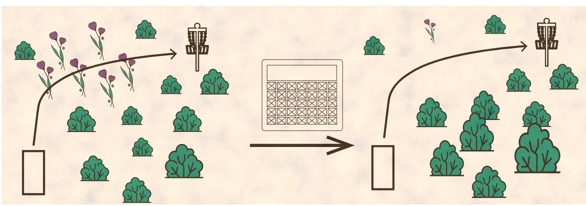
However, soil is a fragile resource and once compaction has occurred in an area it cannot be undone without intense human intervention, and even then, the structure of the soil has been lost, leading to a host of issues including reduced infiltration rates leading to runoff and reduced air pockets for tree roots and soil organisms (Horn, et al., 1995). In an effort to prevent soil compaction at basket sites, I designed an intervention to both address the issue and contribute to player experience and enhance course function. Utilizing a series of concentric rings composed of a poly-based aggregate paving system such as HEX-Pave (standartpark-usa.com) around the basket location, and color-coding them to indicate distance from the basket, could both prevent/ reduce soil erosion and continue to allow ground covers to persist while indicating to the players the distance from which they are putting. (fig. 4.12).

fig. 4.13: “tree love”: tree cage landscape intervention at tee pad sites to reduce tree damage

"Tree Love"

Another type of degradation noted in this project, and by those opposed to disc golf due to the negative environmental impacts it poses, is vegetation damage as a result of disc collisions with trees on the course. This is because "Normally, pathogens such as bacteria or fungi are unable to penetrate the bark, but if the bark tissue is damaged by injury, infection is more likely." (treeremoval.com). Once an infection takes hold in one tree it can potentially travel to others, or if the infected tree dies and falls it can weaken the forest community in which it resides, causing widespread damage (Wohlleben, et. al., 2016).

During the case study research in this project it was determined that the most frequent occurrences of tree damage were between 20-60 feet from the tee pad location. I developed a design intervantion to protect the trees in these areas of the course by installing a 'tree cage' around their trunks at common disc flight heights, roughly from 6-15' from the ground elevation. Constructed with a highly durable poly-based material coated in a reflective plastic film such as metalized duralar, a series of vertical strips mounted on steel rings would be installed around the tree trunks in the vicinity of the tee pad, protecting them from disc impacts. Again, the primary function of this intervention would be to reduce or prevent degradation from occurring, but additionally this feature would generate aesthetic interest on the course by reflecting the surrounding forest and would generate player awareness as over time the rings would become battered and their reflections distorted, indicating the damage to the forest that could be occurring without them.(fig. 4.13)



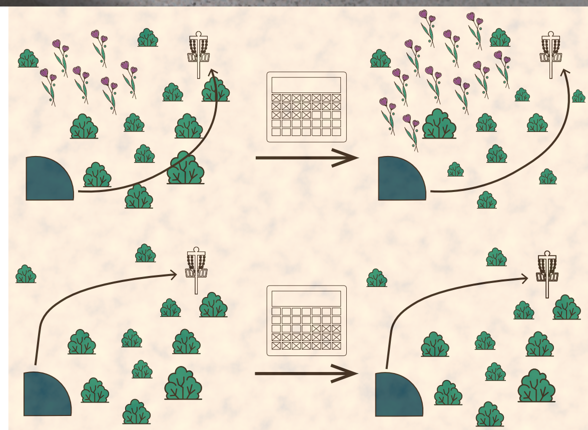


fig. 4.14: “rotational play”: curved tee pad and mandatory route indicator landscape intervention at sensitive vegetation hole sites to reduce trampling during flowering

“Rotational Play”

The third intervention established did not result from findings from the case study analysis conducted within this project, but from observations made during play prior to the project beginning. Because disc golf courses are often installed in natural areas there is potential for disturbance of sensitive wildlife populations, particularly certain vegetative species. In my observations, there is a particular hole on one of the case-study sites, Dexter Park Disc Golf Course, which features a population of the native wildflower Camas (Camassia spp.). This species can suffer during its reproductive cycle if damaged prior to fertilization (Portland Nursery, 2021) and I would cringe as I watched players trample flowers in bloom seeking out their disc that had landed amongst the patch. This situation causes direct conflict between the benefits of locating holes in open prairie or woodland vegetative cover types, which are proven resilient typologies according to the research in this project, with the presence of Camas and other sensitive wildflower species. During most times of the year these locations would be well suited to disc golf play, except for these vulnerable times during the plants reproductive cycles during which they are not.

The intervention developed to address this issue features a basket location in a different direction than the regular location, a wide-angled tee pad to accommodate throws in both directions, and a mandatory flight path indicator ring that can be moved back and forth easily to inform players of which basket they are meant to play for at that time. Mandatory flight paths, otherwise known as ‘mando’ on disc golf courses, are regular features meant to increase difficulty of a hole when natural obstacles are not present. Therefore, this intervention would also increase course enjoyment and difficulty while facilitating protection of sensitive areas at any given time of the year. (fig. 4.14)

chapter 5: Discussion & Conclusion

- Project Limitations
- Disc Golf Course as:
    - Defensible Space
    - Invasive Species Management
    - Environmental Education Opportunity

Project Limitations

A year feels like a decent amount of time to complete a project of this scope, but then we are reminded that we work with landscapes, where a year is a blink of the eye. The intensely dynamic nature of the outside world makes it incredibly difficult, frustrating, intriguing, and enjoyable to study and explore. This complexity, though, and the timescales on which these places operate, can make a project such as this feel futile and quite inconsequential. It is important to note that although conclusions were drawn and then interpreted and applied to a new design, there are many factors left un-explored and unknown.

The primary limitation of the research conducted during this project was time and seasonality. The research (site documentation) was completed during a matter of months, during just one season, in the fall. This meant leaves on the ground, covering potential observations, and plants in dormancy, concealing yet other factors. On top of the span of time, other factors including a 2-year-old son, a job, other courses in progress, and the on-going effects of the global pandemic limited my site visits to just one each, as opposed to my original plan of 3 each. This led to fewer data points than I would have liked and only documenting the sites during one time of day under just one set of weather conditions. Maintenance schedules for each course also played a role, as some had just been chipped, or mowed, while others were overdue for some work. Overall, to truly grasp the effects of disc golf play on the land, a full year of documentation, during different seasons and with much more data, would be required. Another factor missing from this project is that of the human. Most disc golf courses are designed, funded, installed, and maintained by the local groups and clubs that play on them, and there is massive knowledge and insight to be gained from speaking with them. This project was not fully developed in time to attain the necessary approval to conduct interviews as part of the research phase, and as such only outside casual conversations were had with players and course owners. It should be noted here that the interest, enthusiasm and support I received during these brief conversations gave me deep satisfaction in knowing that this is important work to do and will be widely accepted and welcomed by the disc golf community.

Lastly, as mentioned previously, the covid-19 global pandemic has impacted the lives of every person on the planet over the course of the last year. There were parts of this project I dreamt of including, such as modeling disc flight patterns within a LiDAR point cloud model to explore how vegetation would be impacted through play. In the past I might have wandered down the halls of our building to seek out the appropriate person to sit with and discover how this could be done, but isolation put barriers in front of all of us that prevented this kind of quick collaboration and community learning. May we all remember this time that we couldn’t swivel around to our studio mate, and one more email or Zoom call felt like too much trouble and may we gain deeper appreciation when the time comes when we can do so again.

disc golf fairway

fire break created on USFS land

Future Applications

This project was inspired by a series of fires that occurred in the Mckenzie River watershed during September 2020. As widespread wildfires become more and more prevalent each year in the Pacific Northwest, the call for defensible space and firebreaks around vulnerable communities gets louder and more evident. A disc golf course, through both the act of playing and routine maintenance (mostly by free volunteer labor) shares many similarities with a man-made fire break or defensible space. Trees are limbed up and underbrush is cleared, removing ladder fuels, and a typical hole fairway on a disc golf course going through forest represents the same width as a fire break constructed by man. The desired distance from a community or town, such in the case of the Oakridge site presented in this project, would offer a reasonable buffer between the encroaching fire and the homes and businesses it threatened to destroy. If disc golf courses were designed in an ecologically sound manner, by a set of principles like those presented in this project, they could be widely accepted by the Forest Service and installed as land management tools to aid in the management of devastating wildfires. This would require a partnership between the disc golf community and the USFS to plan for the location, installation, and management of the course on USFS land, for which the sport of mountain biking has set a precedent.

Perhaps the greatest opportunity presented by the sport of disc golf is the passion and willingness of the local groups and clubs based in cities and small towns alike all over the world. On public and private courses alike, volunteer groups come together on a regular basis to install new equipment, lay down chips, remove hazardous or undesirable vegetation, or otherwise conduct maintenance on their local course. If it means expansion of an existing course or installing a new course to play, this community will come together rain or shine and do the work, for free. A major issue in our natural areas, especially near human civilization, is the presence or prevalence of invasive and naturalized species. A hiking trail may cut a path through a patch of invasive Himalayan Blackberry, but a disc golf course will clear a 60' wide area if it means they don't have to trod through it to retrieve their disc. After initial removal is complete, the regular foot traffic on the site could subdue its recurrence, and regular work parties from the course patrons could eventually eradicate it from the site. The potential for a user group to directly participate in the management and improvement of the landscape in which they recreate is not present in many applications as most recreation styles are more localized in their facilities (i.e. hiking and biking trails). However, the unique nature of disc golf, occupying a larger spatial vs. linear area allows for impactful work that could positively benefit the land as well as the players. This concept of participation with the landscape leads to the final potential future for disc golf courses, one that addresses a much larger issue and could have longer lasting effects on our natural world.

Disc golf does not discriminate in its appeal; children, the elderly, wealthy, impoverished, republican, democrat, libertarian…you can encounter just about any demographic on a course. Some prefer to play alone, some only with friends, some play every other day or more, others just a few times a year. You can have a brand name bag or even a cart holding up to 40 discs, or you can play carrying just one $5 driver you bought at Wal-Mart. The point being that it is an activity that draws all walks of life into the outdoors, at least for an hour or two. This is important because, according to one study (Klepeis, et al., 2001) Americans only spend 8% of their life outside. This disconnect is causing a massive lack of interest and motivation in protecting our natural areas and preserving them for future enjoyment, by humans or otherwise. Disc golf appeals to those who may not gain satisfaction from hiking through the woods with no real objective in mind or are not physically capable of higher intensity activities like mountain biking, or do not have the patience or heart for fly fishing. It offers a short time commitment, small financial commitment, and best of all, it's fun!

This exposure to such a diverse group offers the opportunity to reinstate a sense of worth and value in our natural areas that may have been lost to them before finding disc golf. For children particularly, the potential to develop disc golf courses as environmental education opportunities should be explored, and that work has already begun. A 2002 thesis from the University of Rhode Island Planning Department explored designing courses as educational centers and determined that

"The inclusion of rotating interpretive signs on the disc course strives to emphasize environmental cognition. The arrangement of the signs depends on course layout, preferably on trails or at the tee areas. The content of the signs depends on the patrons and the intent of the educators. Educationally oriented recreation settings enhance cognitive outcomes with interactive devices...Systematic programming of course graphics should reinforce environmental education curricula. The promotion of quality course design and sensible activity helps to legitimize and bolster the integrity of this community recreational opportunity." (Hotchkiss, 2002). The inclusion of this work in course designs could increase opportunities for grant funding and community partnerships to build and maintain courses.

If the design principles proposed in this project were adopted and courses were not viewed as potential threats to natural area integrity, the possibilities could continue to grow. As the sport of disc golf continues to gain momentum and popularity worldwide, it is important that it grows in a sustainable manner and potential negative impacts are addressed prior to leaving a lasting impression on those expressing concern. Using a landscape analysis-based sequence to identify problem areas and then selecting a course site and creating a design based upon those findings could significantly bolster the confidence in land managers and concerned citizens that disc golf can really be the ecologically friendly activity it claims to be.

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about the author

Hillary is a second generation native Oregonian and outdoor recreation enthusiast. After completing her Bachelor's degree in Natural Resource Conservation & Technology from OSU-Cascades, she decided to pursue a Master's degree in Landscape Architecture in order to satisfy her commitment to preserving and improving our outdoor spaces. She is a mother, a lover of animals, a hiker, a mountain biker, a rock climber, a gardener,
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