Linfield College

Cozine Creek Inventory and Assessment

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ENVS 485 Environmental Problem Solving

Linfield College, Spring 2016

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ACKNOWLEDGEMENTS

We would like to express our gratitude and appreciation to the individuals who have provided us with assistance and support throughout the completion of this project. We would like to thank the staff of the Greater Yamhill Watershed Council, Luke Westphal, Theresa Crain, and Neyssa Hays, for being a partner in this project and for providing encouragement, guidance and GIS data. We would also like to thank Linfield professors and staff, Dr. Tom Love and Ken Kebisek for their help with bird inventory data; Barbra Van Ness for help and guidance with GIS; Rachael Woody from Linfield Archives for assistance with historical documents and photographs; and Javier Mendoza for information on current management practices associated with the Cozine Creek property. Additionally, we are grateful for the members of the community of McMinnville, as well as the Linfield College administrators, faculty, and staff who participated in our stakeholder questionnaire. Finally, we would like to thank Dr. Nancy Broshot and Dr. Bill Fleeger for their expertise and guidance in producing this report.

INTRODUCTION

The Property:

Since the founding of the College in 1858, Linfield College has owned nearly a 30 acre property adjacent to the main campus along the banks of Cozine Creek in McMinnville Oregon. This report provides a comprehensive inventory and assessment of the natural environment of this property and considers the history, current uses and stakeholder concerns and preferences associated with this site. The purpose of this document is to provide the College with a greater level of knowledge about the types, location and condition of the various natural resources as well as the social uses and relationship to the campus and community that the property supports. It is our hope that the College will use this information to develop a management plan and implement stewardship actions that maintain and enhance the ecological values and social uses of this valuable campus resource.

Cozine Creek:

Cozine Creek is 11.3 miles long and flows mostly in Yamhill County with a small portion in Polk County. The creek has an average elevation of 157 feet. The creek is heavily altered by culverts, stormwater and sewage pipes, and irrigation diversions. Located at the north end of the Linfield College campus in McMinnville, Oregon, the Cozine Creek property is a stretch of land bordered by Highway 99W on the north and west edges, Davis Street to the east, and the Linfield College campus to the south. With Cozine Creek running eastward through its center, the property is mostly flat, except for steep edges that border the property. The property provides flood mitigation during the rainy winter and spring months; therefore, vegetation, wildlife, and management in the area are limited to flood resistant species, behaviors, and techniques.

The Watershed:

Cozine Creek is part of the Lower Yamhill Watershed, a 63,750-acre watershed that includes the towns of Carlton, Lafayette, Dayton, and McMinnville in Oregon. The Lower Yamhill Watershed is one of eight sub-watersheds that are part of the Yamhill River Basin, located just west of Salem. Land cover and use in the Yamhill sub-basin is approximately 56% agriculture, 38% forestry, 4% rural residential, and about 2% urban. Part of Cozine Creek passes

through the city limits of McMinnville, which is important to note because this urban setting influences the ecological quality of the site (ODEQ 2016).

The Yamhill River Basin is part of the larger Willamette Basin Watershed. The Willamette Basin watershed is about 7.3 million acres and ranges from Portland to just south of Eugene, Oregon. The Willamette Basin is essential to Oregon's population and economy because it encompasses 70% of the state's population, 75% of the state's employment, and 12% of the state's land area. A majority of the Lower Yamhill Watershed is located in Yamhill County. The very southern tip of the watershed's drainage reaches into nearby Polk County. Cozine Creek is one of two major streams in the western Lower Yamhill Watershed, the other being the South Yamhill River. Cozine Creek flows into the South Yamhill River on the east side of the City of McMinnville (Yamhill Basin Council 2001a).

Climate:

The climate of the Willamette Valley is relatively mild year round. It is characterized by warm, dry summers and cool, wet winters. There is a distinct lack of extreme weather. Average summer temperatures hover in the low 80s ºF and in winter the mid 30s ºF. The climate closely resembles the Mediterranean climates that occur in California, though winters in Oregon are normally wetter and cooler. The majority of precipitation, approximately 50% of annual total rainfall, occurs from December through February, lesser amounts in autumn and spring, and very little during summer. The City of McMinnville receives an average of 41 inches of rain per year, with the U.S. average being 37 inches. Snowfall is low, falling normally in January and only averaging six inches per year. The total number of days with measurable precipitation in McMinnville is 136. McMinnville experiences on average 154 sunny days per year (Taylor 2016).

Soil & Geology:

The Cozine site has two main soil types. Wapato silty clay loam (a mesic Fluvaquentic Endoaquoll) makes up the soil closest to the creek (USDA 2006). This poorly drained soil's parent material is loamy alluvium. It may be noted that if properly drained and protected from flooding Wapato silty clay loam would be considered prime farmland. Woodburn silt loam (a mesic Aquultic Argixeroll) is the other soil type and is found just above the Wapato soil (USDA

2009). The parent material consists of silty glaciolacustrine deposits and is moderately well drained. The Woodburn soil is further broken up into two categories based on the percent slope. At zero to three percent slopes all areas are considered prime farmland, whereas areas with greater percent slopes are not considered prime farmland (USDA 2015).

Vegetation and Wildlife:

There are four habitat types found in the Willamette Valley: riparian forest, wet and dry prairie, upland Douglas-fir forests, and oak savanna (Yamhill Basin Council 2001a). Only riparian forest and oak savanna pertain to the Cozine Creek property. Topography in the Willamette Valley is relatively flat, with elevations ranging from sea level to 122 m (USGS 2015b). Historically, Cozine was surrounded by white oak savanna and riparian forest. White oak savanna consists mainly of Oregon white oak (*Quercus garryana*), with Pacific madrone (*Arbutus menziesii*), black cottonwood (*Populus trichocarpa*), red alder (*Alnus rubra*), and white ash (*Fraxinus latifolia*), with poison oak (*Toxicodendron diversilobum*) in the understory (Yamhill Basin Council 2001a). Oak woodlands provide habitat for a variety of animals (Hagar and Stern 2002). Large, mature oaks often contain cavities and have large dead branches that provide homes for several species of rodents and birds including voles, woodpeckers, and white-breasted nuthatches. The acorns produced by oak trees feed many species including raccoons, squirrels, and black-tailed deer. Oak trees also host several species of epiphytes, including lichens and mistletoe (*Phoradendron villosum*), that provide food for animals including bluebirds (Rosenberg and Vasely 2010). The open canopy of oak woodlands also provides a lot of space for reptiles to sun themselves (Oregon Wildlife Institute 2016a).

Riparian habitats are areas next to streams, creeks, rivers, etc. and are dominated by black cottonwood (*Populus trichocarpa*), willow (*Salix* sp.), and some regions have white ash and red alder (*Alnus rubra*) in the understory. Many riparian species are adapted to fire. A special riparian species present on the property is camas lily (*Camassia quamash*) (Yamhill Basin Council 2001a). Important features of riparian areas are the high levels of woody debris and dense vegetation. Woody debris decreases the flow of water. This is important as it allows sediment and/or gravel to accumulate and spread across the creek bed areas, providing habitat for aquatic organisms including fish. Dense vegetation is also important as it provides shade to cool the water, a vital requirement for many aquatic species, and allows excess nutrients to be taken

up by plant roots before they enter the water (Yamhill Basin Council 2001a; ODEQ 2009). Riparian zones are an important habitat for several animal species (Neimiec et al. 1995; ODFW 2016a). Oregon ash provides food for deer in the form of seedlings and sprouts as well as food and shelter for beaver and nutria, the latter of which is an invasive species in Oregon (Niemiec et al. 1995). Mammals like raccoons and deer also use riparian areas because they provide a dependable source of water (ODFW 2016a).

At present, much of the wet prairie and oak prairie habitats in the area are now restricted to wildlife refuges and small protected areas due to the surrounding area being converted to urban areas, pasture, agricultural fields, and vineyards. Invasive species include Himalayan blackberry (*Rubus discolor*) and *Rosa multiflora* (Yamhill Basin Council 2001b).

The Social Context:

According to local history, the Cozine property is located along the old Indian trail that later became the main thoroughfare and center of the City of McMinnville (Holmes 1956). The property connects the campus and community and is located only a few blocks away from McMinnville's cherished downtown business district. The property has played a vital role in the history of the college and is still used by classes for educational purposes and by students and residents as an access route to and from town. Along with property both up and downstream that is owned by the City of McMinnville, the site serves to mitigate seasonal flooding and is frequently partially underwater during winter and spring. The property also hosts a main underground sewage line serving the City of McMinnville. Currently the property is only minimally managed by the college and stakeholders hold a variety of perspective about how the site should be managed and maintained in the future. However, there is general agreement that the property is a valuable asset to the campus and community and that the ecological quality of and social uses of the site could be improved.

VEGETATION, WILDLIFE, AND AQUATICS ASSESSMENT

Alexandra McCarrel, Marisa Specht, and Kathryn van Dyk
Chapter Editor: Alexandra McCarrel

INTRODUCTION

To understand and assess the function and structure of a natural area such as the Cozine Creek property located on the Linfield College campus, it is essential to analyze its natural resources. These factors include the area's hydrology, vegetation, wildlife, geology, and geography. Located within the Lower Yamhill Watershed, Cozine Creek contains a range of aquatic and terrestrial resources. The creek itself is host to various anthropogenic problems, especially within McMinnville city limits. Despite concerns about water quality, the property supports a range of vegetation, wildlife, and aquatic organisms. The purpose of this study is to assess, inventory, and describe the vegetation, wildlife, and aquatic characteristics of Linfield College's Cozine Creek property. We identified anthropogenic and biological threats to the creek, including thermal pollution and invasive plants, and these threats were assessed to determine how they might affect terrestrial and aquatic organisms.

METHODS

- All trees greater than 20 cm dbh (diameter at breast height; 1.37 m above ground) were inventoried. For each tree, species, dbh (in cm), GPS location, whether it was alive or dead, and any special visible attributes such as beaver chew, cavities, or broken branches recorded. Tree cores were taken from one Oregon white oak and five Oregon ash trees to compare growth rates and ages.
- Shrub species were recorded as they were observed. Percent cover of different species and percent of exotics were estimated along the creek banks by measuring the linear distance along the bank of areas of differing dominant plant species. An estimate of percent cover of non-native species was estimated from these measurements.
- Herbaceous species were recorded as observed. We delineated the boundaries of areas with a high density of Himalayan blackberries as well as those dominated by camas lilies using a

hand-held GPS. These areas were mapped using GIS to indicate areas of concern for restoration efforts.

- Bird data was collected through observation by Linfield College students, faculty, administration, and staff.
- Mammal data was collected by sightings, tracks, bones, and beaver chew observed by Linfield College students, faculty, administrators and staff.
- Reptile and amphibian data was collected by observations made by Linfield College students, faculty, administrators, and staff.
- Cozine Creek's temperature; depth; pH; flow rate; turbidity; levels of ammonia, phosphate, and nitrate; and levels of *E. coli*, *Aeromonas*, *Salmonella*, and other coliform bacteria were measured using methods described in the ENVS 385 Research Methods water quality assessment from 2015 (Blanco et al. 2015).
- The aquatic organisms present in Cozine Creek were inventoried using a 1995 fisheries resource inventory using electrofishing techniques conducted by the Oregon Department of Fish and Wildlife (White 1995).

SECTION 1: VEGETATION

INVENTORY AND ASSESSMENT

Trees and Shrubs:

The Cozine Creek property hosts a combination of white oak savanna and wetland/riparian habitats. This site is used mainly for flood mitigation during the rainy winter and spring months, therefore, vegetation and management are limited to flood-resistant species and techniques (Yamhill Basin Council 2001a).

Dominant vegetation found in oak savanna habitats is Oregon white oak, in conjunction with Pacific madrone, black cottonwood, red alder, Oregon white ash, and poison oak in the understory. Dominant vegetation in wetland/riparian zones is black cottonwood and willow, with some red alder and white ash in the understory. A special riparian species present on the Cozine Creek property is camas lily. This plant was a staple in the Kalapuyan diet and represents a culturally significant aspect of the property. Major invasive species in the area include Himalayan blackberry (*Rubus discolor*), reed canarygrass (*Phalaris arundinacea*), and rose (*Rosa multiflora*). Invasive species are important to note because they outcompete and displace native species (Yamhill Basin Council 2001a).

We found the most common tree on the Cozine Creek property was Oregon white ash followed by Oregon white oak (Figure 1.1). Tree species comprising less than 5% of the community are represented in the 'Other' category. Tree species included in 'Other' can be found in Appendix A, as can listings of all plant species observed on the property. The high abundance of Oregon white oak is indicative of Oregon white oak prairie habitat, which historically dominated the habitat surrounding the property (Yamhill Basin Council 2001a). We also found willow, black cottonwood, and red alder on the property. The presence of these species are indicative of a riparian/wetland habitat. Historically, this habitat has also been found to surround the Cozine Creek property (Yamhill Basin Council 2001a).

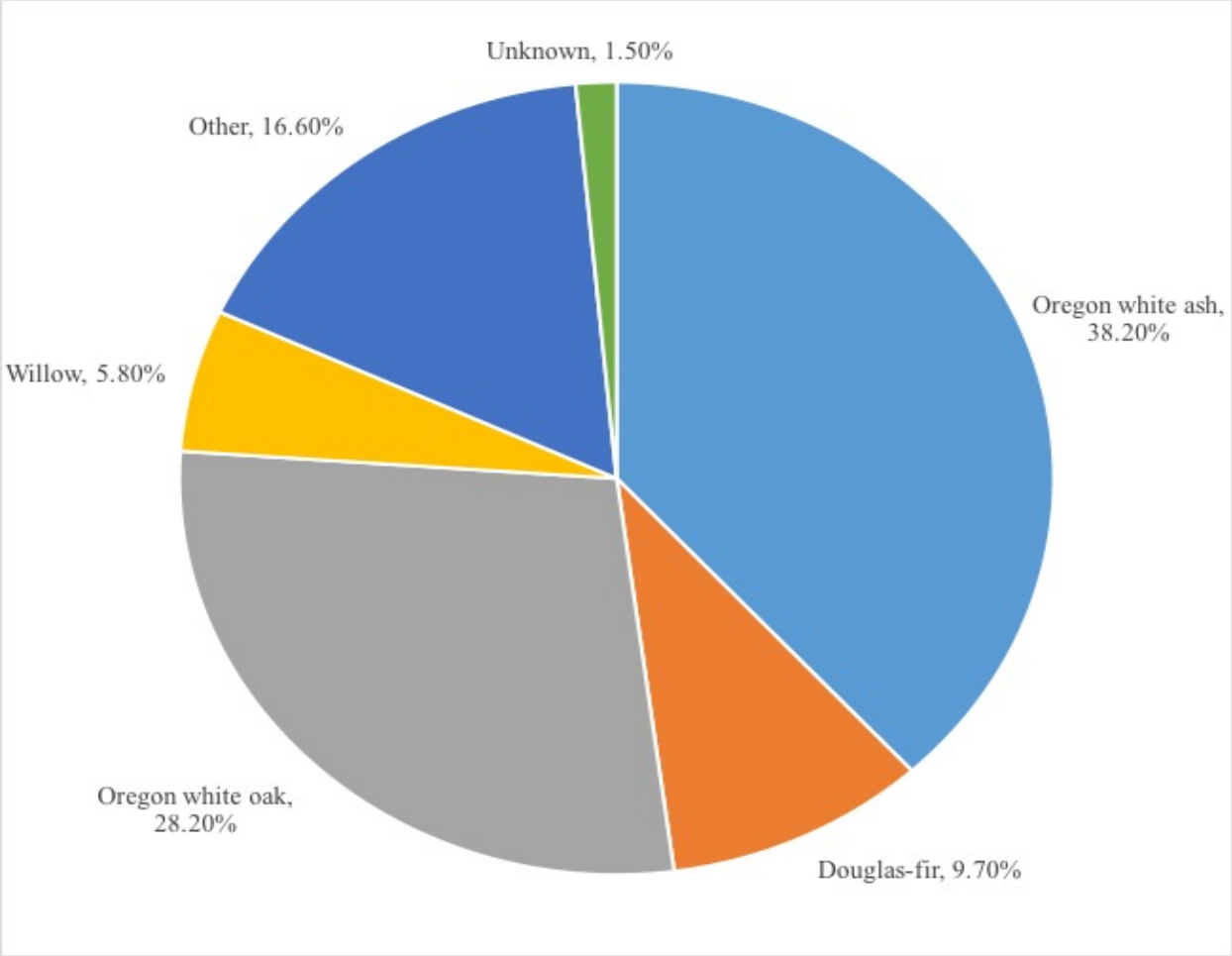

Figure 1.1: Tree species abundance on Linfield College's Cozine Creek Property. Trees with multiple trunks were counted as a single individual. Tree species comprising less than 5% of the entire tree community of the property are represented in the 'Other' category.

The mean dbh of the most abundant tree species (Oregon ash) was 37.3 cm (Table 1.1). The mean dbh of the second most abundant species (Oregon white oak) was 66.1 cm. However, the total dbh for ash trees on the property was 4814.3cm, whereas the total dbh for oak trees was 6215.2cm. This indicates that Oregon white oak is the most dominant tree species. The species with the largest dbh was incense cedar, however, it was represented by only two individuals, one of which was the largest tree measured. We also analyzed tree cores from one Oregon white oak tree and five Oregon ash trees to determine the average growth rate of Oregon white oak compared to Oregon ash. We found the five cored Oregon ash trees on the property had grown more than three times faster over the last ten years than the single cored Oregon white oak. We found it took 100 years for the cored oak to grow 10 cm in dbh, whereas it only took at about 20

years for each cored ash to grow 10 cm in dbh. The dbh of the cored oak was 39.5cm and was calculated to be at least 142 years old. The average dbh of the five cored ash trees was 29cm and we only counted up to 37 years for the oldest ash cored. The ash trees should be at least 10-20 years older. This is important because it shows how much faster the ash trees grow compared to the oaks. There were some ash trees in the understory of some large oaks on the property, which means that they could quickly outgrow the oaks, shade them out, and eventually kill them.

Table 1.1: Abundance of trees that were measured and tagged. Mean dbh (standard deviation) for each species is listed. Species are listed by decreasing abundance.

Tree species: *Scientific name* (common name)	Number of individuals measured	Average dbh (cm) and (standard deviation)
Fraxinum latifolia (Oregon ash)	131	37.3 (17.5)
Quercus garryana (Oregon white oak)	92	66.1 (21.2)
Pseudotsuga menziesii (Douglas-fir)	31	56.1 (33.8)
Salix sp. (willow)	27	27.6 (12.8)
Acer macrophyllum (big leaf maple)	16	44.8 (19.0)
Sequoia sempervirens (coastal redwood)	12	31.8 (8.7)
Prunus sp. (cherry)	7	26.3 (8.4)
Thuja plicata (western red cedar)	6	27.6 (18.7)
Populus trichocarpa (black cottonwood)	5	95.6 (51.8)
Pinus ponderosa (ponderosa pine)	3	20.7 (3.7)
Crataegus monogyra (English hawthorne)	2	27.0 (6.8)
Cunninghamia lanceolata (China fir)	2	24.1 (1.8)
Calocedrus decurrens (incense cedar)	2	111.2 (188.4)
Umbellularia californica (Oregon myrtlewood)	2	16.4 (1.8)
Pyrus malus (apple)	1	42.7
Robinia pseudoacacia (black locust)	1	45.4
Juglans nigra (black walnut)	1	48.3
Catalpa sp. (catalpa)	1	26.0
Picea engalmanii (Engelmann spruce)	1	20.6
Juglans regia (English walnut)	1	39.6
Crataegus douglasii (black hawthorne)	1	35.0
Oemleria cerasiformis (Indian plum)	1	30.7
Alnus rubra (red alder)	1	49.1
Liquidambar styraciflua (sweet gum)	1	41.8
Platanus occidentalis (sycamore)	1	72.7
Liriodendron tulipifera (tulip tree)	1	34.2

We also examined each measured tree for special visible attributes (e.g., beaver chew, cavities, broken branches, boles covered in English ivy, etc) and found that most of the 362 trees had no special attributes. The major feature recorded was trees with boles covered in English ivy, which may result in recommendations for restoration.

Approximately 87% of the measured trees on the property were native, but we also observed many non-native, ornamental tree species that accounted for about 13% of the trees measured. These were most likely planted by Linfield College's Facilities Services who manage the property. Forty-six percent of the total number of woody plant species on the property were native, 52% were exotic, and 13% were invasive including Himalayan blackberry and *Rosa multiflora* (see Appendix A for designations). Of the total number of herbaceous plant species, we found 40% were native, 53% were exotic, and 15% were invasive including Italian arum, English ivy, and creeping jenny. Some woody plant and herbaceous species were counted in more than one category. Invasives are important to note because they displace native species.

We analyzed the distribution of trees species on the property with respect to the floodplain status (Figure 1.2). A distinction, however, was found in examining tree distribution in the floodway, which is defined as a channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height (FEMA 2016). This is the area that floods annually. The Oregon white oak trees were not in the floodway, whereas the majority of the ash were within it. This indicates a separation between the oak woodland habitat and riparian habitat found on the property.

We noticed some Douglas-fir and ash trees growing under some large oaks outside the floodway and this is concerning because the ash trees on this property are growing at three times the rate of the oaks. These young trees can quickly outgrow and shade out the large oaks eventually leading to the oaks' death.

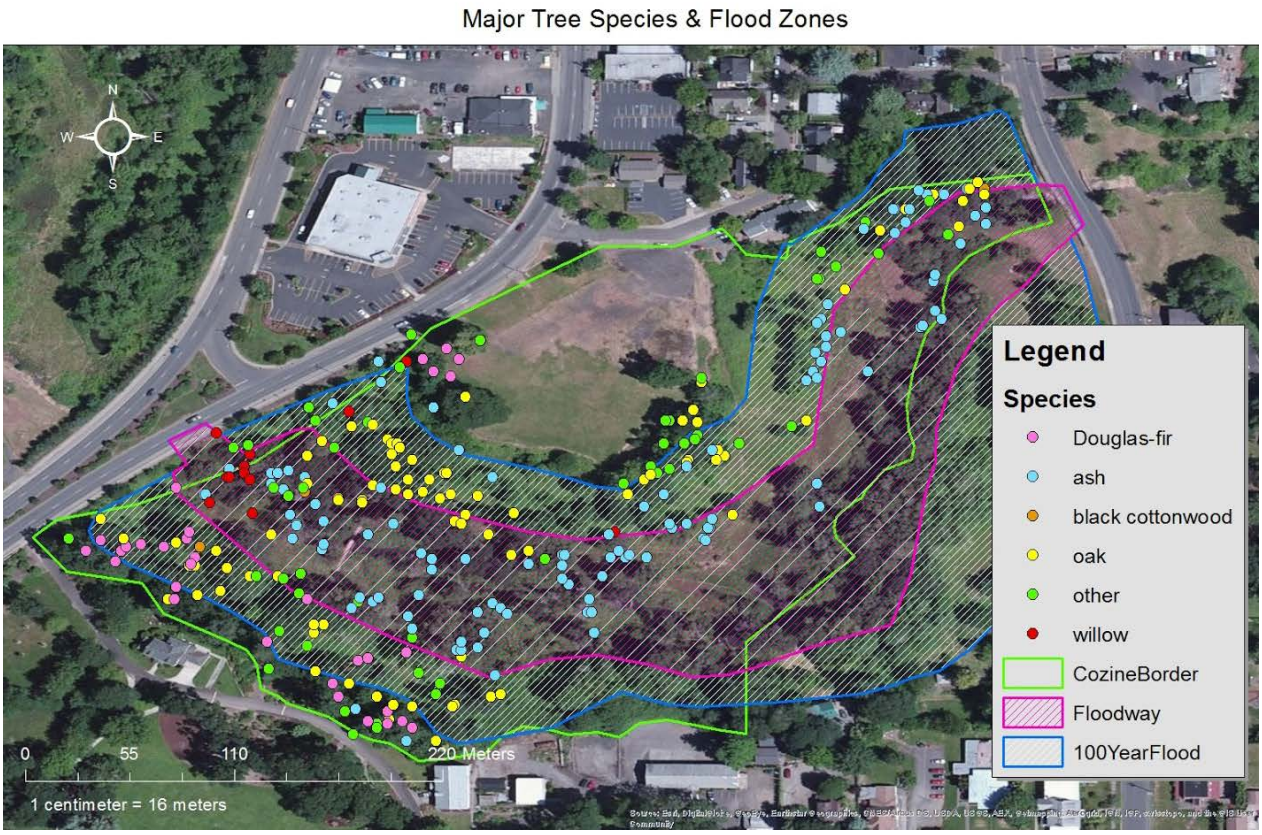

Figure 1.2: Map of location of trees >20cm dbh relative to floodplain (made by Reese Yonemura)

We mapped areas with high density of two species of concern: *Camassia quamash* (a culturally significant species that also is a beautiful wildflower) and *Rubus discolor* (a highly invasive species in the Willamette Valley) (Figure 1.3). There are two large patches and two smaller patches of *Camassia quamash* on the northern bank of the creek, covering an area of approximately 2,500m^2, approximately 2% of the property area. This is good because this riparian species is culturally important. It was a staple in the Kalapuyan diet (Yamhill Basin Council 2001a). Areas with a high density of *Rubus discolor* were found along the southern border of the property and along the creek banks. The total area of the property covered by *Rubus discolor* is about 27,600m^2, almost 25% of the entire property area. This is concerning because this species is highly invasive and outcompetes native vegetation all over the Willamette Valley.

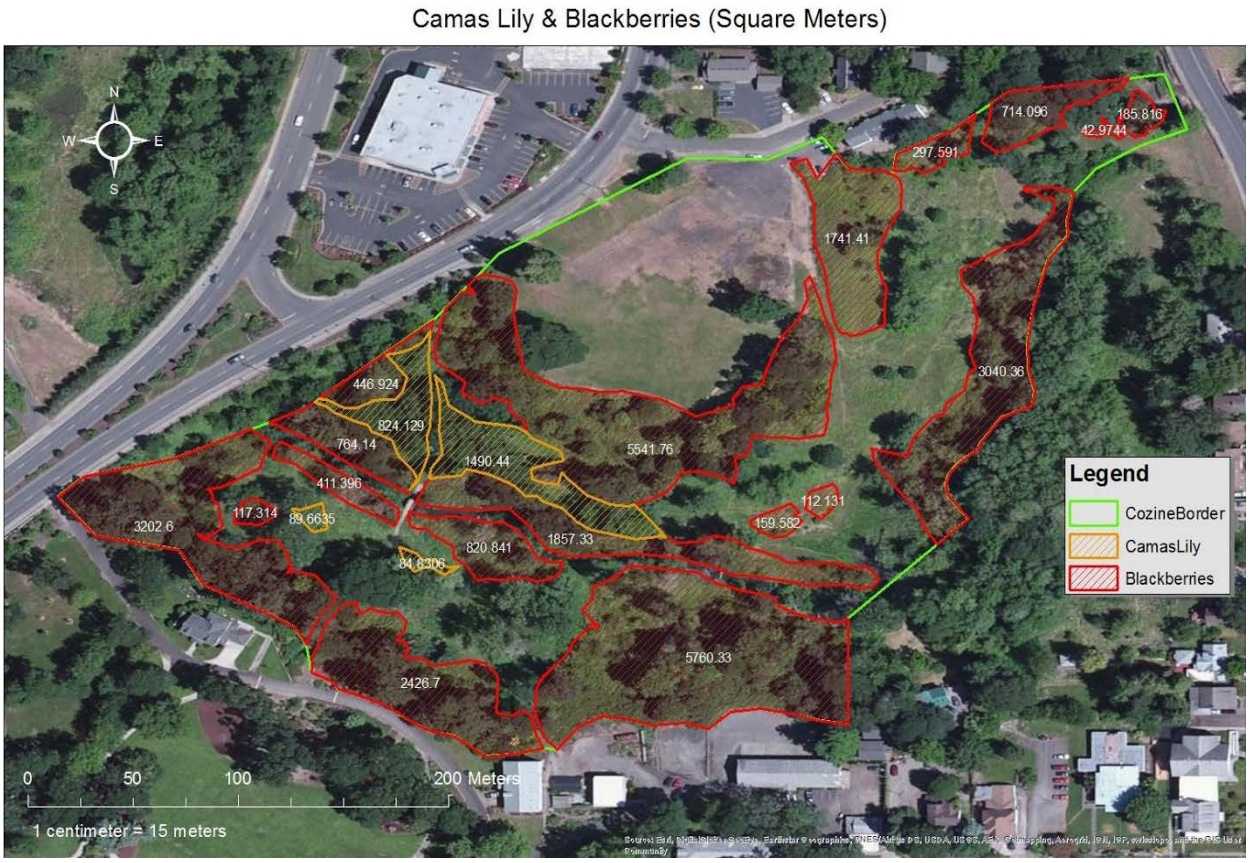

Figure 1.3: Map of presence of Camas lily (*Camassia quamash*) and Himalayan blackberry (*Rubus discolor*) on the Cozine Creek property (made by Reese Yonemura).

We also estimated and analyzed the percent cover shrub species along the creek bank. We estimated two-thirds of the bank was covered by non-native plant species. All the non-native species found along the banks were also invasive species (e.g., Himalayan blackberry (*Rubus discolor*), rose (*Rosa multiflora*), and some reed canary grass (*Phalaris arundinacea*)). However, many native plant species were also prevalent along the banks including creek dogwood (*Cornus stolonifera* var. *occidentalis*), willow (*Salix* sp.), snowberry (*Symphoricarpos albus*), Douglas spirea (*Spiraea douglasii*), chokecherry (*Prunus virginiana*), and ninebark (*Physocarpus capitatus*).

SECTION 2: WILDLIFE

INVENTORY AND ASSESSMENT

Introduction:

Linfield College's Cozine Creek property supports many species of birds, mammals, reptiles, and amphibians. None of the species currently are listed under the Endangered Species Act, but some (e.g., white-breasted nuthatch and acorn woodpecker) could disappear from the Willamette Valley in the future (Rosenberg and Vasely) with the continued loss of Oregon white oak habitat. The Cozine Creek property examined in this study has many vegetation habitat types including grassy areas, shrubs, upland oak, and riparian zones. The oak woodland provides homes for animals dependent on open canopies, including several bird and reptile species (Rosenberg and Vasely 2010). The presence of many animal species enriches the biodiversity of the Cozine property.

Birds:

Of the 106 bird species expected in nearby habitat similar to Cozine Creek (Miller Woods), 54 have been observed on the property (Table 1.2). All 54 bird species are listed as species of least concern (Cornell Lab of Ornithology 2016). Full list of observed and expected bird species is available in Table 2.1 in appendix B.

Table 1.2: Bird species observed on the Cozine Creek property.

Mallard duck *(Anas platyrhynchos)*
Turkey Vulture *(Cathartes aura)*
Green heron *(Butorides virescens)*
Spotted Sandpiper *(Actitis macularius)*
Belted kingfisher *(Megaceryle alcyon)*
Killdeer *(Charadrius vociferous)*
Eurasian collared dove *(Streptopelia decaocto)*
Mourning dove *(Zenaida macroura)*
Band-tailed pigeon *(Patagioenas fasciata)*
Rock pigeon *(Columbia Livia)*
Barn owl *(Tyto alba) ?*
Western screech owl *(Megascops kennicottii) ?*
Anna hummingbird *(Calypte anna)*
Northern flicker *(Colaptes auratus)*
Acorn woodpecker *(Melanerpes formicivorus)*
Red-bellied sapsucker *(Melanerpes carolinus)*
Downy woodpecker *(Picoides pubescens)*
Pacific Slope Flycatcher *(Empidonax difficilis)*
Western wood pewee *(Contopus sordidulus)*
Spotted towhee *(Pipilo maculatus)*
Song sparrow *(Melospiza melodia)*
White-crowned sparrow *(Zonotrichia leucophrys)*
Golden-crowned sparrow *(Zonotrichia atricapilla)*
Dark-eyed junco *(Junco hyemalis)*
Brewer's blackbird *(Euphagus cyanocephalus)*
Brown-headed cowbird *(Molothrus ater)*
Black-headed grosbeak *(Pheucticus melanocephalus)*
Evening grosbeak *(Coccothraustes vespertinus)*
House finch *(Haemorhous mexicanus)*
Pine siskin *(Carduelis pinus)*
American goldfinch *(Spinus tristis)*
Lesser goldfinch *(Spinus psaltria) ?*
European starling *(Sturnus vulgaris)*
House sparrow *(Passer domesticus)*
Warbling Vireo *(Vireo gilvus)*
Scrub jay *(Aphelocoma californica)*
American crow *(Corvus brachyrhynchos*)
Tree swallow *(Tachycineta bicolor)*
Violet-green swallow *(Tachycineta thalassina)*
Vaux's swift *(Chaetura vauxi)*
Black-capped chickadee *(Poecile atricapillus)*
Chestnut-backed chickadee *(Poecile rufescens)*
Common Bushtit *(Psaltriparus minimus)*
Brown Creeper *(Certhia Americana)*
White-breasted nuthatch *(Sitta carolinensis)*
Red-breasted nuthatch *(Sitta canadensis)*
American robin *(Turdus migratorius)*
Cedar waxwing *(Bombycilla cedrorum)*
Orange-crowned warbler *(Vermivora celata)*
Yellow-rumped warbler *(Setophaga coronate)*
Wilson's warbler *(Cardellina pusilla)*
Common yellow throat *(Geothlypis trichas)*
Western tanager *(Piranga ludoviciana)*
Bewick's wren *(Thryomanes bewickii)*

Oak woodland habitat is very important to both resident and migratory bird species. Many of the bird species observed on the Cozine Creek property have a preference for oak woodland including mourning doves, white-breasted nuthatches, acorn woodpeckers, downy woodpeckers, and American goldfinches.The avian species of greatest concern is the white-breasted nuthatch. This species depends on large diameter white oak trees for habitat and feeds partially on acorns. As the Willamette Valley continues to shift from oak to coniferous forest, this avian species continues to decline in abundance (Hagar and Stern 2002). Other bird species found in the Cozine area are dependent on cavities for nesting include western screech owls, northern flickers, acorn woodpeckers, red-bellied sapsuckers, downy woodpeckers, pacific slope flycatchers, violet-green swallows, black-capped chickadees, chestnut-backed chickadees, white-breasted nuthatches, red-breasted nuthatches, and Bewick's wrens. Shrub nesting bird species

found on the Cozine property include song sparrows, Brewer's blackbird, American goldfinches, and common yellowthroats (The Cornell Lab of Ornithology 2016).

Mammals:

Eleven of the expected 42 mammal species have been observed on the Cozine Property (Table 1.3). All of the identified species are common in the Pacific Northwest and are not threatened species (ODFW 2016a). Full list of expected mammal species is available in Table 2.2 in appendix B.

Table 1.3: Mammal species observed on the Cozine Creek property. Some mammals, like squirrels and bats, have yet to be identified to species.

Moles—species uncertain
Bats—species uncertain
Deer mouse *(Peromyscus)*
Raccoon *(Procyon lotor)*
Striped Skunk *(Mephitis mephitis)*
Opossum (*Didelphis virginiana)*
Beaver *(Castor Canadensis)*
Nutria *(Myocastor coypus)*
Black tailed deer *(Odocoileus hemionus)*
Eastern Fox Squirrel *(Sciurus niger)*
Squirrel – species uncertain

The mammals observed in Cozine Creek included raccoons, striped skunks, deer mice, black-tailed deer, nutria, moles, squirrels, and bats. Most of these animals are very common throughout the United States (ODFW 2016a). The Oregon Department of Fish and Wildlife lists California *Myotis* bats, Townsend's big-eared bats, and western grey squirrels as sensitive species (species a of conservation interest in the Willamette Valley) due to the decline of oak habitat (ODFW 2016c), however we have not identified bats and squirrels to species yet. Western grey squirrels depend on Oregon white oak for habitat and acorns for food. Their populations will drastically decline if oak woodlands continue to be destroyed and invasive Eastern grey squirrels that thrive in coniferous environments will become more prominent in the Willamette Valley (ODFW 2016b). Better identification of the mammals on our site would be important.

The Cozine Creek area is great habitat for black-tailed deer. The Cozine Creek area has many shrub species (e.g., choke cherry, creek dogwood, Himalayan blackberry, and poison oak)

that black-tailed deer browse upon, a creek from which they can drink, and trees where they can find shelter (Bennett 2007). Black-tailed deer sightings and tracks show black-tailed deer are taking advantage of this habitat. Both beaver chew and a beaver carcass were found in the Cozine Creek area. Beavers live in wooded riparian zones such as the Cozine Creek property. Their preferred food and housing material are cottonwood and willow (ODFW 2016a), both of which are found on the Cozine property, but not in large quantities. Beavers will consume white oak and Oregon ash, but they are not their preferred species. The fact that the beaver did not live may be due to a lack of adequate preferred species. After the beaver carcass was found, no new beaver chew was found, suggesting that there may be no more beavers on the Cozine Creek property. The one that was found may have washed in during a flooding event.

Nutria, an invasive species (Niemiec et al. 1995) have been observed on the Cozine Creek property. Nutria can be very damaging in both natural and urban areas. They burrow into banks of streams and rivers, which can cause serious erosion and often lead to collapsing streambeds and roadways. Nutria forage for food and will dig up roots, crops, lawns, and garden plants (ODFW 2016a).

Amphibian and Reptiles:

Three of the expected 26 reptile and amphibian species have been observed on the Cozine Property (Table 1.4). Red-bellied newts, pacific tree frogs, and garter snakes, all of which are common in the Pacific Northwest (Oregon Wildlife Institute 2016a) have been observed. Full list of expected reptile and amphibian species is available in Table 2.3 of appendix B.

Table 1.4: Reptile and amphibian species observed on the Cozine Creek property.

Red bellied newt *(Taricha rivularis)*
Pacific tree frog (*Pseudacris regilla)*
Common garter snake *(Thamnophisirtalis)*

Few reptiles and amphibians have been observed at the Cozine Creek property. We have only seen the Pacific tree frog, red-bellied newt, and a garter snake. All of these species are widely dispersed throughout the Pacific Northwest (ODFW 2016a). The low numbers of amphibians and reptiles may be due the poor connectivity of the Cozine area that prevents escape from flooding events, fertilizer and pollution run-off from Baker Street, and culverts under Baker

and Davis Streets that may hinder movement of aquatic species. The culverts under Cozine Creek limit the connectivity reptiles could use to move into and out of the property. The number of amphibians and reptiles also may be limited by the annual flooding events that occur in winter and spring (Burbink et al. 1998).

Cozine Creek as a Wildlife Corridor:

As an urban creek, Cozine had potential to act as a wildlife corridor. Urban wildlife corridors create environments where wildlife and humans can coexist, limit negative impact to wildlife from urban development, and create recreational areas within cities. Riparian areas like Cozine Creek are ideal locations for urban corridors because water promotes the growth of vegetation that attracts animals (Dallimer et al. 2012).

Birds benefit from wildlife corridors. Roads and other barriers do not deter most bird species because flight allows for connectivity. Cities with high levels of natural cover and vegetation have greater bird biodiversity (Dallimer et al. 2012). The Cozine Creek area offers birds a place to nest and feed in an urban setting. Many species of birds have been observed there, suggesting it is functioning as a wildlife corridor.

Wildlife corridors also are important for mammals. Natural areas attract mammals and help draw them from areas where they are not wanted, such as vineyards and yards. Mammals have been found to be eleven times more likely to be found in urban natural areas than in vineyards, helping decrease unwanted interactions between humans and animals. Urban natural areas are better at attracting mammals if they contain native species and have connectivity with other natural areas (Hilty and Merenlender 2004). The Cozine Creek area may be serving as a wildlife corridor for some mammals although all but small mammals also can cross roads more easily than amphibians or reptiles (Burbink et al. 1998).

Reptiles and amphibians often spend the majority of their lives in a single habitat corridor. When flood events occur, slow moving reptiles usually cannot escape and die. Corridors that experience recurring events, like the annual flooding in Cozine, can become sinks for reptiles and amphibians as they are drawn to the area but die in floods (Burbrink et al. 1998). Reptiles also are negatively affected by the presence of roads. Reptiles enjoy basking in roads, which leads to high.The location of the Cozine property between two roads also may limit the migration for mating of amphibians. Amphibians also are negatively affected by pollution and

fertilizers runoff. Many species are sensitive to light and sound because it can result in deafness, increase stress, and alter mating and feeding behavior (Andrews et al. 2008).

SECTION 3: AQUATICS

INVENTORY AND ASSESSMENT

Drainage and Flooding:

Cozine Creek drains through an area of 11.3 square miles. The drainage area is predominantly agricultural land with some urban development after the creek enters the city limits of McMinnville. The North Fork of Cozine Creek flows southeasterly from its origin point northwest of McMinnville. The creek drains approximately two square miles before its confluence with the main stem of Cozine Creek. West Cozine Creek flows northeasterly and drains 0.6 square miles before its confluence with Cozine Creek (FEMA 2010). Only parks and open spaces are allowed on the floodplains in McMinnville, including those of Cozine Creek. The lack of development allows the Cozine Creek area to be available for floodwater storage, minimizing the impact of periodic flooding on human development (Yamhill County 2009).

Yamhill County frequently deals with periodic flooding events caused by intense rainfall from large winter storms occurring between late October and the end of April (Figure 1.4). Cozine Creek often experiences major flooding in December, January, and February. The earliest floods in the region after Europeans arrived were recorded in 1843 and 1844. In 1861 a 100-year flood event occurred. This is considered by some to be the largest flood witnessed by residents, but no measurements of volume were taken at that time. The largest recorded flooding event occurred in 1996 and peaked at a discharge of 47,000 cubic feet per second (Lucker 2011). The average peak flow for Cozine Creek is 17.45 cubic feet per second above Davis Street and 9.8 cubic feet per second further upstream, west of Fellows Street. The flow can increase dramatically after heavy rainfall and the backup of the South Yamhill River (Johnson and Sullivan 1999).

Figure 1.4: Map of 100 year flood zone and floodway in Cozine Creek (made by Reese Yonemura)

Stormwater:

The City of McMinnville relies on Cozine Creek as one of its perimeter endpoints of stormwater drainage, especially during flood events. Stormwater runoff flows to Cozine Creek either by pipes or in natural open channels. There are also numerous manhole covers that lead to the McMinnville sewer system that runs under Cozine Creek (Figure 1.5). Approximately two-thirds of McMinnville's storm drains eventually discharge into the creek, and much of McMinnville's drainage system has storm drains that are undersized. These factors result in annual flooding. Currently, there are no requirements by the U.S. Environmental Protection Agency (EPA) on stormwater quality for the city of McMinnville. Recommendations by the EPA have been made to monitor the stream's water quality, although little action has been done because Cozine Creek is considered a lower priority than other streams in the county.

McMinnville does have a stormwater quality sampling program that began in the late 1980s that measures pollution levels and other water quality variables (Yamhill Basin Council 2001). For additional information, an extensive Cozine Creek watershed assessment was conducted in 1999 by the spring ENVS 485 Environmental Problem Solving Seminar class that investigated channel habitat type and modifications, flooding history and assessment, and hydrology and water use (Johnson 1999; Johnson and Sullivan 1999; Koenig and Ziegler 1999; Zeigler 1999).

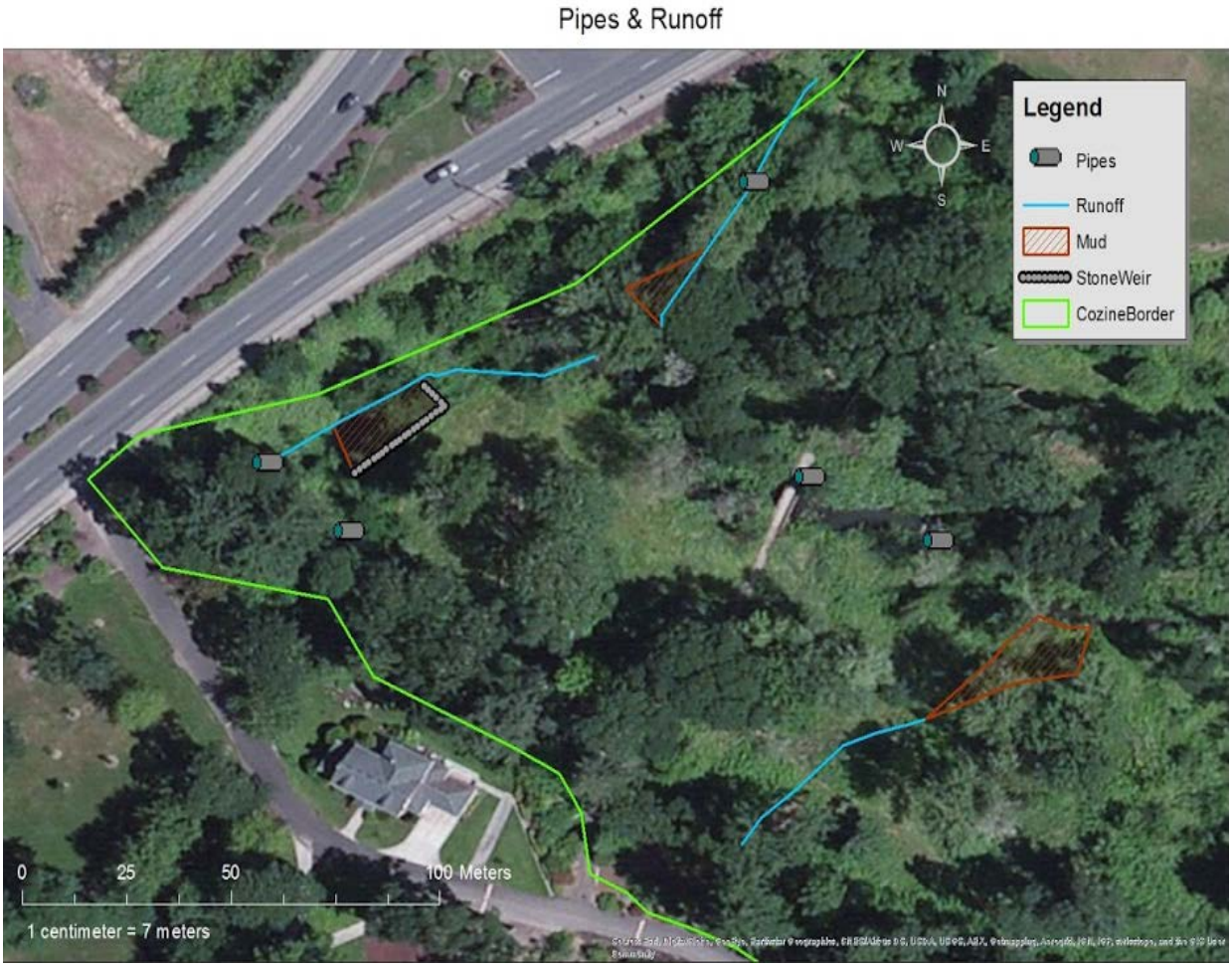

Figure 1.5: Map of stormwater pipe locations and sewer manhole covers in Cozine Creek (made by Reese Yonemura)

Water Quality:

Environmental Research Methods (ENVS 385) classes have been testing the water quality of Cozine Creek since 2011. The studies have shown that Cozine Creek has low dissolved oxygen and pH, as well as high water temperature, turbidity, phosphate, coliform

bacteria, and biochemical oxygen demand (Colahan et al. 2011; Bailey et al. 2012; Hollenbeck et al. 2013; Fahy et al. 2014; Blanco et al. 2015). These factors contribute to water quality issues that can negatively affect aquatic life (EPA 2015).

Water quality tests in spring 2016 suggested that Cozine Creek had turbidity and nitrate levels above the recommended levels of 10 FTUs and 2 ppm respectively (Yamhill Basin Council 2004; EPA 2015). Excess turbidity in the creek can lead to changes in fish physiology and behavior. Higher turbidity can clog fish gills, lowering growth rates, slowing egg and larval development, and reducing disease resistance (USGS 2015a). Nitrate levels are above the recommended maximum levels of 2 ppm for sensitive freshwater fish. Elevated nitrate levels in Cozine Creek can lead to reduced reproduction and growth rates in fish. Phosphate and ammonia levels in Cozine Creek are below the maximum levels, 0.1 ppm for phosphate and 0.2 ppm for ammonia, in order to promote thriving fish populations.

As measured this spring, Cozine Creek barely meets the minimum recommended flow rate for freshwater fish, which is 20 cm/s (Yamhill Basin Council 2004) (Table 1.5). In fall 2015 the flow rate did not meet the recommended rate. The creek's pH levels fall in the recommended range of 6.5 to 8.5, and *E. coli* levels are below the maximum amount of 406 colonies per 100 ml of water for freshwater fish. Water temperatures in Cozine Creek in spring 2016 were below the recommended level of 18°C for freshwater fish (Yamhill Basin Council 2004). Water temperatures in fall 2015 was the highest recorded since 2011, an average of 16.6°C, though this was also below the maximum recommended temperature level of 18°C. Temperatures in the Lower Yamhill Watershed are frequently above the recommended amount however, possibly leading to delayed salmonid migration, reduced growth and reproduction, inhibited smoltification, altered competitive dominance, and the creation of disease problems (Carter 2005). For additional information regarding Cozine Creek's water quality, refer to Appendix C.

Table 1.5: Recommended levels of freshwater water quality variables. Recommended levels are from the Yamhill Basin Council 2004 and the EPA 2015

Water Quality Variables	Recommended levels of freshwater water quality variables
pH	6.5-8.5
Flow (cm/s)	20 cm/s minimum
Temperature (°C)	18°C maximum
Turbidity (FTUs)	10 FTUs maximum
Ammonia (ppm)	0.2 ppm
Nitrate (ppm)	2 ppm
Phosphate (ppm)	0.1 ppm
E. coli (# per 100ml)	406 per 100 ml of water
Aeromonas (# per 100 ml)	N/A
Salmonella (# per 100ml)	N/A
Other Coliforms (# per 100ml)	N/A

Macroinvertebrates:

Macroinvertebrates are important water quality indicators because their presence and population abundances are directly related to dissolved oxygen and pollution levels. Their populations shows short term, long term, and cumulative effects of stream pollution because macroinvertebrates cannot escape their environments. Populations of macroinvertebrates increase with higher creek nutrients, particularly nitrogen, in response to an increase in the rate of decomposition of detritus that provides food for the organisms. Higher alkalinity levels increases macroinvertebrate populations by increasing the rate of detritus decomposition. Macroinvertebrates are a vital food source for aquatic organisms, influencing higher trophic levels, including anadromous fish species (Wallace and Webster 1996).

Macroinvertebrates are analyzed using a pollution tolerance index (PTI), broken down into three categories. Category 1, assigned three point, contains pollution-sensitive

macroinvertebrates. Category 2, assigned two points, contains macroinvertebrates that can tolerate a wide range of environments. Category 3, assigned one point, contains pollution tolerant macroinvertebrates. PTI is the total sum of the points and the quality of the stream is defined by the score; 23 or more points excellent, 17 to 22 good, 11 to 16 fair, and fewer than 10 poor (Olomukoro and Dirisu 2013). Cozine Creek was found by the fall 2015 ENVS 385 class to have significantly higher PTI and species richness in 2015 than 2014. In 2013, Cozine Creek had a PTI index of 7, in 2014 it decreased to 5, and in 2015 it increased to 9. The PTI between all of these years are below 10, representing poor water quality of the steam. The number of pollution tolerant species increased between 2013 and 2015, including midge larvae, aquatic worms, and snails. The increase in pollution tolerant species could possibly be a result of increased nutrient pollution into the creek (Blanco et al. 2015).

Fisheries:

Before European settlers moved into Yamhill County in the 1800s, the fish populations were higher and more diverse in the Yamhill County Watershed. Log jams created bends, riffles, and pools in rivers, diversifying the habitat. Fish passage barriers such as culverts and dams were non-existent and old-growth forests shaded streams, resulting in cooler water temperatures and greater dissolved oxygen. These factors are beneficial for fish populations and species diversity (Yamhill Basin Council 2001c). Historically Pacific lamprey (*Entosphenus tridentatus*), an anadromous parasitic lamprey, were present in the watershed. They are no longer recognized as a potential species inhabiting Cozine Creek as they had not been reported in the last 100 years (Yamhill Basin Council 2001c).

Despite the expansion of agriculture and urban development beginning in the 1900s numerous native aquatic species potentially could be found in Cozine Creek (ODA 2013). A 1995 fisheries resource inventory using electrofishing techniques was conducted by the Oregon Department of Fish and Wildlife (ODFW). The study found numerous aquatic species in the creek (Table 1.6). All the aquatic species found in the 1995 inventory were native to the Willamette Valley (White 1995). The latest comprehensive fish inventory for Cozine Creek happened more than 20 years ago. Another fish inventory is recommended by ODFW to study the possible correlation between the declining water quality in the creek and fish biodiversity and

abundance, especially since the creek could have changed drastically over the past two decades (ODFW 2010).

Table 1.6: Fish and aquatic invertebrate species likely to be found in Cozine Creek according to the Oregon Department of Fish and Wildlife (White 1995; Giannico et al. 2014).

Common Name	Scientific Name
Reticulate and prickly sculpin	*Cottus sp.*
Speckled dace	*Rhinichthys osculus*
Longnose dace	*Hinichthys cataractae*
Redside shiner	*Richardsonius balteatus*
Threespine stickleback	*Gasterosteus aculeatus*
Northern pike minnow	*Ptychocheilus oregonensis*
Largescale sucker	*Catostomus macrocheilus*
Signal crayfish	*Pacifasticus leniusculus*

The Yamhill County Watershed supports large numbers of anadromous fish species including cutthroat trout (*Oncorhynchus clarki clarki*), winter steelhead trout (*Oncorhynchus mykiss*), and Coho salmon (*Oncorhynchus kisutch*). As mentioned above, these species of salmonids have specific water quality requirements that must be met in order for them to thrive in freshwater habitats. Salmonids in general can only tolerate a maximum water temperature standard of a 7-day average high of 64.4ºF/18ºC. Higher than ten formazin turbidity units (FTU) in a low flow stream like Cozine Creek is detrimental to salmonid physiology and behavior. A flow rate of 20 cm/s is the recommended minimum for migrating salmonid species. Salmonids require a pH range of 6.5 to 8.5 to have optimal egg production and survival. A nitrate level of 2 ppm and ammonia level of 0.2 ppm is the maximum level for most sensitive freshwater species such as Coho salmon. For phosphate, 0.1 ppm is the recommended maximum level in freshwater streams and rivers. Coliform bacteria levels, such as *E. coli*, must remain under 406 per 100 ml of water. When these water quality requirement are not met, salmonid populations suffer (Yamhill Basin Council 2004).

Cutthroat trout are native to the Yamhill basin, including Cozine Creek. They prefer slow moving water with overhanging vegetation. They can spawn in a variety of habitats, including

small headwater streams in the fall and winter (Yamhill Basin Council 2001c). Some cutthroat trout are residential and do not migrate. Currently cutthroat trout are not found in Cozine Creek, possibly because of the creek's elevated water temperatures in the summer and fall, nitrate, and turbidity levels. Major restoration efforts would need to be done, including riparian restoration that would result in gravel accumulation, as well as the removal of juvenile fish passage barriers, before cutthroat trout can reclaim the creek (ODFW 2010).

Winter steelhead trout also are native to the Yamhill Basin. Compared to salmon, populations of steelhead trout are relatively small in the watershed. These began as hatchery releases into the South Yamhill River from 1964 to 1982 to increase populations. The hatchery releases were a success, and steelhead trout populations increased. Steelhead return to spawn in freshwater creeks, like Cozine, in winter and early spring. Unlike many salmonids, they may spawn more than one season. Steelhead trout are unique in that they move further upstream than any other salmonid species. Steelhead trout prefer fast moving water with stream slopes of more than five percent. Steelhead need cool water temperatures and large woody debris. Cozine Creek is technically part of spawning winter steelhead trout habitat, although there have not been any recent documented sightings of them in the creek, possibly due to inadequate spawning gravel, low flow rates, and excess turbidity and nitrate levels (Yamhill Basin Council 2001c; White 1995).

Coho salmon are abundant in the Yamhill County Watershed. In 2014, researchers speculated the Yamhill River Watershed may contain the highest naturalized population of Coho salmon in the Upper Willamette River Watershed (Greater Yamhill Watershed Council 2015). Coho salmon however are not native above the Yamhill Basin. ODFW in the 1950s started a stocking program aimed to establish new Coho salmon runs in the Upper Willamette Valley, including the Yamhill Basin. Coho salmon were released from the 1950s to the 1980s, and they began to establish populations in the South Yamhill River after 1974. Coho salmon releases were discontinued in the 1980s due to concerns that the non-native Coho salmon would outcompete native cutthroat trout and winter steelhead. Coho salmon currently spawn in the Yamhill Watershed from October to January. They prefer gravel bars and upper watersheds with cold clear water. Cozine Creek is technically classified as salmon spawning ground, although no populations of Coho salmon have been documented in the past 20 years in Cozine Creek. This could be because Cozine Creek does not have adequate spawning gravel and has elevated nitrate

and turbidity levels. If spawning habitat is improved and nutrient and sediment pollution decreases, Cozine Creek possibly could be reclaimed as salmon spawning ground (Yamhill Basin Council 2001c).

Fish Passage Barriers:

Fish passage barriers are human-made or natural obstructions that impede the passage of fish (Yamhill Basin Council 2001c). Cozine Creek has numerous fish passage barriers, the majority of them being at road crossings. A medium fish passage barrier is the culvert on Ford Street that crosses Cozine Creek 0.3 miles below Linfield College. The culvert's lower end is submerged in the creek but the upper end has high water velocity, creating a barrier to juvenile fish. Another medium fish passage barrier is located below Elmwood Street and is owned by the City of McMinnville (Yamhill Basin Council 2001c). There is a large culvert acting as a fish passage barrier located under Baker Street above the college and another larger culvert that functions as a fish passage barrier under Davis Street below the property. These two culverts are barriers to juvenile fish during dry summer months when the culvert is not submerged (Yamhill Basin Council 2001c). Fish passage barriers are detrimental to a creek's aquatic biodiversity because they can impede fish movement and migration, lowering the abundance of certain fish populations. Juvenile fish can become trapped if the fish passage barrier is too large for them to get over. Fish passage barriers can block native migratory fish, such as Coho salmon, from their spawning grounds, leading to decreases in population size (ODFW 2015). Further information is available regarding fish species, habitat, and passage barriers in the 1999 Cozine Creek Watershed Assessment (Abel et al. 1999).

CONCLUSIONS AND RECOMMENDATIONS

The area covered by oak woodland and prairie has declined in Willamette Valley. As this habitat shrinks due to agricultural and urban development, animals that rely on large oak woodlands also may begin to disappear. The loss of oak woodlands could result in a decline in animal biodiversity in the Willamette Valley, and may result in the loss of species such as the white-breasted nuthatch and western grey squirrel (Rosenberg and Vasely 2010).

The Cozine Creek property has potential to exist as an oak woodland remnant. Oregon white oak is the second most abundant tree species found on the property and accounts for almost 30% of the entire tree community. While measuring trees, however, we noticed many younger trees including Oregon ash and Douglas-fir growing under and into the canopy of large oaks. We determined Oregon ash on this property grows at least three times faster than the oaks. This is cause for concern because these younger trees could reach the oak trees' height in a few years, shade out the oaks, and cause the oaks to decline and ultimately die (ODFW 2006). This already is happening in several places. The dbh of the cored oak (39.5cm) was similar the average oak dbh (37.3 cm). This suggests the average oak on the property is approximately 150 years old (we counted 142 rings at the dbh height of the cored oak tree; the age could be 10-20 years more). Some of the very large diameter oaks (the dbh for the largest oak was 125.7cm) will be considerably older. The large number and size of the Oregon white oaks on the property, along with the many dead branches and cavities they possess, serve as important habitat to animals that require the species and its attributes (Hagar and Stern 2002). The open canopy of oak habitat allows for the growth of grasses and shrubs, providing ideal habitat for reptiles, shrub nesting birds, and many mammals such as deer (Hagar and Stern 2002 and Oregon Wildlife Institute 2016). The oak habitat is very important. If the college wants to preserve a small but important remnant of the disappearing oak habitat on its campus, we recommend removing some of the understory trees near the large oaks and for facilities to not plant new trees near the oaks.

We found a majority of the white oak trees outside of the floodway, and a majority of the white ash and willow trees within the floodway. This indicates a distinct separation between the oak woodland and riparian habitats found on the property. The location of these riparian species (white ash and willow) is important, especially the ones found right along the creek. The roots of

these trees are essential in stabilizing stream banks, and they also reduce floodwater velocity, which reduce downstream flood peaks (USDA 1996).

The creek itself is potentially suitable habitat for many species of amphibians and is a stable year-round source of water for many animal species. We observed red-bellied newts and pacific tree frogs, but more amphibian species could exist in the area. The water also is important for birds and mammals.

Reptile, amphibian, small mammal, and fish diversity could increase if wildlife corridors were added to reconnect our section Cozine Creek to the upstream and downstream sections, as well as to nearby natural areas. One way to facilitate this would be to restructure the culverts located under Davis and Baker Streets, as well as the rest that block Cozine Creek. This could most easily be done when existing culverts are being modified or upgraded, but would be cost prohibitive to do independently. This would require a major hydrological analysis to ensure the changes did not have major impacts on the current flood zones.

Adding bird and bat houses to the Cozine Creek area may attract more bird species, especially cavity nesters, and bat species. This will increase the biodiversity of the property, increase wildlife sightings on the property, and making the Cozine Creek area an attraction for birders.

We also found approximately two-thirds of the shrubs along the creek bank were non-native, invasive species including Himalayan blackberry, *Rosa multiflora*, and reed canary grass. Vegetation along creek banks is important because it provides many ecological functions. Dense creekside vegetation, along with trees like white ash, provide shade keep the water cool, a requirement for many aquatic species (Yamhill Basin Council 2001a). The vegetative strip also acts as a buffer that helps keep sediment and excess nutrients from running into the stream. Reduced erosion of sediment occurs because the root systems of the woody plants retain soil and take up excess nutrients. As trees along the stream die and fall into the water, pools can be created that provide habitat for fish and amphibians. Fallen leaves provide food for a variety of aquatic organisms (ODEQ 2009). Although we found many invasive plant species along the banks, we also found areas with many native shrub species such as snowberry, chokecherry, willow, and ninebark. Because native vegetation along the creek is an indicator of a healthy, functional riparian zone, we recommend that the invasive shrub species be removed. Areas with

a large component of native shrubs might be able to recover, but other areas that are almost completely covered with invasive species would need to be replanted with native species.

We found many of the tree boles on the property covered with English ivy, an invasive species that is widespread in urban areas in western Oregon. English ivy is detrimental to trees because it grows rapidly to the tree top and shades out the tree's canopy and apical meristems, leading to the decline and ultimately the death of the tree. It also outcompetes and displaces native ground cover (ODA 2016). To preserve present native vegetation and native vegetation to increase in density, we recommend removal of the ivy that is on the Cozine property.

The Cozine Creek property also has a two large and several smaller patches of camas lily, a culturally important and beautiful wildflower in the Yamhill area (Yamhill Basin Council 2001a). This patch of camas is the largest that exists in McMinnville (personal communication Kareen Sturgeon). The areas that contain camas should be a high priority for future restoration efforts. Patches of invasive species (e.g., Italian arum) should be sprayed after the camas has died back and mowing should only be done after the camas has set seed. The camas attracts many people to the area while it is blooming, increasing the value of the property in the eye of the public.

The Cozine property also has many large areas covered by Himalayan blackberry. Future restoration efforts should remove this highly invasive species. However, some neighbors expressed concern about their removal because their presence provided protection of their property. For this reason, any major removal plans, especially along the borders of the college's property, will need to be coordinated with many stakeholders.

Cozine Creek's water quality varies among years and between seasons. The limited water quality studies done by ENVS 385 classes suggest the creek has excess levels of nitrate and high turbidity and water temperature. These studies suggest Cozine Creek is not suitable to host salmonid species despite the creek being classified as salmonid spawning ground. Salmonid species would not be able to establish populations in Cozine Creek because of a lack of gravel needed for spawning, juvenile fish passage barriers, low rate of flow, and elevated water temperature and turbidity. Macroinvertebrate studies have found a preponderance of pollution tolerant species, including aquatic worms and snails. Cozine Creek's PTI for 2013, 2014, and 2015 were all below 10, representing poor water quality.

We would recommend another fish inventory be done in Cozine Creek to see if and how fish biodiversity and abundance has changed since the last one done in 1995. Fish habitat could be improved by the addition of logs or boulders to slow down the flow of water during flooding events. This would allow gravel to accumulate in the creek. However, because of the sewer pipes that are installed under the creek, this could be problematic. Macroinvertebrate counts should be continued in order to track short term, long term, and cumulative effects of stream pollution and water quality changes. Additional water quality monitoring in the spring and fall every year could help track fluctuating water quality measurements in Cozine Creek. The majority of water quality issues for Cozine Creek however are coming from upstream sources, including temperature, turbidity, and pollutants. Improving the creek upstream would help the water quality more than anything we could do in our section. The addition of water quality monitoring and fish inventories upstream will be important first steps in improving the habitat.

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THE SOCIAL CONTEXT

Rachael Gernhart and Reese Yonemura
Chapter Editor: Rachael Gernhart

INTRODUCTION

The history of the Cozine Creek property, as well as the current management practices and uses of the site, as well as concerns and preferences of stakeholders, provide important context for determining the future management of this unique area of campus. This chapter first focuses on the site history and the current uses and management practices associated with the property. We then detail the results of a questionnaire sent to important stakeholder groups in order to better understand the issues and concerns associated with this property. We conclude with sev-eral recommendations for how Linfield College may wish to incorporate stakeholder concerns and preferences into a future management plan for the property.

METHODS

- Historical accounts of Yamhill County, the City of McMinnville, Linfield College and Cozine Creek were gathered from multiple sources of literature including: *Oregon 1859: A Snapshot in Time (2013), and Linfield's Hundred Years (1956).*
- We collected data on uses and stakeholder perceptions and preferences through an emailed questionnaire, or in-person interview (Appendix D).
- We sent a notification letter to abutting homeowners of the Cozine Creek property inviting their questions and involvement in the project (Appendix D).
- Supplementary information for the site history was obtained through the Linfield Archives including documents, newspaper accounts, institutional data and Linfield's Oak Leaves yearbook.
- Maps used in this document were created using GIS data collected by students and additional data layers obtained through the Greater Yamhill Watershed Council and Yamhill County.

INVENTORY AND ASSESSMENT

Land Use History

Yamhill County was named after its original inhabitants, the Yamhill Indians, who lived along the Yamhill River. The tribe, which was a band of the Kalapuya Indians, had a similar culture and lifestyle to other bands of Kalapuya in the Willamette Valley. In 1855, the Yamhill Indians move to the Grand Ronde Reservation, which was supposed to be a temporary reservation, but was later made permanent by President James Buchanan (Marschner 2013).

The town of McMinnville began when John Gordon Baker travelled across a well-worn Indian Trail and crossed a creek and settled down in the area (McMinnville Downtown Association A n.d.). The old Indian Trail ran north and south along what is currently Baker Street and Highway 99, crossing Cozine Creek, (Holmes 1956). Shortly after Baker arrived, William T. Newby, an Oregon Trail emigrant, showed up in 1843 at the age of 24. Newby built his home on a Donation Land Claim that was near the old Indian Trail. Ten years later in 1853, Newby constructed a grist mill after getting permission from the territorial legislature to alter the creek system in McMinnville. He made a ditch, to direct some of the water from Baker Creek to Cozine Creek (Richardson 2010).

Following Newby's arrival, Sebastian C. Adams arrived and helped get the city platted in 1856, and later incorporated in 1876. Adams goal was to build a community, which included building a school for children. Adams decided to not create an ordinary grammar school, but an academy of high school or college status. Newby offered Adams five acres for a school, and later signed a deed for 10 more acres. Linfield College, founded as McMinnville College, was chartered in 1858 (Holmes 1956).

Samuel and Mahala Cozine, (Figure 2.1), had a blacksmith shop near where Linfield College stands today (Richardson 2010). Samuel Cozine was born in Kentucky in 1820. He later headed west to Oregon on a wagon train, where he met Mahala Arthur. The two married in 1845 and bought 640 acres in McMinnville (McMinnville Downtown Association B n.d.). In the 1870s, McMinnville College had reached its capacity and needed more land, and new buildings. The Cozine's offered 20 acres of land, starting at the south edge of town, beginning at the top of the hill beyond Cozine Creek on the Sheridan Road (Figure 2.2). Five more adjoining acres were offered by the widow of Elder Chandler, Ms. Chandler (Holmes 1956). This is the parcel that Linfield College owns which is now referred to as the Cozine Creek property.

Figure 2.1 Samuel and Mahala Cozine (Frank G. Abell n.d.)

McMinnville College was renamed when Frances E. Ross Linfield decided to leave the college her properties, valued at time at more than $250,000. In honor of Mrs. Linfield's husband, Reverend George Fisher Linfield, the college was renamed to Linfield College (Holmes 1956).

In 1902 a footbridge was built across the Cozine Creek Ravine. The original bridge was located in front of Pioneer Hall connecting on the other side of the ravine where Columbus High School was located (Figure 2.2**)**. The earliest photograph we found was taken in 1903 (Linfield College Archives 2012). A new deck and railings were added to the footbridge in 1917 at a cost of $437.50 (McMinnville College Bulletin A 1917).

Figure 2.2 Photograph of Cozine Bridge from town looking at Pioneer Hall (Linfield College Archives 2012).

In the 1930s, as part of landscape improvements, Dwight Miller tore down the bridge and rebuilt an entirely new one. Construction of the second bridge, which did not take place until 1938 when Dr. William G. Everson was elected president of the college, resulted in the bridge moving nearer to the President's house. The President's house and Pioneer Hall are helpful to use as landmarks to understand where the footbridge was located (Holmes 1956). Miller in 1947, replaced the sills and deck of the bridge (McMinnville College Bulletin B 1947). The Cozine Footbridge was considered the main entrance to campus and was also known as Lovers' Lane, as Linfield couples strolled the bridge that crossed the Cozine Ravine (Figure 2.3).

The Oak Leaves yearbooks, from 1920 to 1960, have photographs of students using the area beneath the footbridge in both the fall when it was dry and in the spring when it was

Figure 2.3 Two people cross the Cozine Footbridge, also known as Linfield's Lovers' Lane (Holmes 1956).

flooded. The annual freshmen-sophomore tugs-o-war were often viewed from the Cozine Footbridge and the creek was used as a natural barrier for separating the opposing teams (Figure 2.4). Ultimately, the Cozine Footbridge was costly to maintain, and in the summer of 1960 was torn down (McMinnville College Review 1962). The land and the area below it was converted into a lower campus park in October of 1960 named after Ralph E Storey, Professor of English at Linfield College (Oak Leaves 1960). The large wooden trestle bridge was replaced with the current

smaller concrete foot bridge, which is often underwater during the winter due to annual flooding (Linfield faculty member, personal communication 2016; Hollenbeck et. al 2013).

Figure 2.4 Annual Tug of War during homecoming festivities in 1947 between the freshmen and sophomore classes, Cozine Creek (Linfield Magazine 2008).

Linfield College purchased the property that Columbus School was built on. The school opened in 1892 at the corner of South Cowls and Baker Street in McMinnville. The school was rebuilt twice on its first location at the corner of Southeast Cowls and Baker Street. The last building at its original site was made of brick and masonry, but was destroyed by the March 1993 Scotts Mills magnitude 5.6 earthquake (Thomas et. al 1996). The earthquake occurred during spring break when students were away. The school was no longer deemed safe and the building was torn down in January 1995 (City of McMinnville, n.d.; Wang 2014). Further inspection the property revealed that the land was at one time a landfill and is currently considered unsafe to build on (Linfield faculty member, personal communication 2016).

Lands adjacent to the stream historically included wet oxbows and standing water. Many of these valuable wetlands along Cozine Creek no longer exist. "Aerial photographs taken in 1994 show the ghostly contours of the oxbows that are now drained," (Empfield 2001). In hilly areas road construction often follows streams since it is the path of least resistance. To prevent

streams and creeks from undercutting roads and infrastructure, bank stabilization, or channel hardening is created (Empfield 2001). Cozine Creek, where Baker Street crosses, was not always channeled through a culvert as it is today. At one point it was a bridge held up by concrete pil-

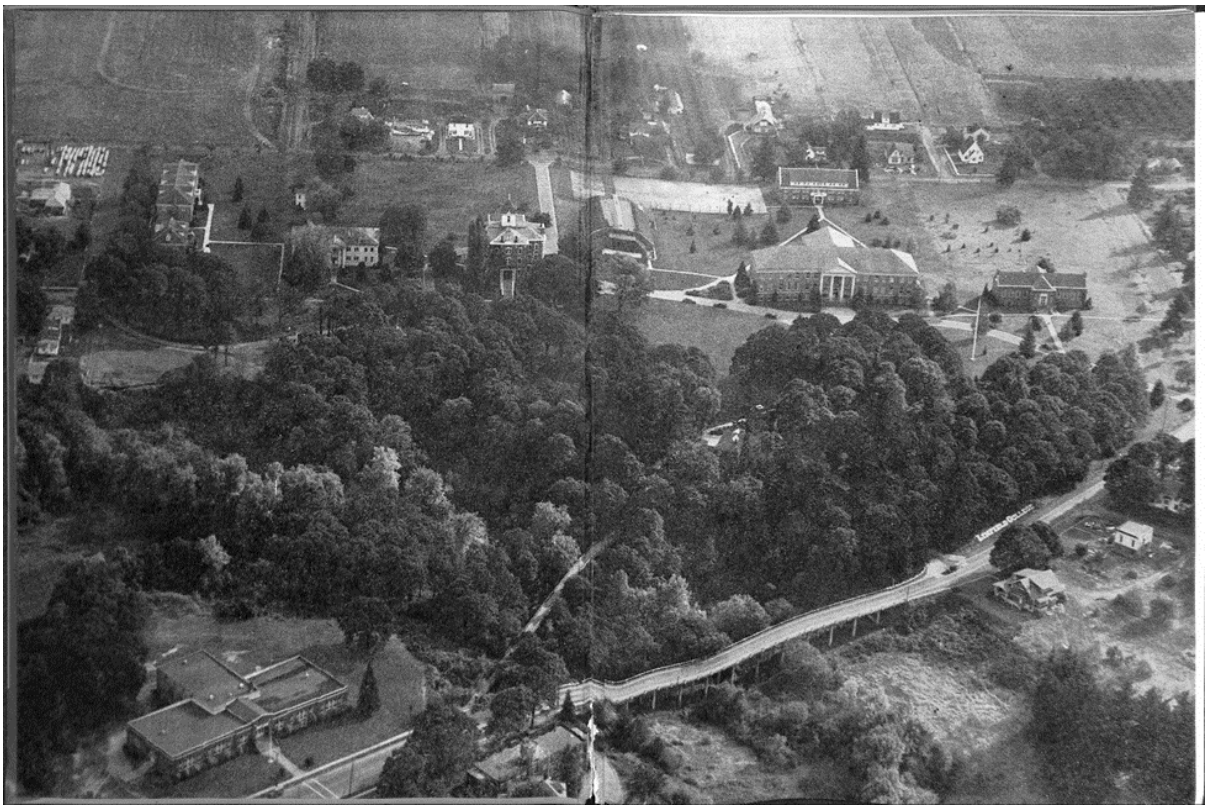

Figure 2.5 An aerial photograph of Linfield College, Columbus School (lower left corner), and the Baker Street bridge over Cozine Creek. Also, slightly visible is the footbridge over the Ravine (Oak Leaves, 1946).

lars, and the street was one lane going in each direction (Figure 2.5). This structure allowed water and wildlife to pass through underneath. At some point in the 1950's the roadway was widened to two lanes in each direction and the bridge was replaced with a cement culvert that has limited the movement of water and wildlife along the creek.

Current Uses and Management Regime

Currently, the Cozine site is contained between two artificial berms that function supports the roadways. On the western end the creek enters through a culvert below SE Baker Street. and exits through a pipe on the eastern end below SE Davis Street (Figure 2.6). According to faculty stakeholders there was a problem with sewage in the 1990s and as a result a new sewer line was

put in to improve the water quality (Linfield faculty member, personal communication 2016).

Figure 2.6 The 100 year Flood Zone and Floodway

The property is frequently flooded in the winter and spring and water is able to escape through a large culvert just below the top of the eastern berm below Davis Street. This overflow culvert is reinforced on both ends by stone barricades wrapped in wire (Figure 2.7). In addition to the flow through the western culvert, storm water is introduced to the site through five drainage pipes. Two pipes, one below the President's house and another below Baker Street, terminate at the south western corner of the property and flow into a stone weir wrapped in wire. The water then enters Cozine Creek below the Baker Street culvert (Figure 2.8). The third pipe drains at the southern edge of the site and intersects a path before dispersing into a field flowing down towards the creek. The fourth pipe enters along the western edge north of the culvert and flows down a channel following the edge of the site to the creek. The fifth pipe drains directly into the creek downstream of the pedestrian bridge.

Figure 2.7 Eastern overflow culvert at end of the Cozine Creek property underneath berm. Photograph by Professor William Fleeger 2016.

Lighting has been placed along the path between campus and Baker St. The lamp poles seem to have been constructed with the understanding that flooding of the site is relatively common, and have been elevated on concrete pillars near the creek. The site also contains nine access points for a sewer main that runs east to west across the property. It should be noted that the manhole covers are bolted down and are likely sealed. According to Oregon building code, plumbing systems are required to be above flood elevation. However, an exception is made if the system is designed to resist the hydrodynamic and hydrostatic forces associated with flooding (OPSC 2014).

Many Linfield College classes utilize the Cozine Creek property for educational purposes. Science students test the DO, flow, temp, pH, set up transects and quadrates to measure trees, practice basic scientific methods and observe the environment to sample vegetation. In addition, they bring back samples of water to the classroom to test for turbidity, bacterial counts,

Figure 2.8 Culvert at Western end of property. Photograph by Rachael Gernhart 2016.

including enteric bacteria such as E coli., salmonella, aeromonas and fecal coliforms, nitrate, ammonia and phosphate. In addition, a bird watching tours go through the Cozine Creek property (Linfield faculty member, personal communication 2016).

Linfield College Facilities frequents the property to make sure the paths are clear. They also mow twice a year. They use to mow more frequently, but now efforts are being put toward protecting the camas lilies. Facilities is also managing the blackberries through the use of herbicides and manual cutting. They are also slowly trying to remove the English ivy, particularly patches near paths. College Public Safety uses Cozine Creek paths to conducts regular patrols on the property (Linfield staff member, personal communication 2016).

Both campus and community members use this area as an access route to and from town. There are also transients that occasionally occupy parts of the property and evidence of transient camping is observable along the creek. In addition to transients, Linfield College students have

also been caught by campus security engaging in illegal activities on the former Columbus School Lot (Linfield College A 2015).

Stakeholders

A questionnaire was sent to 136 people representing four different stakeholder groups. The stakeholder groups we identified were Linfield College Administration, faculty and staff, students and external stakeholders, which included the City of McMInnville and non-profit conservation organizations such as the Greater Yamhill Watershed Council. Twenty five individuals responded (n=25) resulting in an overall response rate of 18% (Table 2.1).

Table 2.1 Questionnaire Response Rates by Stakeholder Group

Stakeholder Group	Number of Questionnaires	Number of Respondents	Response Rate
External Stakeholders	13	3	23%
Staff and Faculty Stakeholders	37	11	30%
Students Stakeholders	83	9	11%
Administration Stakeholders	3	3	100%
TOTAL	136	n = 25	18%

In response to open ended questions asked in the questionnaire, several administrative stakeholders indicated that they were unfamiliar with the property. Administrators expressed concern about illegal activity and inappropriate use of the property. Administrative stakeholders were supportive of using the property for educational purposes, but expressed a concern about maintaining the privacy of the president's residence.

Faculty and staff stakeholders identified drainage and flooding issues as a concern because this limits the potential restoration of the site. A few individuals in this group thought increasing foot traffic on the property would contribute to illegal activity or damage wildlife habitat. Close to 50% of respondents in this stakeholder group mentioned that the college does not seem to value the property, or consider it part of the campus. For example, one faculty/staff

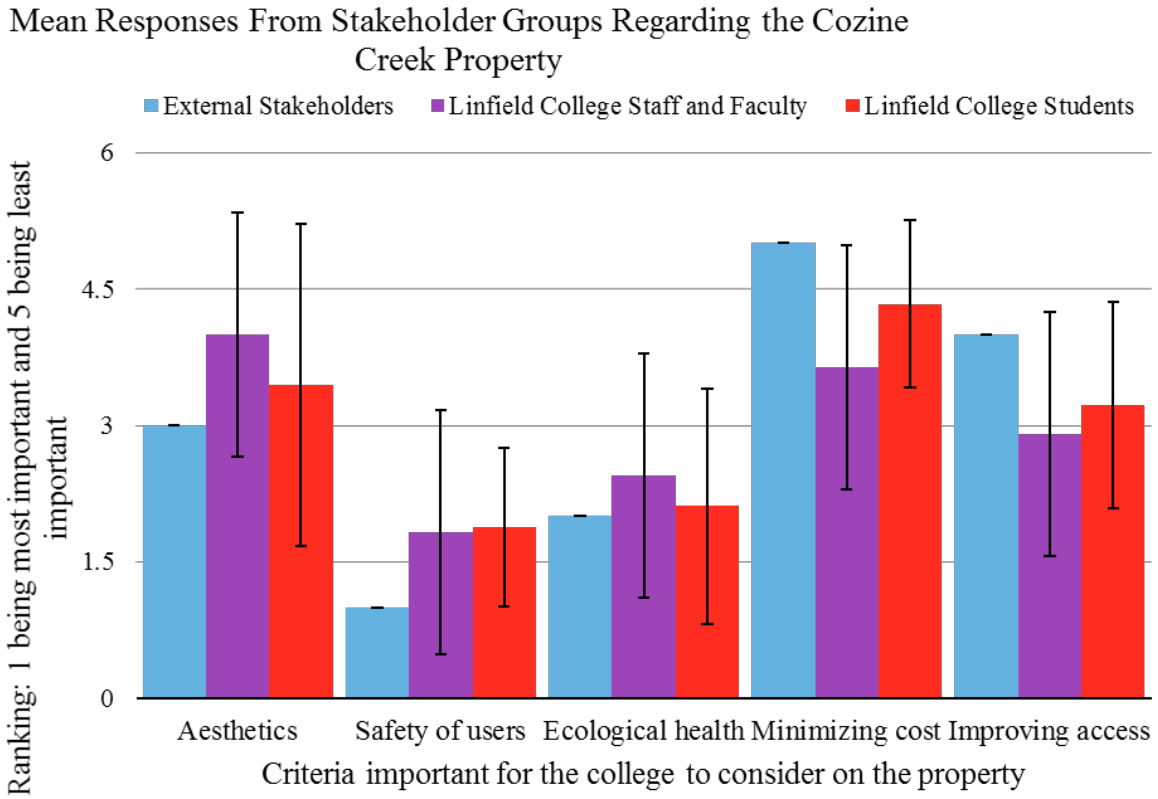

Figure 2.9 Mean responses from stakeholder groups regarding the Cozine Creek property.

stakeholder said "Given the college's stated priorities in sustainability, I do think the college should be willing to spend some money to maintain/improve the ecological health of a creek that runs through our property." Nearly half the faculty and staff stakeholders mentioned the homeless and transient problem on the site and a concern about safety. One faculty member stated, "I wouldn't want students working down there alone." Invasive plant removal was mentioned by eight respondents, and concerns were high regarding the blackberry and ivy; however, a two respondents made opposing arguments about the blackberry serving as habitat to wildlife and as a buffer zone to the property. In addition, most stakeholders in this group wanted better and/or more walking paths, more native plants and less trash being dumped. Several staff and faculty stakeholders recommend building various structures, including adding lighting, putting in signage, building larger structures, such as amphitheater, laboratory or classroom, adding art projects, and building another footbridge. Nearly all of the staff and faculty stakeholders recognized

the sites potential for educational purposes. Several faculty noted in their responses that the property is already used extensively by classes.

Student stakeholders frequently mentioned safety concerns, and several recommend more lighting and College Public Safety patrols. For example one student commented that "I wouldn't feel safe going there alone" and another stated that "I've seen some sketchy people there." Invasive plants were also mentioned, including blackberry and ivy and signage was recommended to reclaim the property as Linfield's. Student stakeholders also mentioned a concern about illegal activity, a lot of trash, and water quality/pollution problems on the property; however, students still believed it was a potential selling point for the college. Three students mentioned that Linfield College neglects the property. One student commented that "I feel like the area is a bit neglected by the college. I for one feel that the college is over-groomed if anything, but I still feel that the property needs some love."

In the open ended questions, the External stakeholders mentioned a concern about fire danger during the summer months and the use of the property by transients. This group mentioned an interest in adding walking trails that would run east and west through the property.

In response to a question asking stakeholders to rank order criteria the college should consider when making decisions about the site, three stakeholder groups, Linfield College faculty and staff, students and External, identified safety as the most important concern of the Cozine Creek property (Figure 2.9). The second most important topic of concern for these three stakeholder groups was improving the ecological health of the property.

Recommendations:

The first recommendation is to make the property safer because safety of students should be priority number one for the college. As noted by the rank order question and by all the opened ended question responses, safety is the most important concern on the Cozine Creek property. All four stakeholder groups were concerned with homeless camps, transients and safety on the property. The safety and homeless problem can potentially be solved if the college better manages the property. The staff, faculty and students feel the college has neglected the property. This could be related to the difference in maintenance this site gets compared to the rest of the campuses more maintained property. The campus is large, Cozine Creek is nearly 30 acres on its own, which means is important to keep communication open with facilities while addressing a

potential management plan. Potential solutions could include adding more lights, remove excess and unwanted venation, and add signage to reclaim ownership. In addition, at the moment, the college campus map does not include the Cozine Creek property. Adding the property and the paths to the map is one step in reclaiming ownership and associating the college with its property.

The second recommendation is to improve the ecological health, as that was the second most important concern for the property in the rank order question across three of the stakeholder groups. Future management actions need to consider the different views on the desirability of removing all of the invasive species, particularly the removal of blackberry bushes, because some stakeholders have mentioned their significance for wildlife habitat and also aid in privacy. Realistically, as some stakeholders noted, this property has extreme limitations due to the land fill that prevents major structures from being built, and that the property is a naturally prone to flooding. A concern some stakeholders had were the costs in restoring the property. The costs of restoration could be addressed by involving students in the process. For example, the college has classes, such as the ENVS 090 class (a class only for volunteering), the Linfield Day of Service that takes place every year, a large student body involved in Greek Life (all of which need community service hours), Circle K and more that are already in place at Linfield and capable of managing and restoring the property.

The third recommendation would be for future classes to get the community involved in restoring Cozine Creek. Linfield College only owns a portion of the creek and it would be great to get more of the creek restored. Two possible places to start would be to contact the City of McMinnville and focus on the area upstream, all the way to City Park, from Linfield College. In addition, reach out to neighbors that have property near the creek, both upstream and downstream from the college, and try and involve the community in helping restore the entire creek.

In the end, as many stakeholders noted, it would be in the college's best interest to create a safer, more ecologically sound area, one that provides educational opportunities to students and the greater McMinnville community. There is no downside in making this property safer, or attempting to reclaim ownership of the Cozine Creek property. Other college campuses have done similar restoration work, including George Fox University and Reed College. Both projects involved the students on campus, the faculty and staff, the city, and administrator's cooperation, but in the end the property and surrounding areas saw major ecological improvement. Hopefully

Linfield College could act as an example for other institutions or organizations looking to improve the ecological health of their property.

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APPENDIX A

Vegetative Study on the Trees, Shrubs, and Herbaceous Plant Species found on Cozine Creek Property for the Spring of 2016

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INTRODUCTION

Linfield College owns a section of property along Cozine Creek. This property, the subject of this project, is located at the north end of the Linfield College campus in McMinnville, Oregon is the Cozine Creek property owned by the college. Bordered by Highway 99W on the northern and western edges, Davis Street to the east, and the Linfield College campus to the south, this property is unique in that it hosts a combination of white oak savanna and wetland/riparian habitats. The property has steep edges and is approximately cut in half by Cozine Creek, which runs eastward through the center. This site is used mainly for flood mitigation during the rainy winter and spring months, therefore, vegetation, wildlife, and management are limited to flood-resistant species and techniques (Yamhill Basin Council 2001a).

Historically, the influence of oak savanna and wetland/riparian habitats around the Cozine Creek property has shaped this site into a unique area dominated by a variety of species. Dominant vegetation found in oak savanna habitats is Oregon white oak (*Quercus garryana*), and often in conjunction with Pacific madrone (*Arbutus menziesii*), black cottonwood (*Populus trichocarpa*), and red alder (*Alnus rubra*), with poison oak (*Toxicodendron diversilobum*) in the understory (Yamhill Basin Council 2001a).

The Cozine Creek property also is located in a wetland/riparian zone. Dominant vegetation in wetland/riparian zones is black cottonwood and willow, with some regions containing Oregon white ash (*Fraxinus latifolia*) and red alder in the understory. A special riparian species present at the Cozine Creek site is camas lily (*Camassia quamash*), a staple in the Kalapuyan diet. At present, much of the oak savanna and wetland/riparian habitats in the Willamette Valley are now restricted to wildlife refuges and small protected areas due to conversion of the surrounding area to urban areas, pasture, agricultural fields, and vineyards.

Major invasive species in the area include Himalayan blackberry (*Rubus discolor*), reed canarygrass (*Phalaris arundinacea*), a native until it hybridized with cultivars, and rose (*Rosa multiflora*). Invasive species are important to note because they often outcompete and displace native species (Yamhill Basin Council 2001a).

This project provides a detailed inventory of the vegetation found on the Cozine Creek property owned by Linfield College. Trees, shrubs, and herbaceous species were investigated to determine species composition and diversity at the site. The major goal of this vegetative inventory was to focus on tree species composition and diversity. Both of these habitats have been found to characterize the area surrounding Cozine Creek. Because the Cozine Creek property is located within oak woodland and riparian habitats, I expected to find Oregon white oak and Oregon white ash the dominant tree species. I also expected to find other tree, shrub, and herbaceous species commonly associated with oak savanna and riparian habitats as well, including Pacific madrone, black cottonwood, red alder, white ash, poison oak, big leaf maple, Douglas-fir, and grand fir. Since oak savannas and wetland/riparian habitats have been declining over the past several decades, characterizing the Cozine property as either or both of these could potentially grant the site higher priority for restoration and preservation efforts (Yamhill Basin Council 2001a).

Another goal of this project was to determine the presence and abundance of any major invasive species at the site, including Himalayan blackberry, rose (*Rosa multiflora*), and reed canary grass, and any sensitive species, including camas lily. Understanding the species composition and diversity of the site's vegetation will be useful in understanding the ecological health of the site and creating a baseline of diversity to compare against after any future restoration efforts (Yamhill Basin Council 2001a).

METHODS

Trees:

Trees with a dbh (diameter at breast height; 1.37 m above ground) greater than or equal to 20 cm were inventoried. The 20 cm dbh limit was used in order to include as many trees as possible without being overwhelmed with numerous small saplings. Every tree meeting this requirement was identified to species and tagged with an identifying aluminum tree tag. For each tree measured, we recorded the species, tag number, dbh (in cm), whether it was alive or dead, as

well as any special visible attributes such as cavities, splits, broken branches, beaver chew, etc. Dbh was measured using a 5m dbh tape (The Ben Meadows Co. Model 30366). The location of each tree was determined and recorded using a hand held GPS unit (Garmin Model: etrex VISTA HCx). The species and their GPS coordinates were mapped using GIS to analyze the spatial distribution of all trees, as well as particular species of interest.

Shrubs and Herbaceous Species:

All shrub and herbaceous plants on the site were identified to the most specific taxa possible and compiled into a list. Woody shrubs were included on the list with tree species, and herbaceous species were included on their own list. Due to time constraints, we did not take as detailed of measurements as we did with the trees (GPS location, abundance, etc). However, boundaries of areas with a high density of Himalayan blackberry or camas lilies were mapped using GIS to determine areas of high concern or special interest for future restoration efforts.

We also measured percent of non-native plant species along the creek banks. We used an Opti-Logic Insight 400 LH Pro Laser Rangefinder (Model 285260) to measure the linear distance along the creek bank of areas of differing dominant plant species and then estimated percent that was non-native. Using the distances and percentage of non-native we recorded, we calculated an estimated percentage of non-native plant species abundance along the creek banks.

RESULTS

We found the most common tree on the Cozine Creek property was Oregon white ash followed by Oregon white oak (Figure 1.1). Tree species comprising less than 5% of the community are represented in the 'Other' category. Tree species in the 'Other' category include big leaf maple, cherry, coastal redwood, black cottonwood, hawthorne, ponderosa pine, western red cedar, black walnut, English walnut, incense cedar, apple, black locust, china fir, Engelmann spruce, Oregon myrtlewood, plum, red alder, sweet gum, sycamore, and tulip. The presence of Oregon white oak with Oregon white ash and poison oak in the understory is indicative of Oregon white oak prairie habitat, which historically dominated the habitat surrounding the property (Yamhill Basin Council 2001a). We also found willow, black cottonwood, and red alder on the property. These species and the dominant Oregon ash trees are indicative of a

riparian/wetland habitat. Historically, this habitat has also been found to surround the Cozine Creek property (Yamhill Basin Council 2001a).

Approximately 87% of the measured trees on the property were native, but we also observed many non-native, ornamental tree species that accounted for about 13% of the trees measured. These were most likely planted by Linfield College's Facilities Services. Forty-six percent of the total number of woody plant species on the property were native, 52% were exotic, and 13% were invasive including Himalayan blackberry and *Rosa multiflora*. Of the total number of herbaceous plant species, we found 40% were native, 53% were exotic, and 15% were invasive including Italian arum, English ivy, and creeping jenny. Some woody plant and herbaceous species were counted in more than one category. Invasives are important to note because they displace native species.

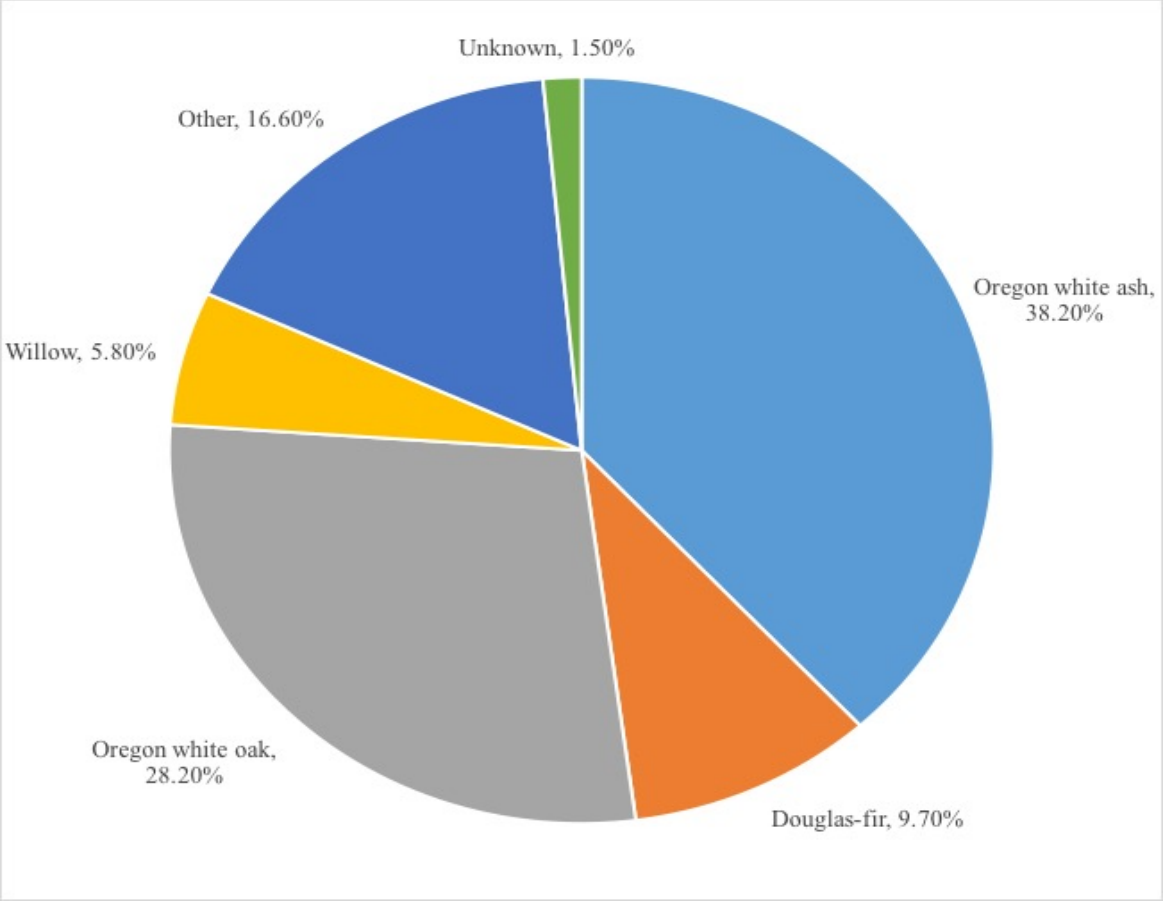

Figure 1.1: Tree species abundance on Linfield College's Cozine Creek Property. Trees with multiple trunks were counted as a single individual.

The mean dbh of the most abundant tree species (Oregon ash) was 37.3 cm (Table 1.1). The mean dbh of the second most abundant species (Oregon white oak) 66.1 cm. However, the

total dbh for ash trees on the property was 4814.3cm, whereas the total dbh for oak trees was 6215.2cm. This indicates that Oregon white oak is the most dominant tree species. The species with the largest dbh was incense cedar, however, it was represented by only two individuals, one of which was the largest tree measured.

We also analyzed tree cores from one Oregon white oak tree and five Oregon ash trees to determine the average age and growth rate of the two species. We found the five cored Oregon ash trees on the property had grown more than three times faster over the last ten years than the single cored Oregon white oak. We found it took 100 years for the cored oak to grow 10 cm in dbh, whereas it only took at about 20 years for each cored ash to grow 10 cm in dbh. The dbh of the cored oak was 39.5cm and the tree was determined to be at least 142 years old. The average dbh of the five cored ash trees was 29cm and we only counted up to 37 years for the oldest ash cored. The ash trees should be at least 10-20 years older. This information shows how much faster the ash trees grow compared to the oaks. There were some ash trees in the understory of some large oaks on the property, which is concerning because they could quickly outgrow the oaks, shade them out, and eventually kill them (ODFW 2006).

Table 1.1: Abundance of trees that were measured and tagged. Mean dbh (standard deviation) for each species is listed. Species are listed by decreasing abundance

Tree species: *Scientific name* (common name)	Number of individuals measured	Average dbh (cm) and (standard deviation)
Fraxinum latifolia (Oregon ash)	131	37.32 (17.508)
Quercus garryana (Oregon white oak)	92	66.12 (21.176)
Pseudotsuga menziesii (Douglas-fir)	31	56.10 (33.763)
Salix sp. (willow)	27	27.60 (12.759)
Acer macrophyllum (big leaf maple)	16	44.81 (19.019)
Sequoia sempervirens (coastal redwood)	12	31.78 (8.695)
Prunus sp. (cherry)	7	26.31 (8.357)
Thuja plicata (western red cedar)	6	27.65 (18.706)
Populus trichocarpa (black cottonwood)	5	95.60 (51.763)
Pinus ponderosa (ponderosa pine)	3	20.70 (3.686)
Crataegus monogyra (English hawthorne)	2	27.05 (6.859)
Cunninghamia lanceolata (China fir)	2	24.10 (1.838)
Calocedrus decurrens (incense cedar)	2	111.20 (188.370)
Umbellularia californica (Oregon myrtlewood)	2	16.40 (1.838)
Pyrus malus (apple)	1	42.70
Robinia pseudoacacia (black locust)	1	45.40
Juglans nigra (black walnut)	1	48.30
Catalpa sp. (catalpa)	1	26.00
Picea engalmanii (Engelmann spruce)	1	20.60
Juglans regia (English walnut)	1	39.60
Crataegus douglasii (black hawthorne)	1	35.00
Oemleria cerasiformis (Indian plum)	1	30.70
Alnus rubra (red alder)	1	49.10
Liquidambar styraciflua (sweet gum)	1	41.80
Platanus occidentalis (sycamore)	1	72.70
Liriodendron tulipifera (tulip tree)	1	34.20

Approximately 87% of the measured trees on the property were native, but we also observed many non-native, ornamental tree species that accounted for about 13% of the trees measured including China fir, catalpa, and Russian olive (Table 1.2). These were most likely

planted by Linfield College's Facilities Services who manage the property. Forty-six percent of the total number of woody plant species on the property were native, 52% were exotic, and 13% were invasive including Himalayan blackberry and *Rosa multiflora.*

Table 1.2: Woody plant species observed in the Cozine Creek Property and identified as native, exotic, or invasive. Taxonomy and native/exotic/invasive status came from Hitchcock and Cronquist 1973, Pojar and MacKinnon 1994, Jensen et al. 2015, and Oregon Department of Agriculture 2016.

Scientific name **(common name)**	**Native (N), Exotic (E), or Invasive (I)**
Abies grandis (grand fir)	N
Acer circinatum (vine maple)	N
Acer macrophyllum (big leaf maple)	N
Aesculus hippocastanum (horse chesnut)	E, I
Alnus rubra (red alder)	N
Amelanchier alnifolia (Pacific serviceberry)	N
Arbutus menziesii (madrone)	N
Calocedrus decurrens (incense cedar)	E (native to east of Cascades and southern Oregon)
Camellia japonica (camellia)	E
Catalpa sp. (Catalpa)	E
Cornus stolonifera var. occidentalis (creek dogwood)	N
Corylus sp. (filbert)	unknown
Crataegus douglasii (black hawthorne)	N
Crataegus monogyra (English hawthorne)	E
Cunninghamia lanceolata (China fir)	E
Eleagnus angustifolia (Russian olive)	E
Fraxinum latifolia (Oregon ash)	N
Ilex aquifolium (English holly)	E, I
Juglans nigra (black walnut)	E
Juglans regia (English walnut)	E
Liquidambar styraciflua (sweet gum)	E
Liriodendron tulipifera (tulip tree)	E
Lonicera sp. (honeysuckle)	E
Oemleria cerasiformis (Indian plum)	N
Physocarpus capitatus (ninebark)	N
Picea engalmanii (Engelmann spruce)	N
Pinus ponderosa (ponderosa pine)	N
Pinus sp. (pine)	unknown
Platanus occidentalis (American sycamore)	E
Populus trichocarpa (black cottonwood)	N
Prunus cerasifera (thundercloud plum)	E
Prunus laurocerasus (English laurel)	E, I
Prunus sp. (cherry)	E, I
Prunus virginiana (chokecherry)	N
Pseudotsuga menziesii (Douglas-fir)	N
Pyrus malus (apple)	E
Quercus garryana (Oregon white oak)	N
Rhododendron sp. (rhododendron and azalea hybrids)	E
Robinia pseudoacacia (black locust)	E, I
Rosa multiflora (rose)	E, I
Rubus discolor (Himalayan blackberry)	E, I
Rubus laciniatus (evergreen blackberry)	E
Rubus ursinus (trailing blackberry)	N
Salix sp. (willow)	N and E
Sequoia sempervirens (coastal redwood)	E (native to southern Oregon and California)
Spiraea douglasii (Douglas spirea)	N
Symphoricarpos albus (snow berry)	N
Thuja plicata (western red cedar)	N
Toxidocendron diversilobum (poison oak)	N
Umbellularia californica (myrtlewood)	E (native to southern Oregon coast and California)
Vaccinium ovatum (evergreen blueberry)	N
Virbunum xbodnantense (Dawn)	E
Yucca filimentosa (yucca)	E

Of the total number of herbaceous plant species (54), we found 40% were native, 53% were exotic, and 15% were invasive including Italian arum (*Arum italicum*), English ivy (*Helix hedera*), and creeping jenny (*Lysimachia nummalaria* (Table 1.3)*)*. Some woody plant and herbaceous species were counted in more than one category. Invasives are important to note because they displace native species.

Table 1.3: Herbaceous plant species observed on the Cozine Creek Property and identified as native, exotic, or invasive. Taxonomy and native/exotic/invasive status came from Hitchcock and Cronquist 1973, Pojar and MacKinnon 1994, Jensen et al. 2015, and Oregon Department of Agriculture 2016.

Scientific name (common name)	Native (N), Exotic, (E), and/or Invasive (I)
Achillea millefolium (yarrow)	N
Ajuga reptans (bugleweed)	E
Allium sp. (onion)	unknown
Arum italicum (Italian arum)	E, I
Bellis perennis (English daisy)	E
Camassia quamash (common camas)	N
Cardamine occidentalis (bitter cress)	N
Carex sp. (sedge)	unknown
Cirsium arvense (Canada thistle)	E
Cirsium vulgare (bull thistle)	E
Colvolvulus arvensis (morning glory)	E
*Conium maculatum (*poison hemlock*)*	E, I
Daucus carota (Queen Anne's lace)	E
Galium aparine (bedstraw; cleavers)	N
Geranium molle (dovefoot geranium)	E
Geranium robertianum (herb Robert)	E, I
Geum macrophyllum (large leaf avens)	N
Hedera helix/H. hevernica (English ivy)	E, I
Hyacinthoides hispanica (wood hyacinth)	E
Hypochaeris radicata (false dandelion)	E
Juncus effuses (common rush)	N
Lapsana communis (nipplewort)	E
Lathyrus latifolius (peavine; sweet pea)	E, I
Ligusticum sarmentosa (parsley leaved lovage)	E
Lysimachia nummalaria (creeping jenny)	E, I
Melissa officinalis (lemon balm)	E
Muscari armeniacum (grape hyacinth)	E
Nandina domestica (heavenly bamboo)	E
Narcisuss pseudonarcisuss (daffodil)	E
Phalaris arundinacea (reed canary grass)	N but has hybridized with E; considered I
Phoradendron flarescens (mistletoe)	N
Plantago lanceolata (English plantain)	E
Polypodium glycyrrhiza (licorice fern)	N
Polystichum munitum (sword fern)	N
Prunella vulgaris (self heal)	E
Pteridium aquilinum (bracken fern)	N
Ranunculus repens (creeping buttercup)	E
Rumex occidentalis (dock)	N
Rumex sp. (thin leaved dock)	unknown
Scippus microcaupus (small-flowered Bulrush)	N
Smilacina racemosa (false Soloman seal)	N
Smilacina stellate (star flower Soloman seal)	N
Solanum dulcamara (bittersweet nightshade)	E
Tanacetum vulgare (tansy)	E
Taraxacum officinale (dandelion)	E
Tellima grandiflora (fringe cup)	N
Thalictrum occidentale (meadow rue)	N
Trifolium pretense (purple clover)	E
Trillium ovatum (trillium)	N
Veratrum californicum (false hellebore)	N
Veronica serphyllifolia (veronica)	N
Veronica americana (American brooklime)	N
Vicia sp. (vetch)	unknown
Vinca major (periwinkle)	E, I
Viola glabella (little yellow wood violet)	N

We also examined each measured tree for special visible attributes as best we could from the ground (e.g., beaver chew, cavities, broken branches, boles covered in English ivy, etc) and

found that most of the 362 trees had no special attributes. The major feature recorded was trees with boles covered in English ivy, which may result in recommendations for restoration.

We analyzed the distribution of trees species on the property with respect to the floodplain status (Figure 1.2). A distinction, however, was found in examining tree distribution in the floodway, which is defined as "a channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height" (FEMA 2016). The majority of Oregon white oak trees were not in the floodway, whereas the majority of the ash trees were within it. This indicates a separation between the oak woodland habitat and riparian habitat found on the property.

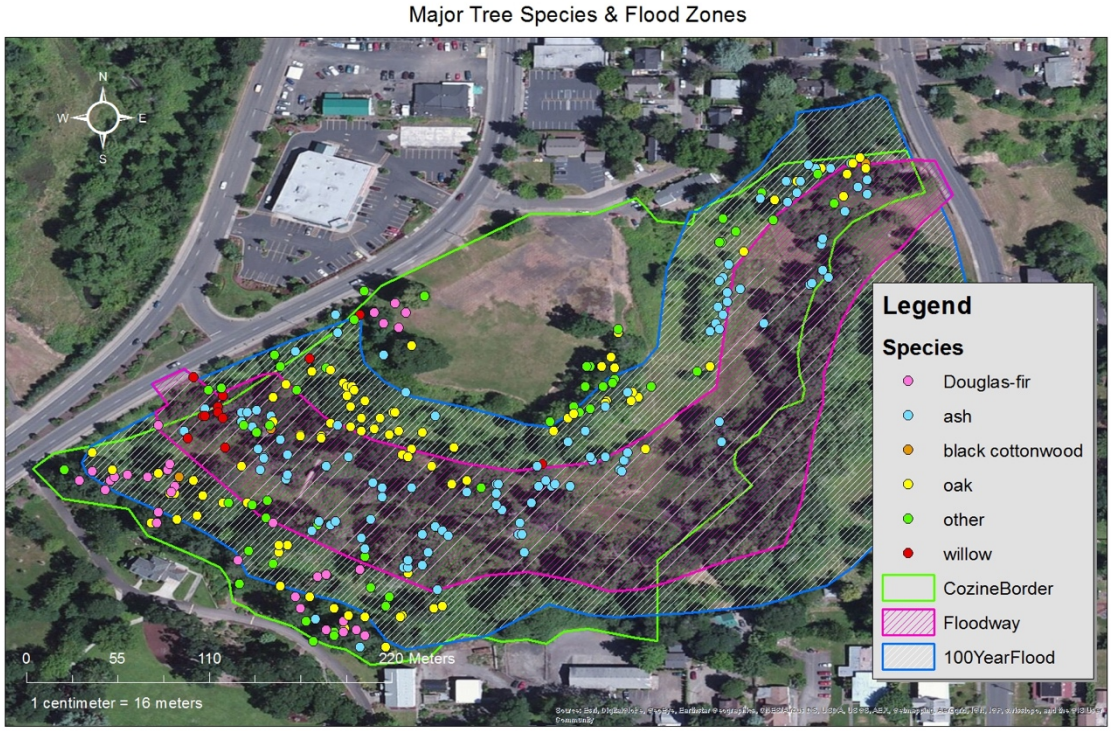

Figure 1.2: GIS map of location of trees >20cm dbh relative to floodplain (made by Reese Yonemura)

We noticed some Douglas-fir and ash trees growing under some of the large oaks outside of the floodway. This is concerning because the ash trees on this property are growing at three times the rate of the oaks and Douglas-fir is also a rapid growth tree species. Such young trees

could quickly outgrow and shade out the large oaks eventually leading to the oaks' death (ODFW 2006).

We mapped areas with significantly high densities of two species of concern: *Camassia quamash* (a culturally significant species that also is a beautiful wildflower) and *Rubus discolor* (a highly invasive species in the Willamette Valley) (Figure 1.3). There are two large patches and two smaller patches of *Camassia quamash* on the northern bank of the creek, covering an area of approximately 2,500m^2, approximately 2% of the property area. This is good because this riparian species is culturally important because it was a staple in the Kalapuyan diet (Yamhill Basin Council 2001a). This flower also attracts people down to the property, which makes the property more important in the public eye. Areas with a high density of *Rubus discolor* were found along the southern border of the property and along the creek banks. The total area of the property covered by *Rubus discolor* was about 27,600m^2, almost 25% of the entire property area. This is concerning because this species is highly invasive and outcompetes native vegetation in the Willamette Valley (ODA 2016).

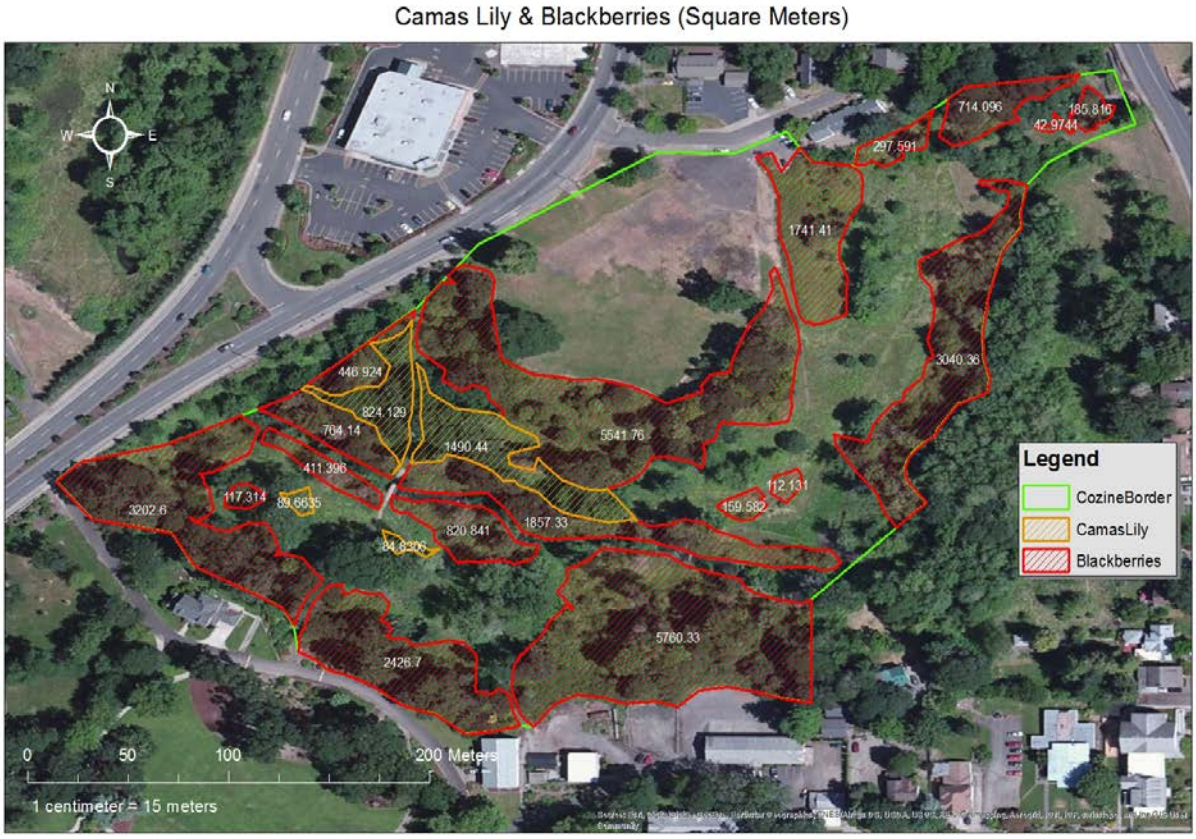

Figure 1.3: GIS map of significant patches of camas lily (*Camassia quamash*) and Himalayan blackberry (*Rubus discolor*) located on the Cozine Creek property (made by Reese Yonemura)

We also estimated and analyzed the percent cover shrub species along the creek bank. We estimated two-thirds of the bank was covered by non-native plant species. All the non-native species found along the banks were also invasive species (e.g., Himalayan blackberry (*Rubus discolor*), rose (*Rosa multiflora*), and reed canary grass (*Phalaris arundinacea*)). However, many native plant species were also prevalent along the banks including creek dogwood (*Cornus stolonifera* var. *occidentalis*), willow (*Salix* sp.), snowberry (*Symphoricarpos albus*), Douglas spirea (*Spiraea douglasii*), chokecherry (*Prunus virginiana*), and ninebark (*Physocarpus capitatus*).

DISCUSSION

The Cozine Creek property has potential to exist as a high quality oak woodland remnant. Oregon white oak was the second most abundant tree species, that had the greatest total dbh, making it the dominant tree species on the property. We also found some black cottonwood and poison oak in the understory, other species commonly associated with oak woodlands (Yamhill Basin Council 2001a). A majority of the oaks were located within the 100-year flood plain, but outside the limits of the wetter floodway zone, which is where coast range oak woodlands are usually found (ODFW 2006a).

A major characteristic of oak woodlands is a relatively open canopy and understory dominated by shrubs, grasses, and wildflowers (ODFW 2006a). During sampling, we noticed some younger trees including Oregon ash and Douglas-fir growing under large oaks. An analysis of the oak and ash tree cores indicated that the ash trees on the property were growing at least 2-3 times faster than the oak. This is concerning because fir encroachment is an important limiting factor in oak woodlands. Firs will shade out mature oaks and seedlings as well as other native shade intolerant plants. Due to shading by encroaching firs and other tree species, densely stocked regenerating oaks often do not develop important open-grown structures including lateral limbs, cavities, and high acorn crops that are important for animals (ODFW 2006a). To preserve and restore existing and potential oak woodlands, maintaining a relatively open canopy and understory is important.

Oak woodlands are consistently found in much drier environments throughout Oregon, but they also occur in wetter regions. In the Willamette Valley, oaks are commonly found in a mosaic of prairies, oak savannah, and riparian habitats across the valley floor and on low

elevation slopes (ODFW 2006a). We found that Oregon ash was the most abundant tree species found on the property, and found some black cottonwood, big leaf maple, red alder, and willow in the understory. A majority of the Oregon ash trees were located within the floodway of the property. These species and their location relative to the floodplain are indicative of a riparian zone (Yamhill Basin Council 2001a).

We found a majority of the Oregon ash trees and willows within the floodway in close proximity to the creek. Vegetation along the creek banks, like these ash and willows along with dogwood (*Cornus stolonifera*), chokecherry (*Prunus virginiana*), Douglas spirea (*Spirea douglasii*), snowberry (*Symphoricarpos albus*) and ninebark (*Physocarpus capitatus*), is very important for riparian habitats as it provides a variety of ecological functions including shade to cool the water, a vital requirement for many aquatic species (Yamhill Basin Council 2001a). This vegetative strip also serves as a buffer that helps keep sediment and excess nutrients from entering the creek. Reduced erosion occurs because the root systems of the woody plants retain soil and take up excess nutrients. As trees along the stream die and fall into the water, pools can be created that provide habitat for fish and amphibians. Fallen leaves provide food for a variety of aquatic organisms (ODEQ 2009).

A large percentage of wetlands in the Willamette Valley have been lost or degraded due to invasive species including reed canary grass, purple loosestrife (*Lythrum salicaria*), and Japanese knotweed (*Fallopia japonica*) (ODFW 2006b). About two-thirds of the vegetation along the creek banks of Cozine Creek was invasive, consisting of mainly Himalayan blackberry and *Rosa multiflora* with some reed canary grass. Himalayan blackberry and *Rosa multiflora* are prevalent in riparian and wetland zones in western Oregon (ODA 2016; State of Oregon 2016). Invasive species impact riparian zones and wetlands by displacing native vegetation and altering water flow and storage function (ODFW 2006b). Although we found many invasive plant species along the banks, we also found areas with many native shrubs including Douglas spirea, snowberry, choke cherry, willow and ninebark. Native vegetation along the creek is an indicator of a healthy, functional riparian zone. We recommend that the invasive shrub species be removed. Areas with a large component of native shrubs may be able to recover on their own if the invasives are removed, but other areas that are almost completely covered with invasive species would need to be replanted with native species.

We also found areas with high densities of Himalayan blackberry along the southern border of the property. The total area of the property covered by Himalayan blackberry was about 27,600m^2, almost 25% of the entire property area. However, some neighbors that expressed concern about blackberry removal because they believed their presence provided protection of their property. For this reason, any major removal plans, especially along the borders of the college's property, will need to be closely coordinated with many stakeholders.

Approximately 25% of tree boles measured on the property were covered in English ivy, a widely distributed invasive species in western Oregon. English ivy is detrimental to trees because it grows rapidly to the tree top where it shades out the tree's canopy and apical meristems, leading to the decline and ultimately the death of the tree. It also outcompetes and displaces native ground cover. This fast-growing species can also make trunks heavier. This is detrimental during storms because heavier trunks and branches will break easier, which could ultimately lead to tree death (ODA 2016).

The Cozine Creek property also has two large and several smaller patches of camas lily, a culturally important and beautiful wildflower in the Yamhill area (Yamhill Basin Council 2001a). This patch of camas is the largest that exists in McMinnville (personal communication with Corine Sturgeon). The areas that contain camas should be a high priority for future restoration efforts. Patches of invasive species (e.g., Italian arum) should be sprayed after the camas has died back and mowing should only be done after the camas has set seed. The camas attracts many people to the area while it is blooming, increasing the value of the property in the eye of the public.

Overall, approximately 87% of the tree species, 46% of the number of woody plant species, and 40% of the number of herbaceous plant species were native. Over half the number of woody plant and herbaceous plant species were exotic anbutd less than 20% of those were invasive. Our results indicate the presence of oak woodland and riparian habitats on the Cozine Creek property. Also, the species associated with these habitats are located where they are commonly found in the Willamette Valley relative to the property's floodway. We recommend that this property be restored and managed to fulfill its potential to provide high quality remnants of both a oak woodland and a riparian habitat by focusing mainly on releasing large oak trees, removing invasive plant species, and replacing them with native vegetation.

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APPENDIX B

Wildlife Assessment of the Cozine Creek Property Analysis Spring 2016

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INTRODUCTION

The Cozine Creek natural area has remnants of oak woodland and riparian habitat that is capable of supporting many species of wildlife. Oregon white oak (*Quercus garryanna*) trees, the second most abundant tree on the Cozine Creek property, provide valuable animal habitat. Large, mature oaks often contain cavities and have large dead branches that provide homes for rodents and birds including voles, woodpeckers, and white-breasted nuthatches. The acorns produced by oak trees feed many species including raccoons, squirrels, and black-tailed deer. Oak trees also host several species of epiphytes, including lichens and mistletoe (*Viscum album*), which provide food for animals including bluebirds (Rosenberg and Vasely 2010).

The riparian area, as well as open areas under oaks, allows the growth of shrubs and grasses. Shrubs provide homes for edge adapted bird species including the black-headed grosbeak (Hagar and Stern 2002). Although there are many native shrubs, including creek dogwood (*Cornus stolonifera* var. *occidentalis*) and snowberry (*Symphoricarpos albus*), there are also some invasive shrubs including Himalayan blackberry (*Symphoricarpos albus*). Himalayan blackberry provides habitat for many birds, mammals, and rodents. Rodents and birds feed on the plant's berries, whereas black-tailed deer feed on the new leaves (Bennett 2007). Black-tailed deer also enjoy grassy areas for browsing for food (Bennett 2007). Oregon white ash (*Frazinus latifolia*) provides food for deer in the form of seedlings and sprouts as well as food and shelter for beaver and nutria, the latter of which is an invasive species in Oregon (Niemic et al. 1995). Mammals like raccoons and deer use riparian areas because they provide a dependable source of water (ODFW 2016a). The riparian zone on the Cozine property

could support several amphibian and reptile species. Open grassy locations provide areas where reptiles can bask in the sun (Oregon Wildlife Institute 2016).

METHODS

- Linfield College students, faculty, administrators, and staff have collected bird data by sight and call over many years. Much of the data reported here is from a Linfield College Principle of Biology laboratory exercise, bird watching excursions by Dr. Tom Love, and reported sightings made by members of our class this spring. The Principle of Biology (BIOL 211) class has observed bird foraging behavior at feeders for one week each spring beginning in 2010. All the birds viewed by staff and students were recorded. Dr. Tom Love began recording avian observations by sight and call beginning in 2007 during walks in the Cozine Creek area. In addition, several members of the faculty, staff, and students have observed and heard birds this spring during the ENVS 485 creek visits.
- Mammal data includes observations of sightings, tracks, bones, and beaver chew made by Linfield College students, faculty, administrators and staff, beginning in 2010.
- Reptile and amphibian data includes observations by Linfield College students, faculty, administrators, and staff. Linfield students in ENVS 495 also searched for amphibians and reptiles on February 25 and March 1 2016 by turning over rocks and logs, though none were found.

RESULTS

Birds:

Of the 106 bird species expected in nearby habitat similar to Cozine Creek (Miller Woods), 54 have been observed on the property (Table 1). All 54 bird species are listed as species of least concern (The Cornell Lab of Ornithology). Six of these species prefer to live in oak habitat while two species are shrub nesting (Hagar and Stern 2002).

Table 1: Expected bird species (Soil and Water Conservation District 2016). Species observed on the Cozine Creek property are in bold.

Mallard duck *(Anas platyrhynchos)*
Ring-necked duck *(Aythya collaris)*
Hooded Merganser *(Lophodytes cucullatus)*
Turkey Vulture *(Cathartes aura)*
Great-blue heron *(Ardea Herodias)*
Green heron *(Butorides virescens)*
Spotted Sandpiper *(Actitis macularius)*
Belted kingfisher *(Megaceryle alcyon)*
Northern Harrier *(Circus cyaneus)*
Sharp-shinned hawk *(Accipiter striatus)*
Cooper Hawk *(Accipiter cooperii)*
Rough-legged hawk *(Buteo lagopus)*
American kestrel *(Falco sparverius)*
Merlin *(Falco columbarius)*
Pheasant *(Phasianus colchicus)*
Wild turkey *(Meleagris gallopavo)*
Ruffed grouse *(Bonasa umbellus)*
Killdeer *(Charadrius vociferous)*
Common snipe *(Gallinago gallinago)*
California quail *(Callipepla californica)*
Mountain quail *(Oreortyx pictus)*
Eurasian collared dove *(Streptopelia decaocto)*
Mourning dove *(Zenaida macroura)*
Band-tailed pigeon *(Patagioenas fasciata)*
Rock pigeon *(Columbia Livia)*
Barn owl *(Tyto alba) ?*
Short-eared owl *(Asio flammeus)*
Great-horned owl *(Bubo virginianus)*
Barred Owl
Western screech owl *(Megascops kennicottii) ?*
Northern pygmy owl *(Glaucidium gnoma*)
Rufous hummingbird *(Selasphorus rufus)*
Anna hummingbird *(Calypte anna)*
Northern flicker *(Colaptes auratus)*
Acorn woodpecker *(Melanerpes formicivorus)*
Red-bellied sapsucker *(Melanerpes carolinus)*
Downy woodpecker *(Picoides pubescens)*
Hairy woodpecker *(Leuconotopicus villosus)*
Olive-sided flycatcher *(Contopus cooperi)*
Pacific Slope Flycatcher *(Empidonax difficilis)*
Western wood pewee *(Contopus sordidulus)*
Willow flycatcher *(Empidonax traillii)*
Spotted towhee *(Pipilo maculatus)*
Chipping sparrow *(Spizella passerine)*
Savannah sparrow *(Passerculus sandwichensis)*
Fox sparrow *(Passerella iliaca)*
Lincoln's sparrow *(Melospiza lincolnii)*
Song sparrow *(Melospiza melodia)*
White-crowned sparrow *(Zonotrichia leucophrys)*
White-throated sparrow *(Zonotrichia albicollis)*
Golden-crowned sparrow *(Zonotrichia atricapilla)*
Dark-eyed junco *(Junco hyemalis)*
Lazuli bunting *(Passerina amoena)*
Western meadowlark *(Sturnella neglecta)*
Red-winged blackbird *(Agelaius phoeniceus)*
Brewers blackbird *(Euphagus cyanocephalus)*
Brown-headed cowbird *(Molothrus ater)*
Black-headed grosbeak *(Pheucticus melanocephalus)*
Evening grosbeak *(Coccothraustes vespertinus)*
House finch *(Haemorhous mexicanus)*
Purple finch *(Haemorhous purpureus)*
Pine siskin *(Carduelis pinus)*
American goldfinch *(Spinus tristis)*
Lesser goldfinch *(Spinus psaltria) ?*
Ruby-crowned kinglet *(Regulus calendula)*
Common nighthawk *(Chordeiles minor)*
European starling *(Sturnus vulgaris)*
House sparrow *(Passer domesticus)*
Pacific-slope flycatcher *(Empidonax difficilis)*
Cassin's Vireo *(Vireo cassinii)*
Hutton's Vireo *(Vireo huttoni)*
Warbling Vireo *(Vireo gilvus)*
Scrub jay *(Aphelocoma californica)*
Steller's jay *(Cyanocitta stelleri)*
American crow *(Corvus brachyrhynchos*)
Common raven *(Corvus corax)*

Cliff swallow *(Petrochelidon pyrrhonota)*
Tree swallow *(Tachycineta bicolor)*
Violet-green swallow *(Tachycineta thalassina)*
Vaux's swift *(Chaetura vauxi)*
Black-capped chickadee *(Poecile atricapillus)*
Chestnut-backed chickadee *(Poecile rufescens)*
Common Bushtit *(Psaltriparus minimus)*
Brown Creeper *(Certhia Americana)*
White-breasted nuthatch *(Sitta carolinensis)*
Red-breasted nuthatch *(Sitta canadensis)*
House wren (*Troglodytes aedon)*
Winter wren *(Troglodytes hiemalis)*
Western bluebird *(Sialia Mexicana)*
Swainson's Thrush *(Catharus ustulatus)*
Hermit Thrush *(Catharus guttatus)*
Varied Thrush *(Ixoreus naevius)*
American Pipit *(Anthus rubescens)*
American robin *(Turdus migratorius)*
Cedar waxwing *(Bombycilla cedrorum)*
Orange-crowned warbler *(Vermivora celata)*
Yellow-rumped warbler *(Setophaga coronate)*
Black-throated grey warbler *(Setophaga nigrescens)*
Townsend's warbler *(Setophaga townsendi)*
Hermit warbler *(Setophaga occidentalis)*
MacGillivray's warbler *(Geothlypis tolmiei)*
Wilson's warbler *(Cardellina pusilla)*
Common yellow throat *(Geothlypis trichas)*
Western tanager *(Piranga ludoviciana)*
Bewick's wren *(Thryomanes bewickii)*
Marsh wren *(Cistothorus palustris)*

Mammals:

Eleven of the expected 42 mammal species have been observed on the Cozine Creek Property. All of the identified species are common in the Pacific Northwest and are not threatened species (ODFW 2016a).

Table 2: Expected mammal species (Soil and Water Conservation District 2016). Species observed on the Cozine Creek property are in bold. Some mammals, like squirrels and bats, have yet to be identified to species.

Trowbridge shrew *(Sorex trowbridgii)*
Moles—species uncertain
Coast mole *(Scapanus orarius)*
Bats—species uncertain
Townsend's mole *(Scapanus townsendii)*
Hoary bat *(Lasiurus cinereus)*
Big brown bat *(Eptesicus fuscus)*
California myotis bat *(Myotis californicus)*
Townsend's big-eared bat *(Corynorhinus townsendii)*
Brush rabbit (*Sylvilagus bachmani)*
Mountain beaver *(Aplodontia rufa)*
Flying squirrel *(Pteromyini)*
Townsend's chipmunk *(Tamias townsendii)*
Douglas squirrel *(Tamiasciurus douglasii)*
Beechey's ground squirrel *(Otospermophilus beecheyi)*
Dusky-footed woodrat *(Neotoma fuscipes)*
Bushy-tailed woodrat (Neotoma cinerea)
Camas pocket gopher (*Thomomys bulbivorus*)
Mazama pocket gopher *(Thomomys mazama)*
Deer mouse *(Peromyscus)*
Gray-tailed vole *(Microtus canicaudus)*
Townsend's vole *(Microtus oregoni)*
Creeping vole *(Microtus oregoni)*
Red-backed vole *(Myodes)*
Pacific jumping mouse *(Zapus trinotatus)*
Porcupine *(Erethizon dorsatum)*
Coyote (*Canis latrans)*
Raccoon *(Procyon lotor)*
Striped Skunk *(Mephitis mephitis)*
Possum—species uncertain
Short-tailed weasel *(Mustela ermine)*
Bobcat *(Lynx rufus)*
Beaver *(Castor Canadensis)*
Nutria *(Myocastor coypus)*
Black tailed deer *(Odocoileus hemionus)*
Roosevelt Elk *(Cervus canadensis roosevelti)*
House mouse *(Mus musculus)*
Black rat *(Rattus rattus)*
Eastern grey squirrel *(Sciurus carolinensis)*
Eastern Fox Squirrel *(Sciurus niger)*
Red squirrel *(Tamiasciurs hudsonicus)*
Western grey squirrel *(Sciurus griseus*
(Squirrel species uncertain)

Amphibian and Reptiles:

Three of the expected 26 reptile and amphibian species were observed on the Cozine Creek property. Red-bellied newts, pacific tree frogs, and garter snakes, all of which are common in the Pacific Northwest (Oregon Wildlife Institute 2016) were observed.

Table 3: Expected amphibian and reptile species (Soil and Water Conservation District 2016). Species observed on the Cozine Creek property are in bold.

Amphibians:
Red bellied newt *(Taricha rivularis)*
Western red-backed salamander *(Plethodon vehiculum)*
Long-toed salamander *(Ambystoma macrodactylum)*
Dunn's salamander *(Plethodon dunn)*
Northwestern salamander *(Ambystoma gracile)*
Clouded salamander *(Aneides ferreus)*
Rough skinned Newt *(Taricha granulosa)*
Ensatina *(Ensatina eschscholtzii)*
Pacific tree frog (*Pseudacris regilla)*
Northern red-legged frog *(Rana aurora)*
Foothill yellow-legged frog *(Rana boylii)*

Reptiles:
Northern Alligator Lizard *(Elgaria coerulea)*
Southern Alligator Lizard *(Elgaria multicarinata)*
Western fence lizard *(Sceloporus occidentalis)*
Western skink *(Plestiodon skiltonianus*)
Rubber boa *(Charina bottae)*
Western racer *(Coluber constrictor)*
Sharp-tailed snake *(Contia tenuis)*
Ring-necked snake *(Diadophis punctatus)*
Gopher snake *(Pituophis catenifer catenifer)*
Western terrestrial garter snake *(Thamnophis elegans)*
Northwestern garter snake *(Thamnophis ordinoides)*
Common garter snake *(Thamnophisirtalis)*
Western rattlesnake *(Crotalus oreganus)*
Western pond turtle *(Actinemys marmorata)*
Western painted turtle *(Chrysemys picta)*

DISCUSSION

Oak woodland habitat is very important to both resident and migratory bird species. Many of the bird species observed on the Cozine Creek property have a preference for oak woodland including mourning doves, white-breasted nuthatches, acorn woodpeckers, downy woodpeckers, and American goldfinches (Hagar and Stern 2002). The avian species of greatest concern is the white-breasted nuthatch. This species depends on large diameter white oak trees for habitat and feeds partially on acorns. As the Willamette Valley continues to shift from oak to coniferous forest, this avian species continues to decline in abundance (Hagar and Stern 2002). Other bird species found in the Cozine area are dependent on cavities for nesting include western screech owls, northern flickers, acorn woodpeckers, red-bellied sapsuckers, downy woodpeckers, pacific slope flycatchers, violet-green swallows, black-capped chickadees, chestnut-backed chickadees, white-breasted nuthatches, red-breasted nuthatches, and Bewick's wrens. Shrub nesting bird species found on the Cozine property include song sparrows, Brewer's blackbird, American goldfinches, and common yellowthroats (The Cornell Lab of Ornithology 2016).

The mammals observed in Cozine Creek included raccoons, striped skunks, deer mice, black-tailed deer, nutria, moles, squirrels, and bats. Most of these animals are very common throughout the United States (ODFW 2016a). The Oregon Department of Fish and Wildlife lists California *Myotis* bats, Townsend's big-eared bats, and western grey squirrels as sensitive species (species a of conservation interest in the Willamette Valley) due to the decline of oak habitat (ODFW 2016c), however we have not identified bats and squirrels to species yet. Western grey squirrels depend on Oregon white oak for habitat and acorns for food. Their populations will drastically decline if oak woodlands continue to be destroyed and invasive Eastern grey squirrels that thrive in coniferous environments will become more prominent in the Willamette Valley (ODFW 2016b). Better identification of the mammals on our site would be important.

The Cozine Creek area is great habitat for black-tailed deer. The Cozine Creek area has many shrub species (e.g., choke cherry, creek dogwood, Himalayan blackberry, and poison oak) that black-tailed deer browse upon, a creek from which they can drink, and trees where they can find shelter (Bennett 2007). Black-tailed deer sightings and

tracks show black-tailed deer are taking advantage of this habitat. Both beaver chew and a beaver carcass were found in the Cozine Creek area. Beavers live in wooded riparian zones such as the Cozine Creek property. Their preferred food and housing material are cottonwood and willow (ODFW 2016a), both of which are found on the Cozine property, but not in large quantities. Beavers will consume white oak and Oregon ash, but they are not their preferred species. The fact that the beaver did not live may be due to a lack of adequate preferred species. After the beaver carcass was found, no new beaver chew was found, suggesting that there may be no more beavers on the Cozine Creek property. The one that was found may have washed in during a flooding event.

Nutria, an invasive species (Niemic et al. 1995) have been observed on the Cozine Creek property. Nutria can be very damaging in both natural and urban areas. They burrow into banks of streams and rivers, which can cause serious erosion and often leads to collapsing streambeds and roadways. Nutria forage for food and will dig up roots, crops, lawns, and garden plants (ODFW 2016a).

Few reptiles and amphibians have been observed at the Cozine Creek property. We have only seen the Pacific tree frog, red-bellied newt, and a garter snake. All of these species are widely dispersed throughout the Pacific Northwest (ODFW 2016a). The low numbers of amphibians and reptiles may be due the poor connectivity of the Cozine area that prevents escape from flooding events, fertilizer and pollution run-off from Baker Street, and culverts under Baker and Davis Streets that may hinder movement of aquatic species. The culverts under Cozine Creek limits the connectivity reptiles could use to move in to and out of the property. The number of amphibians and reptiles also may be limited by the annual flooding events that occur in winter and spring (Burbink et al. 1998).

CONCLUSIONS

Although the Cozine Creek property does not consist of pristine oak or riparian habitat, it still attracts many species of wildlife, especially birds. The property provides ideal habitat for cavity nesters and birds that depend on large oak trees, especially the white-breasted nuthatch. Other cavity nesting species such as acorn woodpeckers have been observed benefiting from the large oak trees and cavities present on the Cozine

Creek property. The open canopy habitat on the Cozine Creek property also supports shrub nesters such as song sparrows, because shrubs do not grow well in close canopy forests. As upland oak forests continue to shrink in the Willamette Valley, shrub nesters and cavity nesters are at risk at being lost in this area. The Cozine Creek property is a moderate habitat for mammals. It may, depending on the identification of species, support animals dependent on oak habitat, including the western grey squirrel. The Cozine Creek property is an ideal habitat for species including black-tailed deer, and stripped skunks. However, the flooding events and poor connectivity of the property make it a poor habitat for mammals including beavers. The presence of nutria may also cause erosion of the banks of Cozine Creek. The Cozine Creek property is a poor habitat for reptiles and amphibians, due to the presence of culverts, poor connectivity, and flooding.

RECCOMONDATIONS

Reptile, amphibian, small mammal, and fish diversity could increase if wildlife corridors were added to reconnect our section Cozine Creek to the upstream and downstream sections, as well as to nearby natural areas. One way to facilitate this would be to restructure the culverts located under Davis and Baker Streets, as well as the rest that block Cozine Creek. This could most easily be done when existing culverts are being modified or upgraded, but would be cost prohibitive to do independently. This would require a major hydrological analysis to ensure the changes did not have major impacts on the current flood zones.

Adding bird and bat houses to the Cozine Creek area may attract more bird species, especially cavity nesters, and bat species. This will increase the biodiversity of the property, increase wildlife sightings on the property, and making the Cozine Creek area an attraction for birders.

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APPENDIX C

Watershed Function, Creek Hydrology, Fish and Fish Habitat, and Comparative Water Quality Analysis Between Spring 2011, 2015, and 2016 for Cozine Creek

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INTRODUCTION

Cozine Creek is a stream 11.3 miles long that mostly flows in Yamhill County and slightly in Polk County. The creek is heavily modified by culverts, piping, and irrigation. Cozine Creek is located in the Lower Yamhill Watershed, part of the Yamhill River Basin in the northwestern Willamette Valley. The creek is one of two major streams in the western Lower Yamhill Watershed, the other being the South Yamhill River. The Yamhill Watershed is 63,747 acres and the majority of the watershed is located in Yamhill County (Yamhill Basin Council 2001).

Cozine Creek is an urban stream that experiences petrochemical pollution and toxic heavy metals from nearby roads, including stormwater runoff from Baker Street and fertilizer and pesticide contamination from lawns and gardens. The Yamhill Watershed that the creek is located in is especially polluted from fertilizer and pesticides from agricultural and urban activities. In 1998 the city of McMinnville sampled water quality in Cozine Creek in preparation for an upcoming stormwater master plan. The city discovered abnormally high levels of fecal coliform bacteria and nitrogen. Nitrogen levels were highest where Cozine Creek entered the city from agricultural lands (Yamhill Basin Council 2001). In 2009, a broken sewer pipe discharged into the stream, leading to higher than allowable amounts of *E. coli* contamination. This pipe was fixed and bacteria levels dropped (ODA 2013).

Cozine Creek is monitored by the state under government regulations and guidelines. The Oregon Department of Environmental Quality (ODEQ) produces an integrated report every two years that is sent to the EPA to meet requirements of the Clean Water Act. The creek's water quality is compared to the total maximum daily load (TMDL). TMDL is the calculated amount of pollutants a water body can receive and still meet Oregon water quality standards (ODEQ 2012a). The latest ODEQ water quality assessment from 2012 declared that Cozine Creek and

the South Yamhill River needs to have further assessments done to measure and monitor certain water quality parameters that are detrimental to a healthy aquatic ecosystem. The parameters of concern were dissolved oxygen, temperature, and bacteria. The South Yamhill River and Cozine Creek also were listed as at risk for pH, nutrients, sediments, toxins, and chlorophyll. ODEQ declared Cozine Creek and the South Yamhill River were severely degraded by high levels of bacterial contamination and high temperatures. These factors are causing the most concern regarding stream health (ODEQ 2012b). Further information about Cozine Creek water quality and water condition evaluations is available in the Cozine Creek watershed assessment conducted in 1999 (Abel et al. 1999a; Abel et al. 1999b).

Additional assessments of Cozine Creek's water quality have been conducted to study the water quality of the creek. The Environmental Science Research Methods (ENVS 385) classes from spring 2011 to fall 2015 have conducted water sample tests and fieldwork at Cozine Creek. The classes compared Cozine Creek to local rural streams (Mill and Gooseneck Creeks) to determine the differences rural and urban settings have on freshwater streams. They found that Cozine Creek had the poorest water quality. The creek had low levels of dissolved oxygen and high levels of *E. coli*, *Aeromonas*, *Salmonella*, and other coliform bacteria. The creek also had low pH levels and flow rates (Colahan et al. 2011). The fall 2015 class also found Cozine Creek had the poorest water quality. Cozine Creek had the lowest pH and dissolved oxygen, and the highest temperature, biochemical oxygen demand (BOD), turbidity, phosphate, *Aeromonas*, and other coliform bacteria levels (Blanco et al. 2015). Cozine Creek again was tested in spring 2016, and the data was compared to past years to determine if and how its water quality changed over the past five years.

Additional past water quality studies have been performed by the Yamhill Basin Council. A 2003/2004 report concluded that Cozine Creek was above the maximum temperature 7-day average of 18°C. The creek in 2003 and 2004 also was above the maximum recommended turbidity levels of 10 FTU, although it did fall in the recommended pH range of 6.5 to 8.5. For bacteria, *E. coli* levels in 2003 and 2004 were above the recommended levels of 406 cells per 100 mL (Yamhill Basin Council 2004).

Cozine Creek is part of the Yamhill Watershed that is host to numerous salmonid species and other aquatic life. Despite its location, the creek is fraught with problems that make it unsuitable for healthy aquatic life, including excess amounts of bacteria and warm water

temperatures (Yamhill Basin Council 2001). In order to understand how the water quality of Cozine Creek impacts aquatic life, an assessment of the creek's water quality variables was conducted. Cozine Creek's water quality variables from spring 2011 were compared to water quality variables from fall 2015 and spring 2016. In addition, water quality variables from Cozine Creek when it was flooding in early March 2016 were compared to water quality variables in late March 2016 when the creek level had dropped. These comparisons were important to see if and how the creek's water quality changes over time and what specific pollution sources are the most worrisome. The results also were important to help us understand how a creek's water quality variables change during a flooding event. By knowing the status of Cozine Creek's water quality, we can start to assess how the creek affects its local aquatic organisms, how recent flooding and stormwater leakage events have impacted the creek and its aquatic life, and how future restoration efforts can be made to improve the water quality of the creek.

Site Description:

Samples were collected from four sites on Cozine Creek on March 10th and March 31st, 2016 (Figure 3.1). The temperature on March 10th was 46°F, and the weather was rainy. Cozine Creek was swollen due to heavy rainfall in the week before sampling. The week of March 10th had approximately 2.61 inches of rain. The temperature on March 31st was 58°F and the weather was clear and sunny. The week before March 31st had an average total rainfall of 0.03 inches (Weather Underground 2016). Four sites were chosen along Cozine Creek, spanning from U.S. 99 to Davis Street. Site 1 was located on a shallow, storm water, side stream running into Cozine Creek approximately 10 meters from the bridge over U.S. 99. The stream was approximately one meter wide and the stream's bottom was covered with large sharp rocks. Site 2 in this study was at site 3 in the 2015 ENVS 385 sampling sites on Cozine Creek. For a site description refer to the ENVS 385's site description for site 3 (Blanco et al. 2015). Site 3 in this study was located at site 2 in the 2015 ENVS 385 sampling sites on Cozine Creek. For a site description refer to the ENVS 385's site description for site 2 (Blanco et al. 2015). Site 4 was located on Cozine Creek just before it flowed into a concrete culvert that travels under Davis Street. Site 4 was approximately four meters wide, flooding into a nearby grass field to the east. The creek banks were eroded and muddy with some woody debris.

Figure 3.1: GIS map of ENVS 385 fall 2015 (red dots) and ENVS 485 spring 2016 (green dots) water sample sites for Cozine Creek (made by Reese Yonemura)

METHODS

We measured Cozine Creek's temperature (ºC), depth, pH, flow rate, turbidity, ammonia, phosphate, and nitrate levels, and *E. coli*, *Aeromonas*, *Salmonella*, and other coliform bacteria populations using methods described in the ENVS 385 Research Methods water quality assessment from 2015 (Blanco et al. 2015).

RESULTS

When we compared this year's data from March 10 and March 31 to that collected in spring 2011 and fall 2015, nitrate was significantly higher on 3/31/16 than in spring 2011 and *Aeromonas* and other coliforms significantly lower (Table 1). The pH, flow, *Aeromonas*, and

other coliforms were significantly lower in fall 2015 than spring 2011, and temperature and phosphate was significantly higher. Temperature and phosphate levels were significantly lower on 3/10/16 than in fall 2015, and turbidity, flow, and nitrate were significantly higher. Turbidity was significantly lower on 3/31/16 than 3/10/16, and pH was significantly higher.

Table 3.1: Mean (standard deviation) for water quality variables at Cozine Creek for spring 2011, fall 2015, March 10th, 2016, and March 31st, 2016. Probability was computed using ANOVA; Means with different letters are significantly different from one another according to the Tukey HSD Connecting Letters Report. Recommended levels are from the Yamhill Basin Council 2004 and the EPA 2015.

	Spring 2011	Fall 2015	3/10/2016	3/31/2016	P-value	Recommended levels of freshwater water quality variables
pH	7.41 (0.153) A	7.18 (0.040) B	7.23 (0.181) B	7.47 (0.029) A	< .0001	6.5-8.5
Flow (cm/s)	31.7 (33.6) A	3.00 (4.41) B	29.5 (10.6) A	19.7 (16.4) A	< .0001	20 cm/s minimum
Temperature (°C)	12.8 (2.53) B	16.6 (0.687) A	10.5 (1.68) C	11.6 (0.899) BC	< .0001	18°C maximum
Turbidity (FTUs)		9.49 (4.05) B	259 (155) A	0 (0) B	< .0001	10 FTUs maximum
Ammonia (ppm)		0.145 (0.132)	0.169 (0.080)	0.130 (5.7×10^{-17})	0.3406	0.2 ppm
Nitrate (ppm)	1.11 (0.333) B	2.64 (3.92) B	6.60 (2.26) A	5.28 (1.81) A	< .0001	2 ppm
Phosphate (ppm)	0 (0) C	0.313 (0.177) A	0.165 (0.109) B	0.070 (0.098) BC	< .0001	0.1 ppm
E. coli (# per 100ml)	28.9 (31.8)	16.8 (39.5)	20.1 (21.5)	0 (0)	0.0985	406 per 100 ml of water
Aeromonas (# per 100 ml)	1360 (261) A	288 (492) B	116 (88.2) BC	30.0 (24.7) C	< .0001	N/A
Salmonella (# per 100ml)	40.0 (22.4)	31.3 (127)	77.0 (121)	4.00 (8.21)	0.2085	N/A
Other Coliforms (# per 100ml)	249 (115) A	54.2 (94.8) B	3.00 (13.4) BC	0 (0) C	< .0001	N/A

DISCUSSION

We found Cozine Creek had significantly higher turbidity levels on 3/10/16 than on 3/31/16 or in fall 2015. This spike in turbidity was probably due to the week of high precipitation before the collection date, increasing the amount of suspended solids in the water from stormwater runoff into the creek. The fall 2015 and 3/31/16 turbidity levels were below the recommended amount of 10 FTUs maximum for a freshwater stream, however it was considerably higher than the recommended on 3/10/16. Cozine Creek in the summer of 2003 and 2004 also was above the maximum recommended turbidity levels of 10 FTU, showing that turbidity levels may have improved in the past decade, ignoring the 3/10/16 spike of turbidity caused by high precipitation. High precipitation events leading to increased turbidity in Cozine Creek can damage salmonid physiology and behavior. If turbidity increases in Cozine Creek, during high rainfall periods, fish health could suffer because high turbidity can lower growth rates, clog gills, slow egg development, and reduce disease resistance. High turbidity also can decrease light penetration into the creek, lowering the productivity and aquatic habitat quality. Suspended particles in the water can provide attachment places for pollutants, such as metals (USGS 2015).

We found pH levels in Cozine Creek were significantly higher in fall 2015 and on March 10, 2016 than in spring 2011. pH levels was significantly higher on 3/31/16 than on 3/10/16. The increase in pH may be due to increased photosynthesis from algae and riparian vegetation or it could be from increased acidity in stormwater runoff (EPA 2012). pH levels in samples from all years fell within the EPA recommended range of 6.5 to 8.5. Thus, pH is not a major concern regarding water quality at Cozine Creek.

Cozine Creek's water temperatures were significantly higher in fall 2015 than in any spring measurements. The significant increase in water temperature during fall 2015 might be because the summer of 2015 was the hottest summer on record in the Pacific Northwest (Dolce 2015). In 2003, Cozine Creek did not meet maximum temperature average of 18°C. However all measurements in spring 2011, fall 2015, and spring 2016 were below the recommended maximum freshwater temperature of 18°C and thus met water quality standards (Yamhill Basin Council 2004).

Despite the ENVS 385 findings regarding temperature in Cozine Creek, the Lower Yamhill Watershed as a whole is still experiencing water temperatures well above the

recommended maximum temperature of 18°C, especially in summer. Out of the 24 sites sampled in the South Yamhill Watershed in 2004, only one site out of 24, upper Gooseneck Creek, met the standard. .Water temperatures can vary significantly during low flow periods during the summer and fall. Middle and lower reaches of streams are most likely to experience low water quality due to high temperature. The loss of flow due to diversions of water and hydrologic changes, such as tilling or impoundments, as well as loss of shade by riparian vegetation, have probably contributed to increases in water temperature in the watershed. The middle and lower reaches of streams can suffer from severe seasonal changes in water quality, making it important to focus on upstream water quality parameters and restoration (Yamhill Watershed Council 2004). It is difficult to control water temperatures in the watershed, including Cozine Creek, because of the naturally occurring variation and the wide reaching effects of removing vegetation, the decrease in water flow due to agricultural activities, and thermal pollution from water running off pavement. Some actions can be recommended however, such as planting trees and other riparian vegetation upstream to increase shade. Better stormwater management upstream can help decrease the amount of warm water runoff from the nearby roads (Palmer and Allan 2006).

We found Cozine Creek's nitrate level was significantly higher this spring than in spring 2011 or fall 2015. Nitrate levels in spring 2016 were well above the recommended minimum of 2 ppm in freshwater streams. Phosphate levels were highest in fall 2015 but also high on 3/10/16; both were above the recommended 0.1ppm maximum for freshwater streams (EPA 2015). The level had dropped below the maximum recommended by 3/31/16. The high nitrate and phosphate levels may be related to the rainfall or runoff from land that had fertilizer application or increased amounts of animal waste (EPA 2015). Cozine Creek's excess nitrate and phosphate levels could lead to increased plant growth and algal blooms, resulting in eutrophication. Eutrophication can lead to decreased oxygen in the water, which can cause declines in fish reproduction, growth rate, spawning rate, and egg development (EPA 2015).

In spring 2016, water samples were collected after a week of a high precipitation (2.61 inches) on 3/10/16 and after a week of low precipitation (0.03 inches) on 3/31/16. We found significant differences in turbidity and pH that may have been due to the increased rainfall. The high turbidity was probably due to the increased sediment in stormwater entering the creek from eroding creek banks and/or nearby roads. During the time between the sampling times, the

suspended solids had time to settle or be flushed out, allowing the creek water to reduce the turbidity level to well below the limit of 10 FTU (Göransson et al. 2013). Although the pH level in Cozine Creek increased between 3/10/16 and 3/31/16, it remained within the recommended pH range of 6.5 to 8.5 (Yamhill Basin Council 2004).

When comparing the water in Cozine Creek between spring 2011 and 2016, there were significantly lower levels of *Aeromonas* and other coliforms in 2016, but *Aeromonas*, *Salmonella,* and other coliform levels are not regulated by the EPA in freshwater streams. In drinking water however, the recommended level for *Salmonella* and other coliforms is 0 mg/L (EPA 2016). The presence of *Aeromonas* in freshwater is may not be a problem because the bacteria is an extremely common microorganism in freshwater streams. Little is understood about the health implications of the bacteria in the water and whether they pose a health risk to humans (Kivanc et al. 2011). The presence of fecal coliform does not necessarily indicate poor water quality. Fecal coliforms are ubiquitous in the environment and can come from natural sources such as animal waste (EPA 2016). Lower fecal coliform bacteria amounts can be an indicator of good water quality because the presence of coliform bacteria, such as *E. coli.* Can indicate failing septic tanks, leaking sewer pipes, or sewer overflow. Excess coliform levels also can be indicators of potentially disease-causing bacteria in the creek (EPA 2015). *E. coli* in the data collected by the ENVS 385 classes in all years were below the EPA maximum amount of 406 colonies per 100 ml of water (Yamhill Basin Council 2004). However, the levels of *E. coli* in 2003 and 2004 were above the recommended maximum limit of 4.6 colonies per 100 ml of water (Yamhill Basin Council 2004). The reduction in bacterial levels to acceptable levels suggests an improvement in that aspect of water quality in Cozine Creek in the past decade.

Macroinvertebrates are important water quality indicators because their presence and population abundances are directly related to dissolved oxygen and pollution levels. Their populations shows short term, long term, and cumulative effects of stream pollution because macroinvertebrates cannot escape their environment. Populations of macroinvertebrates increase with higher creek nutrients, particularly nitrogen, in response to an increase in the rate of decomposition of detritus that provides food for the organisms (Wallace and Webster 1996). Macroinvertebrates are analyzed using a pollution tolerance index (PTI) that has three categories. Category 1, assigned three points, contains pollution-sensitive macroinvertebrates. Category 2, assigned two points, contains macroinvertebrates that can tolerate a wide range for environments.

Category 3, assigned one point, contains pollution tolerant macroinvertebrates. PTI is the total sum of the points and the quality of the stream is defined by the score; 23 or more points excellent, 17 to 22 good, 11 to 16 fair, and fewer than 10 poor (Schumaker 2016).

The ENVS 385 classes in 2013, 2014, and 2015 collected macroinvertebrates and calculated the PTI for Cozine Creek. Cozine Creek was found to have significantly higher PTI and species richness in 2015 than 2014. This might suggest the water quality improved compared to 2014, however, the number of pollution tolerant species also increased between 2013 and 2015 (Blanco et al. 2015). Continuing macroinvertebrate counts in the creek is recommended to track short and long term water quality changes by examining macroinvertebrate abundance and taxa differences.

When comparing these short snapshots of data collected poor over the past years, it is difficult to make a definite conclusion as to trends in Cozine Creek's water quality. The findings regarding nitrate and turbidity suggest water quality has decreased because these two variables have increased beyond recommended levels. However, the findings regarding temperature suggests the opposite because it has decreased below the maximum. The rest of the watershed experiences frequent warm water temperatures above the recommended amount of 18°C, suggesting the temperature should continue to be a highly monitored parameter (Yamhill Basin Council 2004). Coliform bacterial levels have declined as well, but they were never above the level that would warrant concern. I would recommend additional water quality monitoring in the future, preferably in the spring and fall every year to track the fluctuating water quality of Cozine Creek. Water quality monitoring should be added upstream where the majority of problems originate from. Pipes draining stormwater into the creek should be diverted in order to reduce the amount of nutrients, warm water, and suspended solids in Cozine Creek. To improve fish habitat, logs or boulders could be placed in the stream, slowing down the flow during flooding events and allowing gravel to accumulate (Palmer and Allan 2006). The purchasing of new dissolved oxygen equipment is recommended due to the fact that the current dissolved oxygen meters were broken and unavailable to use for spring 2016.

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Appendix D

Project Summary

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Project Summary of Stakeholders for the Social Resources Inventory and Assessment

Introduction:

Students majoring in Environmental Studies that are enrolled in the class Environmental Problem Solving Seminar at Linfield College, in partnership with the Greater Yamhill Watershed Council, are conducting an inventory and assessment of the college's property adjacent to Cozine Creek (located between Baker Street and Davis Street) in McMinnville, OR. The goal of the inventory and assessment is to develop a better understanding of the health and habitat quality of this property and its relationship to the Greater Yamhill Watershed. As part of the inventory, we are reaching out to key stakeholders to learn more about their perspectives on this property. The purpose of the project summary of the stakeholders is to see the perceptions, issues and concerns users have with this site. .

In order to implement any future strategies or recommendations and ensure a smooth transition for future changes, it is valuable to include the community from the beginning. Stakeholders for this inventory and assessment are being defined as individuals or groups that can reasonably be expected to be affected by Linfield's property and any activities, services or actions that take place now or into the future (Global Reporting Initiative, 2013). The project objective is to identify as many stakeholders as possible and understand how they perceive the property in order to provide a more comprehensive understanding of the site. The roles of stakeholders change throughout a project lifecycle (Nordmeyer, 2016) but for this first phase it is only necessary to identify stakeholders, determine the methods to be used to communicate to the stakeholders and deliver the questionnaire, and evaluate the responses. The benefit of including stakeholders early on reduces distrust of the project outcome and ensures more commitment to any future objectives (Nordmeyer, 2016). It is important to include a broad range of organizations and individuals even though the focus is on a local property (ATSDR, 2015). We identified the following

stakeholders for the Cozine Creek property: external, Linfield College staff/faculty, Linfield College students, and Linfield College administration.

Methods:

The four stakeholder groups we wanted to reach out to consisted of individuals that are in some way connected to the property. The external stakeholders we contacted were individuals or organizations outside of the college that have an opinion, some use, or concern with the property. The external stakeholders consisted of groups like the Greater Yamhill Watershed Council, Soil and Water Conservation District, McMinnville Police Department, McMinnville City Council, McMinnville Parks and Recreation and neighbors abutting the property. These external stakeholders have important perspectives because Linfield College is not the only one that uses the property or has a connection to the property. In addition, including external stakeholders gives the community the opportunity to get involved with this property and potentially create a more sustainable community. In addition to the organizations that may have an opinion, we sent a letter to property owners abutting the property [Appendix A]. This letter was designed and intended for opening of dialogue to the outside community, and served as an informational tool to explain how students would be frequenting the property in the upcoming semester. More importantly, this is potentially going to be a multi-year effort and as discussed earlier, we found it only beneficial to start communicating to the community as early as possible.

In addition to the external stakeholder group, we identified three groups in the Linfield College community that were vital in understanding the Cozine Creek property: the administration of the college, the staff and faculty of the college, and the students of the college. Splitting up the Linfield College community into these three groups was intended to help us gain a better understanding of the various community members of the Linfield College campus. For example, Linfield College students are on campus for about four years, whereas faculty and staff on average have been here longer, making their perceptions and understanding of the property potentially different.

A questionnaire [Appendix B] was sent out to all stakeholder groups via email, or in-person interviews. The questionnaire had to parts, open-ended questions, and then the last question was a rank order question.

Results:

In total we sent the questionnaire to 136 people. Twenty-five individuals responded to the questionnaire, which totaled in a response rate of 18%. The questionnaire was sent out to 13 external stakeholders [Table 2.1]. Three external stakeholders responded to the questionnaire, which resulted in a response rate of 23%; however, one of the responses was not used qualitatively because the questionnaire was not filled out. The questionnaire was sent out to 37 faculty and staff stakeholders. Eleven individuals responded to the questionnaire, which resulted in a response rate of 30%. The questionnaire was sent out to three Linfield College administrators. Three individuals responded to the questionnaire, which resulted in a response rate of 100%; however, all three respondents did not fill out the questionnaire in full, limiting our use of it. The questionnaire was sent out to 83 Linfield College student stakeholders. Nine individuals responded to the questionnaire, which resulted in a response rate of 11% [Table 2.1].

The external stakeholders were concerned with the homeless camps and safety of users on the property. In addition, general concerns were revolving around accessibility and safety. They recommended developing a walking path through the property that would run east to west. The stakeholders mentioned the uncleanliness of the property, the garbage and the fire potential due to brush growth.

Table 2.1 Questionnaire Response Rates by Stakeholder Group

Stakeholder Group	Number of Questionnaires	Number of Respondents	Response Rate
External Stakeholders	13	3	23%
Staff and Faculty Stakeholders	37	11	30%
Students Stakeholders	83	9	11%
Administration Stakeholders	3	3	100%
TOTAL	136	n = 25	18%

The faculty and staff identified drainage and flooding issues as a concern. The property floods annually and may limit the future management of the property. Almost 50% of respondents in this stakeholder group mentioned that the college does not seem to value the property, or consider it part of the campus. A faculty/staff stakeholder said "Given the college's stated priorities in sustainability, I do think the college should be willing to spend some money to maintain/improve the ecological health of a creek that runs through our property." Close to half of the faculty and staff stakeholders mentioned the homeless and transient problem on the site, and that this causes a safety was a concern. For example, on faculty member stated, "I wouldn't want students working down there alone." Invasive plant removal was mentioned by eight respondents, and concerns were high regarding the blackberry and English ivy; however, a couple of respondents made opposing arguments about the blackberry serving as habitat to wildlife and as a buffer zone to the property. In addition, stakeholders wanted better and/or more walking paths, more native plants, less garbage/electronics being dumped. A few individuals thought increasing foot traffic on the property would contribute to illegal activity or damage to the habitat. These stakeholders did not want it to be a park-like environment; regardless of their opinion on what the property should look like, all stakeholders believed the property to have extreme educational potential.

Student stakeholders all believed safety was an issue in the open ended questions. The majority of the students recommended adding lights or more College Public Safety patrols. "I wouldn't feel safe going there alone" and "I've seen some sketchy people there," said two student stakeholders. Invasive plants were also mentioned, including blackberry, and also removing the English Ivy. Signage was recommended to reclaim the property as Linfield's. The student stakeholders also mentioned that there was illegal activity, a lot of trash, and water quality/pollution problems on the property; however, students still believed it was a potential selling point for the college. Three students mentioned that Linfield College neglects the property. "I feel like the area is a bit neglected by the college. I for one feel that the college is over-groomed if anything, but I still feel that the property needs some love," said one student.

The administration stakeholders had a general consensus that they approve of the property being used for educational purposes. However, the administration also expressed concerns over the annual flooding, the privacy of nearby residents, the security of the area (particularly revolving around illegal activity, and also they were curious about the city's perspective. "I'm not

sure who the owners are," said one administration stakeholder. "Some students a few years ago wanted to put a park down there, but this would be a considerable undertaking. Students willing to help now, will eventually graduate – that needs to be considered," said another stakeholder.

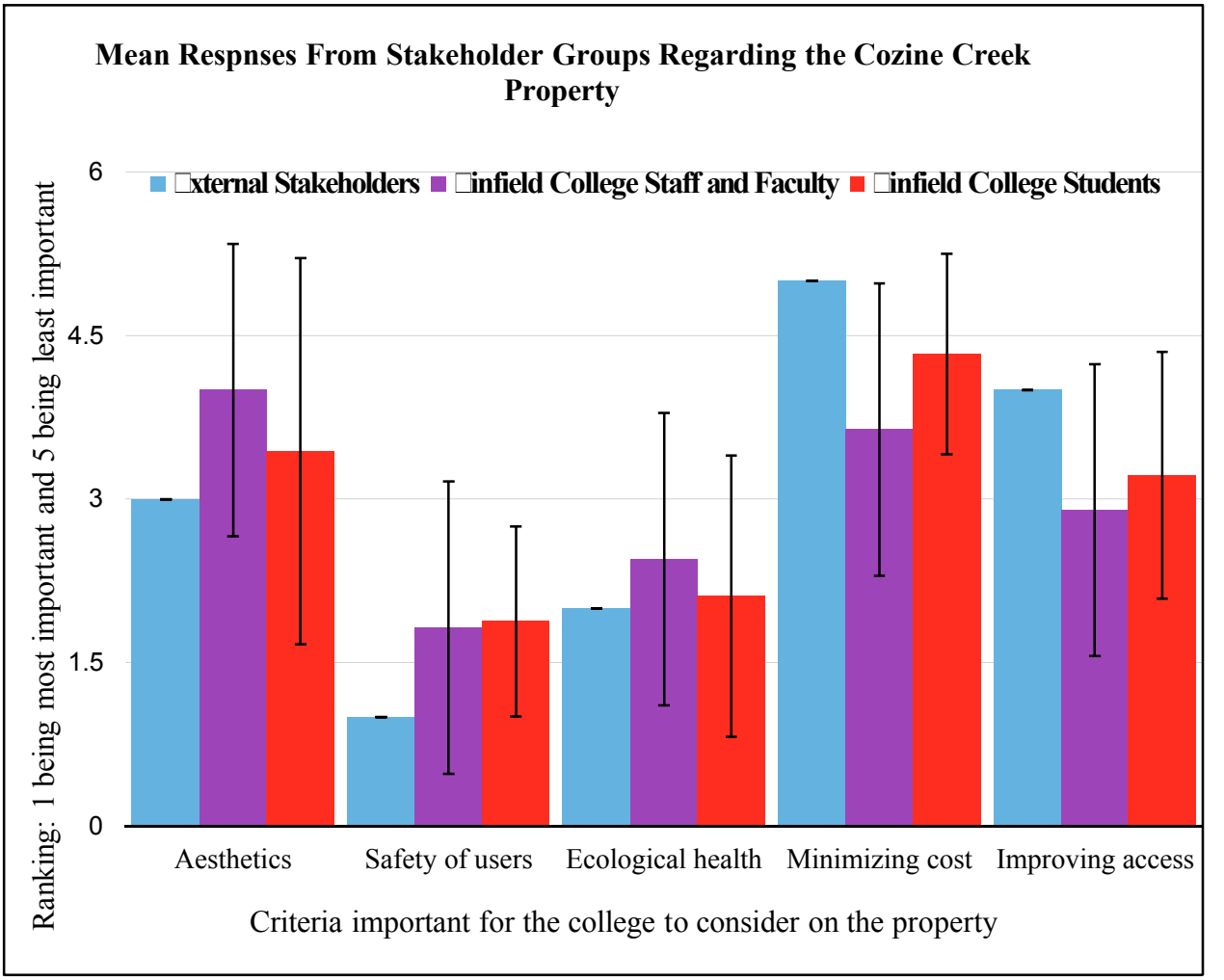

Figure 2.1 Mean responses from each stakeholder group for the rank question.

The final question in the questionnaire was a rank order question. Unfortunately, only three stakeholder groups are represented because we could not use the responses from the administration stakeholder group. The most important topic of concern from the three stakeholder groups was safety of users on the property [Figure 2.1]. External stakeholders and students believed minimizing cost to the college was the mean least important concern. Ecological health was second most important for all three stakeholder groups. Aesthetics of the property was the mean least important topic of concern for the faculty and staff stakeholders.

Discussion:

For three stakeholder groups: external, Linfield College students, and Linfield College faculty and staff, the most important concern was safety on the Cozine Creek property. For the same three stakeholder groups, ecological health was the second most important concern for the property. Both external stakeholders and Linfield College student stakeholders had minimizing cost to college as a least concern.

One of the administration stakeholders did not believe they had enough knowledge of the site. This is valuable because another stakeholder in this group was also confused with the property, stating that they were not sure who the owners were. The confusion around the property, from the administrative respondents, might shed light on the other stakeholder responses about the college's lack of ownership or valuing of the site. The administration was not the only stakeholder confused as an external stakeholder was also confused about the site stating that they did not know of the location of the property we were talking about.

All four stakeholder groups were concerned with homeless camps, transient people and safety on the property. Three of the four stakeholder groups were concerned with the ability to restore the property because of the limitations of it flooding so often. Three of the four stakeholder groups also were supportive of the potential for academic or educational uses of the property. There were two conflicting perspectives on what should be done with the property. Some administration and faculty and staff believed the area should not be made into a park, as increasing foot traffic would only cause more problems, like affecting the wildlife. Other faculty and many students wanted it made into a park to make it more accessible to people and help make the property safer. Faculty, staff and students felt the property had more potential use for educational purposes, and that was an idea supported by administrators, which shows education was accepted across stakeholder groups.

Recommendations:

The first recommendation is to make the property safer. As noted by the rank order question and by all the opened ended question responses, safety is the most important concern on the Cozine Creek property. All four stakeholder groups were concerned with homeless camps, transient people and safety on the property. The safety and homeless problem can potentially be solved if the college better manages the property. As noted earlier, one administrator did not

know that Linfield College was the owner of the property. The staff, faculty and students feel the college has neglected the property, which makes sense when some administrators are confused as to the ownership. It would make sense for the college to pursue reclaiming ownership of the property and putting more energy and resources into the property. Faculty, staff and students feel like the property is neglected and that potentially contributes to the frequent concerns about safety and inappropriate use of the site. Safety of students should be priority number one for the college. Generally those concepts, the disassociation the college has with the property and the safety/illegal activity, seemed connected to the "sketchy" feeling users got from the property. This could be related to the difference in maintenance this site gets compared to the rest of the campuses more maintained property. The campus is large, Cozine Creek is nearly 30 acres on its own, which means is important to keep communication open with facilities while addressing a potential management plan.

The second recommendation is to improve the ecological health, as that was the second most important concern for the property across three stakeholder groups. There are benefits if the college cleaned up the property and reclaimed ownership. Two of the benefits the college may see from cleaning up the property and reclaiming ownership are a safer place for students and a healthier environment for wildlife. This would solve the two biggest concerns of the stakeholders, safety and ecological health. Future management actions need to consider the different views on the desirability of removing all of the invasive species, particularly the blackberry bushes, because some stakeholders have mentioned their significance for wildlife habitat and also aid in privacy. Realistically, as some stakeholders noted, this property has extreme limitations due to the land fill that prevents major structures from being built, and that the property is a naturally prone to flooding. While large structures may not be plausible, smaller structures could drastically change the atmosphere and neglected feeling stakeholders feel on the property. The college could incorporate signage, both educational and stating ownership, newer paths, lighting, emergency help towers, and seating.

A concern some stakeholders had were the costs in restoring the property, fortunately, the college has a department that is dedicating resources to the management of the property, which means faculty, staff and students are going to be involved well into the future in managing the property and restring the ecological health. There are already systems in place at the school and in the Environmental Department that can be taken advantage of and redirected to focus on the

management and restoration of Cozine Creek. These systems include the ENVS 090 class, a class that is only volunteering for environmental causes, the Linfield Day of Service that takes place every year, the large student body involved in Greek Life (all of which need community service hours), Circle K and more.

The third recommendation would be for future classes to get the community involved in restoring Cozine Creek. Linfield College only owns a portion of the creek and it would be great to get more of the creek restored. Two possible places to start would be to contact the City of McMinnville and bounce ideas off of them, particularly focusing on the area between Linfield College and Joe Dancer Park that is upstream from Linfield. In addition, reach out to neighbors that have property near the creek and try and involve the community in helping restore the entire creek.

In the end, as many stakeholders noted, it would be in the college's best interest to create a safer, more ecologically sound area, one that provides educational opportunities to students and the greater McMinnville community. There is no downside in making this property safer, or attempting to reclaim ownership of the Cozine Creek property. Other college campuses have done similar restoration work, including George Fox University and Reed College. Both projects involved the students on campus, the faculty and staff, the city, and administrator's cooperation, but in the end the property and surrounding areas saw major ecological improvement. Hopefully Linfield College could act as an example to other institutions or organizations looking to improve the ecological health of their property.

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Appendix A

Dear

Linfield College's Environmental Studies majors, in partnership with the Greater Yamhill Watershed Council, are conducting an inventory and assessment of the college's property adjacent to Cozine Creek. The purpose of this project is to develop a better understanding of the health and habitat quality of this property and its relationship to the Greater Yamhill Watershed.

We are reaching out to key stakeholders to learn more about your perspectives on this property. To accomplish this, we have included a short questionnaire below. We anticipate that it will require approximately 10-15 minutes to of your time to answer these questions and to return your responses by email. We are willing to set up a time to meet with you if you prefer to answer these questions in person.

Your responses to these questions will help students better understand the uses as well as the issues and concerns stakeholders have about this property. Your participation in this study is completely voluntary and your responses will be kept confidential. Only the faculty members, Nancy Broshot and William Fleeger and the student involved in designing this questionnaire, Rachael Gernhart, will have access to your original responses. However, your responses to these questions may be reported anonymously in our inventory and assessment report. For example," "a faculty member reported that they used this property frequently for classroom projects…"

Questions:

How have you been involved with the property Linfield College owns adjacent to Cozine Creek?

From your perspective, what are the major issues or concerns associated with this property?

What actions, if any, would you like the college to take to manage or improve this property?

Please rank order the following criteria according to what you believe should be the most important for the college to consider addressing when making decisions about the site (1=most important, 5=least important):

Aesthetics (visual appeal); Safety of users; Ecological health of Cozine Creek;

Minimizing cost to the college; Improving access and use of property

If you agree to participate in this study, please respond to the questions above and return them by email to rgernhart@linfield.edu or wfleeger@linfield.edu. If you have questions or concerns about this questionnaire or would like more information about any aspect of this project please contact William Fleeger at the email address above or call 503-883-2341. We appreciate your time and assistance with this project.

Sincerely,

Rachael Gernhart
Environmental Studies (Policy) Major

Appendix B

March 8, 2016

Environmental Studies Program
Linfield College
900 SE Baker Street
McMinnville, Oregon 97128-6894

Dear Neighbor,

Linfield College's Environmental Studies majors, in partnership with the Greater Yamhill Watershed Council, are conducting an inventory and assessment of the college's property adjacent to Cozine Creek. The purpose of this project is to develop a restoration plan for the property

and improve the ecological health and habitat quality of this property and the Yamhill watershed. We envision that this will occur in two phases. The first phase involves conducting a natural resource inventory and site assessment. The second phase involves the development of a management and restoration plan for the property.

As part of the first phase, we are reaching out to stakeholders and neighbors, such as yourself, to inform you about this project and to notify you that students will be frequenting the property to measure trees, map native and non-native plant populations, sample water quality and document overall site condition. Students are also interested in talking to you and learning more about your ideas and perspectives on this property. If you would like to learn more about this project or get involved please feel free to reach us at the contact information below. We would look forward to talking with you.

Sincerely,

William (Bill) Fleeger Ph.D. (faculty)
wfleeger@linfield.edu
(503)-883-2431
-or-
Rachael Gernhart (student)
rgernhar@linfield.edu
(503)-502-0900

APPENDIX E

Reese Yonemura

ENVS 485

Geographical Information System (GIS)

GIS is a program that allows the user to analyze and visually represent geographical and spatial data. Data can be retrieved through reliable and consistent government sources such as the United States Geological Survey, or as data collected in the field and lab (USGS 2015). The data can then be compiled and organized into charts, tables, and maps. In the case of the Cozine Site Inventory, the focus will be on the ownership and borders of properties, the type and coverage of plants, drainage, pipeshed, paths, and potential points of interest.

Tax lot data was provided by the Greater Yamhill Watershed Council (GYWC) and was used to identify ownership of relevant properties. This allowed the study to identify the boarders of Linfield property including the neighboring tax lots' number, owners, and addresses.

Data on flood zones in the Yamhill area is fairly limited. The data used to create the 100 year flood zone and floodways was taken from an online GIS site made by Yamhill County. The data itself was not able to be directly imputed into the program used and was manually entered using tax lots and satellite imagery for reference (Yamhill County 2016). Thus the 100 year flood zone and floodways map should only be used to understand the general size and shape of each zone and not relied upon for accuracy.

The collection of field data was done through the use of Garmin GPS units, each labeled with the user's name to avoid confusion. The GPSs were used to collect points where lighting, pipes, and maintenance access covers were located, including tracks following drainage flows, roads, paths, and the edges of regions containing heavy brush and Himalayan Black Berries were recorded. Points of interest such as snags, animal carcasses, signs of animals, and game trails were recorded separately. The data for the trees in cosine was collected from specimens with a diameter at breast height (DBH) exceeding 20 cm. Once deemed acceptable, each tree's coordinates were recorded from the average of no less than 50 GPS measurements.

Furthermore, each tree was identified, measured for DBH, and tagged for reference. This data was then imputed into a digital format using excel before finally mapped out using GIS.

Maps

Figure 1: The different routes through the Cozine site and their classifications.

Figure 2: All of the trees measured with a DBH greater then 20cm and their species, in relation to the different flood zones.

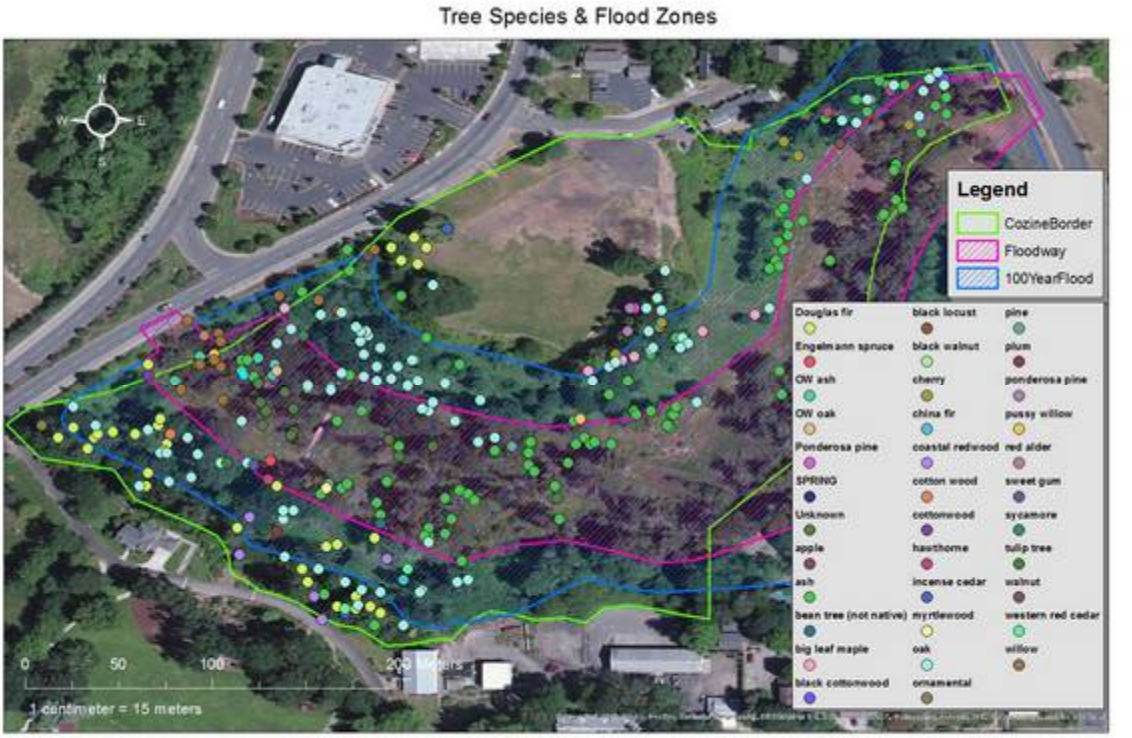

Figure 3: The expanse of Camas lily and Himalayan blackberries. Area represented in square meters.

Figure 4: The entire length of Cozine creek in relation to the Cozine site.

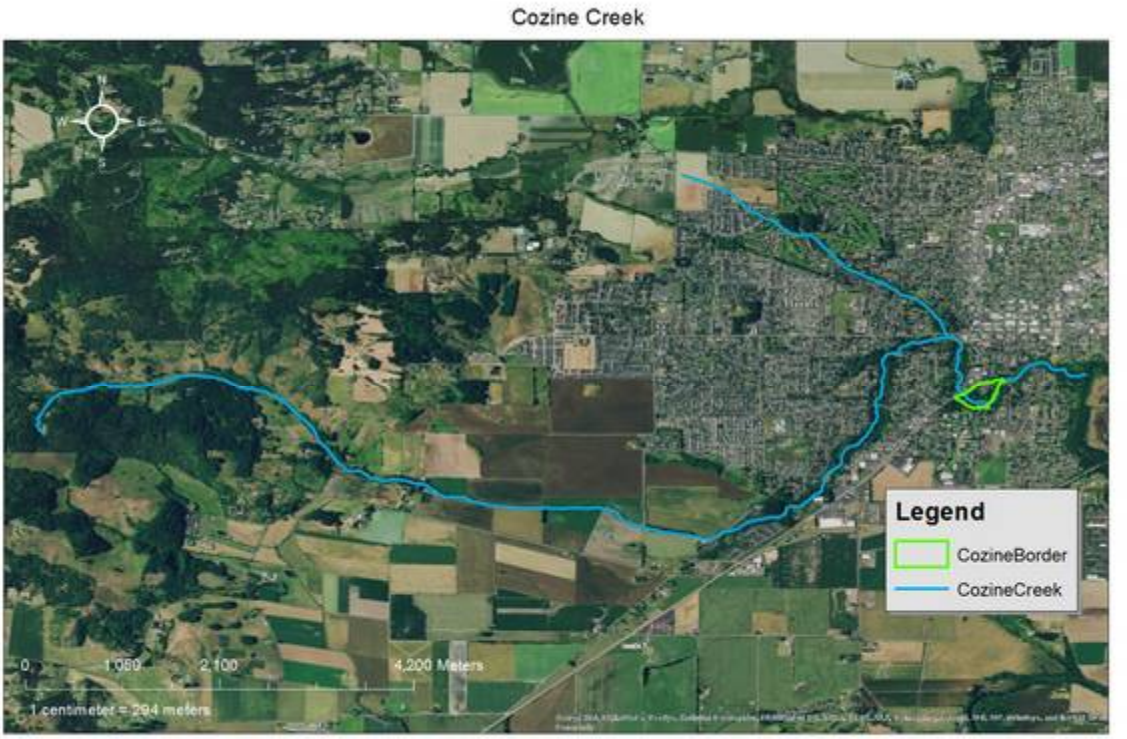

Figure 5: This is the tree data filtered down to only represent the major tree species within the site in relation to the flood zones.

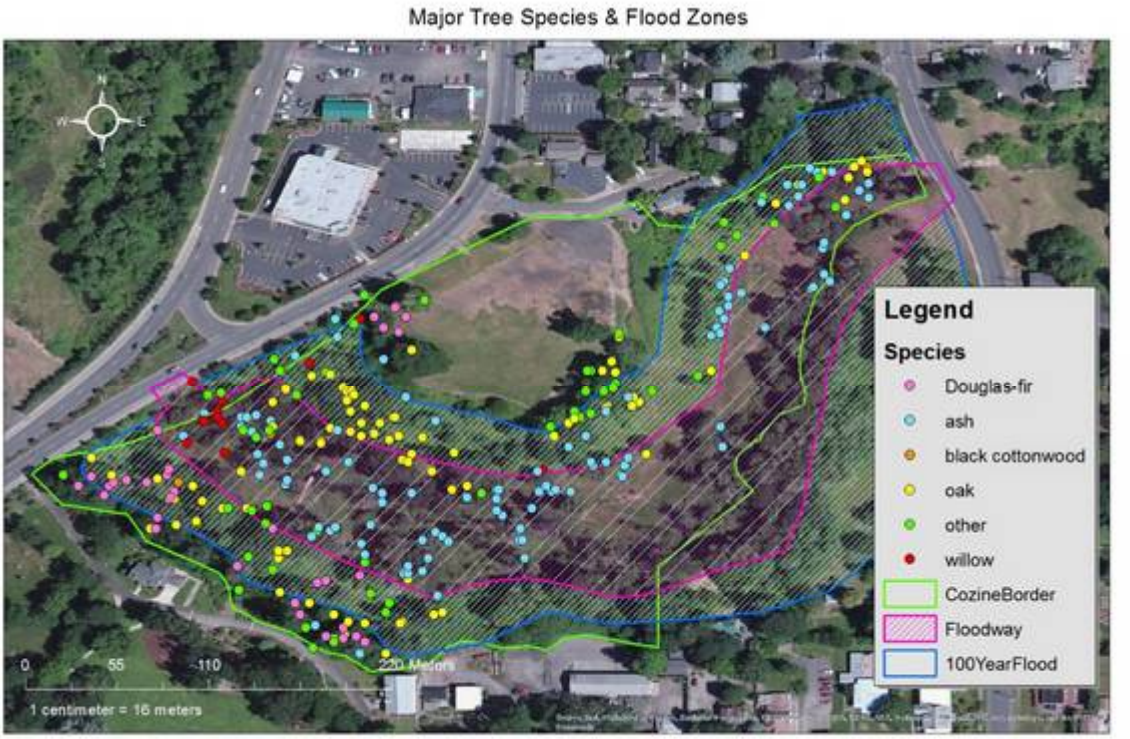

Figure 6: The location of pipes and the paths runoff follows. Other factors that affect runoff, including weirs and mud fields are also shown.

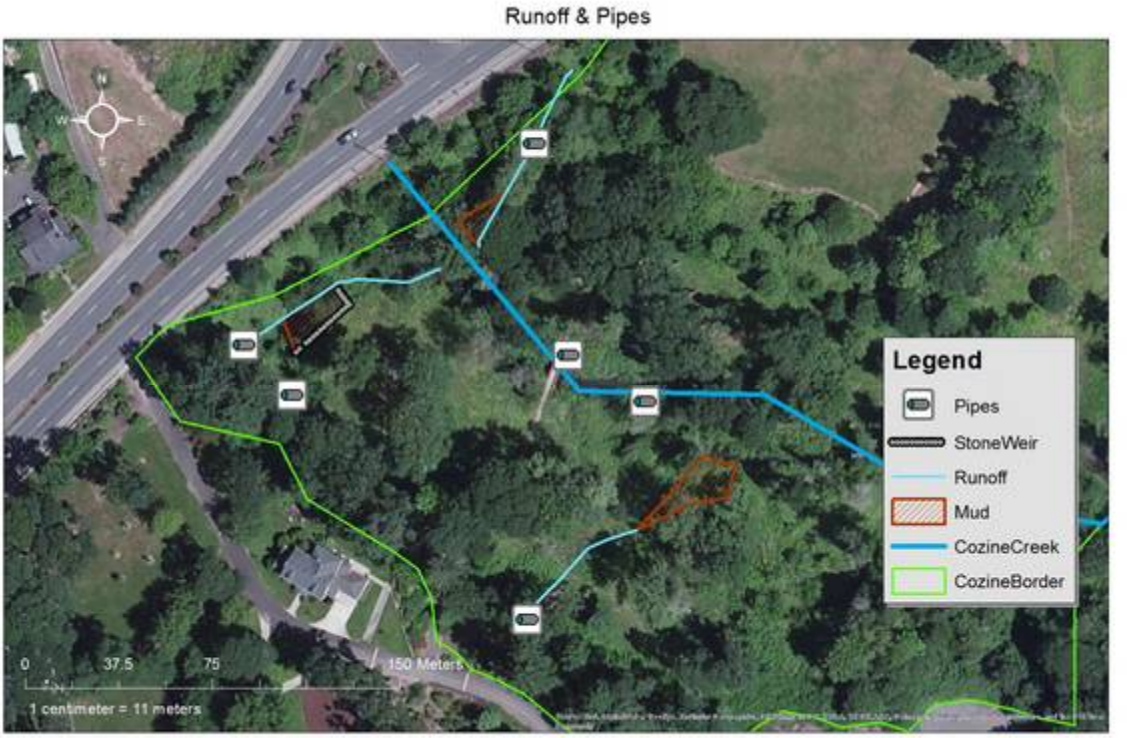

Figure 7: The locations of manholes and lamps throughout the site.

References

USGS. 2015. National Geospatial Program.

http://www.usgs.gov/ngpo/

Yamhill County. 2016. Geographic Information Systems (GIS).

http://www.co.yamhill.or.us/gis