PROPOSAL FOR CONSERVATION RESEARCH

Geomorphic and Anthropogenic Influences on the Distribution of Invasive Plant Species in the Luckiamute Watershed, Polk and Benton Counties, Oregon

Prepared By

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INTRODUCTION

Invasive plant species in western Oregon are a pervasive problem that disrupt native habitats and create annual economic losses of millions of dollars for public and private landowners (Oregon Department of Agriculture, 2001). Nationwide, the United States experiences annual losses of over $130,000,000.00 due to non-native species (Pimentel and others, 2000). Vegetative disturbance of natural ecosystems by geomorphic and anthropogenic processes affect soil substrate conditions, nutrient availability, canopy shading (solar influx), and riparian hydrology. The most abundant concentrations of invasive species are typically associated with disturbed zones that have been altered by human activity. As such, disturbed zones on the landscape act as primary conduits for the dispersal of non-native species (Pabst and Spies, 1998). Understanding the controls on spatial distribution of invasive plants in the context of disturbance regime is critical for designing effective watershed conservation and restoration plans.

The purpose of this research is to conduct a reconnaissance survey to delineate associations between geomorphic (landslides and floods) and anthropogenic disturbance (road construction, logging, and agriculture) regimes, and distribution patterns of invasive plant species in the Luckiamute Watershed of western Oregon (Figure 1). The Luckiamute is associated with a unique combination of geomorphic and land-use conditions that are well-suited for the study of causal factors that control spatial distribution of invasives in the region. The results of this preliminary work will form the basis of more extensive studies in the region and have potential use for development of larger scale predictive models of invasive plant dispersion.

PROJECT RATIONALE

Multidisciplinary research on the Luckiamute Watershed has been ongoing since the summer of 2001 under the aegis of the Environmental Science Institute (ESI) at Western Oregon University (WOU). This research has involved integrated science modules including geomorphology, field botany, and environmental chemistry. The geomorphology module has focused on landscape analysis, geographic information systems, and surficial mapping methodology. The botany module has emphasized characterization of riparian habitats, floristic changes over time, impacts of invasive plant species, and field monitoring methodologies. The environmental chemistry module has examined land use and water quality issues in the Luckiamute basin.

Work on the Luckiamute was more recently advanced via a cooperative agreement between ESI and the Luckiamute Watershed Council (LWC), a community organization dedicated to conservation, habitat restoration, and sustainable land use in the river basin (www.wou.edu/luckiamute). With funding from the Oregon Watershed Enhancement Board (OWEB), LWC is currently conducting a phase I assessment to document existing biotic and abiotic conditions, and to establish priorities for future conservation projects. The invasive plant research proposed herein forms an important part of this community-based watershed enhancement effort.

PHYSIOGRAPHIC SETTING OF THE LUCKIAMUTE WATERSHED

Topography and Climate

The Luckiamute River comprises a portion of the Willamette basin in west-central Oregon (Figure 1). This seventh-order watershed (sensu Strahler, 1957) drains eastward from the Coast Range into the Willamette River and occupies a total drainage area of 815 km^2. The Luckiamute basin is bounded by the Willamette River to the east, the crest of the Coast Range to the west, Green Mountain and Mary's River to the south, and Rickreall Creek watershed to the north (Figure 1). Land surface elevations range from 46 m (150 ft) at the confluence with the Willamette River to 1016 m (3333 ft) at Fanno Peak. The Luckiamute has an average gradient of 3 m/km, a total stream length of 90.7 km, and an average basin elevation of 277 m (910 ft) (Rhea, 1993; Slack and others, 1993). Fanno Ridge separates the watershed into two tributary sub-basins, with the Little Luckiamute to the north and the main stem of the Luckiamute proper to the south (Kings Valley) (Figure 1).

Taylor and Hannan (1999) summarized historic climate data for western Oregon. The Luckiamute straddles Oregon Climate Zones 1 (Coastal Area) and 2 (Willamette Valley), with westerly Pacific marine air serving as the primary moisture source. Precipitation patterns are strongly seasonal with 75% of annual total occurring from October to March. Annual precipitation varies greatly from west to east across the Luckiamute watershed, as governed by westerly airflow and lee-side rain shadow effect in the Coast Range. Precipitation ranges from 3600 mm/yr along the northwestern boundary to 1140 mm/yr in the center of the Willamette Valley, a west-to-east precipitation gradient of 95 mm/km (Figure 1). Analyses of stream flow records at Helmick State Park reveal that flooding and high discharges on the Luckiamute directly correspond to seasonal precipitation patterns.

Bedrock Geology

Yeats and others (1996) and Snavely and Wells (1996) provided comprehensive summaries of the bedrock geology in the Luckiamute region. Lithostratigraphic units are grouped into four spatial domains in the Luckiamute, as recognized on the basis of outcrop pattern (Figure 2). These domains include the Siletz River Volcanics domain (south), the Tyee domain (west-southwest), the Yamhill-Intrusive domain (north-northwest), and the Spencer-Valley Fill domain (east). The Siletz River Volcanics domain comprises 19% of the watershed and is associated with outcrop of seafloor basalts. The Tyee domain (29% of total area) is underlain primarily by Tyee Formation with local mafic intrusives supporting ridge tops. The Yamhill-Intrusive domain occupies 23% of the watershed and is characterized by outcrop of equal portions Yamhill Formation and mafic intrusives. The Spencer-Valley Fill domain (29%) is underlain by a patchwork of Spencer Formation and Quaternary alluvium. Each of these bedrock spatial domains is associated with unique landform assemblages and surficial processes.

Surficial Geology

Geomorphic systems of the Luckiamute watershed can be divided into a valley-floor regime to the east and hillslope-colluvial regime to the west (Figure 3). Style of surficial process and landform associations are controlled by topographic position, underlying bedrock geology, and resistance to erosion. Hillslope landforms and colluvial processes dominate the Siletz River, Tyee, and Yamhill-Intrusive domains, while fluvial landforms and alluvial processes are characteristic of the Spencer-Valley Fill domain.

The lower Luckiamute is characterized by a mix of alluvial stratigraphic units and geomorphic surfaces. Landforms include active channels, floodplains, fill terraces, and strath-pediment surfaces (McDowell, 1991). In addition to these fluvial landforms, the lower Luckiamute is also associated with swaths of low-relief colluvial hillslopes supported by the Spencer Formation (Figure 3). Pleistocene through Holocene terrace development records a complex history of base level fluctuation, internal erosion-deposition cycles, and glacial-outburst floods (Missoula Floods) from the Columbia River system. The active channel of the lower Luckiamute is incised 8 to 9 m below the floodplain, with higher level terrace surfaces at 12 to 15 m above mean annual stage (Reckendorf, 1993). The higher-level terrace surfaces are covered with rhymically-bedded, silty slack-water deposits of the Willamette Formation (Missoula Flood deposits; 13.5-12 Ka). These late Pleistocene surfaces are inset with lower terrace and floodplain deposits that are predominantly Holocene in age (post-Missoula Flood; <12 Ka) (Figure 3; O'Connor and others, 2001).

Parsons (1978) presented a geomorphic overview of the Coast Range portion of the Luckiamute. On average, hillslope gradients range from 25 to 30% with maxima up to 90%. Local relief is on the order of 300 to 500 m. This portion of the Luckiamute watershed is dominated by colluvial hillslope processes including slide, debris flow, creep, tree throw, and faunal turbation. Fluvial transport and erosion occur in narrow, low-order tributary valleys. Upland landforms include ridge tops, side slopes, hollows, landslide scars, and dissected pediments. Narrow valley-bottoms are geomorphically active with channels, floodplains, low terraces, and small-scale debris fans (Balster and Parsons, 1968).

Land Use

Since European settlement, the dominant economic activities in the Willamette Valley have centered on agriculture in the lowlands and timber harvesting in upland forests. Over the past several decades, industrialization and rapid population growth have resulted in significant impact to the habitat of the region. A large portion of the upper Luckiamute is owned by private timber companies and 67% of the watershed classified as forest. In contrast, the eastern valley section is comprised of a mix of agricultural lands (15% of total), native vegetation (3%), and urban development (1%) (Urich and Wentz, 1999). Primary commodities in the agricultural zones include grass seed, wheat, hay, oats, and mixed crops (clover, sweet corn, mint, alfalfa, filberts) (Wentz and others, 1998).

Vegetation

The Coast Range portion of the Luckiamute watershed lies in the *Tsuga heterophylla* Zone of Franklin and Dyrness (1988). Dominant forest species include *Pseudotsuga menziesii* (Douglas fir), *Tsuga heterophylla* (western hemlock), and *Thuja plicata* (western red cedar), with lesser occurrence of *Abies grandis* (grand fir). These species formed part of the classic old growth timber stands that were logged extensively in the Pacific Northwest during the early 1900's. Disturbed upland zones are characterized by *Alnus rubra* (red alder) and *Rubus spp* (blackberry). *Acer macrophyllum* (big leaf maple) is a common late succession species in valley bottoms and hollows. Balds with meadow grasses and mosses occur locally along higher elevation ridge tops. Lower reaches of the Luckiamute watershed lie in agricultural crop and pasture land, with local patches of mixed *Quercus garryana* (Oregon white oak) and urban mosaic species.

STATEMENT OF THE PROBLEM

Non-native invasive plant species are problematic for both native and agricultural plant communities as they can compete for resources and displace competitors. Local extirpation of native plant species has obvious impacts on wildlife and natural habitats. Competition between plant species is a part of any habitat, but introduction of non-native species disrupts relationships evolved among native plants and their communities within those specific habitats. A number of non-native, invasive plant species have previously been documented at select Luckiamute field localities and are listed in Table 1.

Table 1. Occurrence of common invasive plant species at select field trip localities in the Luckimute watershed.

NAME	ORIGIN	GEOGRAPHIC OCCURRENCE		
		Black Rock	Helmick State Park	Sulphur Springs
Capsella bursa-pastoris (shepherdspurse)	Europe	X	X	X
Cichorium intybus (cichory)	Mediterranean		X	X
Cirsium arvense (Canada thistle)	SE Eurasia		X	X
Cirsium vulgare (bull thistle)	Eurasia		X	X
Conium maculatum (poison hemlock)	Europe		X	X
Cytisus scoparius (scotch broom)	Europe	X		X
Daucus carota (wild carrot)	Europe		X	X
Digitalis purpurea (foxglove)	Europe	X		X
Dipsacus fullonum (common teasel)	Europe	X	X	X
Hedera helix (English ivy)	Eurasia, Africa	X		
Hypericum perforatum (common St. Johnswort)	Europe		X	X
Lamium purpureum (purple deadnettle)	Europe	X	X	X
Leucanthemum vulgare (oxeye daisy)	Europe			X
Phalaris arundinacea (reed canarygrass)	Agricultural	X	X	X
Rubus armeniacus (Himalayan blackberry)	Armenia	X	X	X
Rumex acetosella (red sorrel)	Europe	X	X	X
Senecio jacobaea (tansy ragwort)	Europe	X	X	
Solanum dulcamara (bittersweet nightshade)	Europe		X	X
Tanacetum vulgare (common tansy)	Europe		X	X
Taraxacum officinale (dandelion)	Europe	X	X	X
Verbascum thapsus (common mullein)	Eurasia	X	X	X

Swanson and others (1990) emphasized the importance of ecological linkages between geomorphic process, landforms, biotic systems, and forest management practices in mountainous watersheds of the Pacific Northwest. Landslides represent a vegetative-disturbance regime that affect soil substrate conditions, nutrient availability, canopy shading (solar influx), riparian hydrology, and fish habitats. Opening of the forest canopy by geomorphic disturbance results in extensive development of understory vegetation and multi-layered forests (Swanson, 1980). Disturbed regolith provides germination sites for a wide variety of shade-intolerant native and non-native species (Pabst and Spies, 1998). Flood disturbance of bottom lands results in similar vegetative response along floodplain and channel zones (Hupp, 1988). An anthropogenic overprint is added to the system in the form of road construction and logging, which dramatically alter hillslope hydrology and increases the frequency of slope failure (Montgomery, 1994; Wemple and others, 2000). The patchwork of geomorphically disturbed hillslopes and valley bottoms in the Oregon Coast Range likely act as a conduit for the dispersal of non-native species in western Oregon. The Luckiamute watershed, a major east-flowing drainage, will provide an exemplary case study for examination of plant invasion patterns in the region.

METHODOLOGY AND ACTION PLAN

Data Collection and Analysis

Spatial patterns of invasive plant distribution will be examined by use of field identification surveys distributed as a function of landscape and land use elements in the Luckiamute Watershed. Table 2 lists a set of landscape-land use classes commonly associated with disturbance regimes in this area. Survey sites will be selected so that each of these landscape-land use categories is represented in the data set. Systematic plant surveys will be conducted at each site to delineate invasive species occurrence (presence / absence), distribution, and population density. Eight to ten species will be selected from the list on Table 1 along with recently identified species of concern. Examples of the latter include *Tussilago farfara* (coltsfoot), *Heracleum mantegazzianum* (giant hogweed), *Polygonum perfoliatum* (mile-a-minute), and *Arundo donax* (giant reed grass) (Oregon Department of Agriculture, 2003). At each sampling site, quadrats will be established with identification number, position (within disturbance regime), shape, and size determined according to procedures outlined in Elzinga and others

(1998). Plant survey data and landscape-land use maps will be compiled into a Geographic Information System for subsequent management and analysis. The data will be analyzed for spatial associations and standard statistical techniques will be employed to identify any significant differences with respect to invasive species composition and density between quadrats and disturbance regimes. As with the sampling strategy outlined above, analytical procedures will follow those outlined by Elzinga and others (1998).

Table 2. Landscape-land use categories used in this study.

Geomorphic Regime	Geomorphic Disturbance	Land Use Disturbance	Physiographic Setting
Upland / Hillslope			
	Slide Scar (<10 yrs)	N/A	western Coast Range
	Low-Order Channel	N/A	
	N/A	Clear Cut (<5 yrs)	
	N/A	Road Corridor	
Valley Bottom/ Riparian			
	Active Channel	N/A	eastern valley
	Active Floodplain	N/A	
Mixed Upland/ Valley Bottom	N/A	Active Grazing	eastern valley
	N/A	Active Crop Production	
	N/A	Fence Line / Road Corridor	

Results of this project will include: (1) delineation of a select set of invasive species that will serve as useful indicators for monitoring the occurrence and spread of non-native plants in the Luckiamute Watershed, (2) identification of geomorphic and anthropogenic disturbance regimes that are acting as principle migration corridors for invasive plant species in western Oregon, and (3) derivation of spatial associations between invasive species and landscape-land use components. These results will form the basis of more extensive studies in the region and have potential use for development of larger scale predictive models of invasive plant dispersion.

Project Personnel

Co-investigators are Dr. Bryan Dutton, Associate Professor of Biology, and Dr. Steve Taylor, Assistant Professor of Geology, both at Western Oregon University. Dr. Dutton's expertise is in the area of field botany, his on-going research interest involves development of an online plant inventory for Polk County. Dr. Taylor's expertise is in fluvial geomorphology, watershed dynamics, and sediment-transport analysis. Both investigators have extensive experience using Geographic Information Systems software. The project will also involve two undergraduate science majors at Western Oregon University. Student colleagues will augment their undergraduate science curriculum with field-based research applications and assist in data collection, analysis, and dissemination of results. This project emphasizes the importance of multidisciplinary undergraduate research and collaborative faculty-student interaction at Western Oregon University.

Proposed Project Timeline

Proposal Submission:	September 30, 2003
Proposal Review / Award:	October-November 2003
Completion of Institutional Agreements:	December 2003
Anticipated Project Start Date:	January 2004
Sampling Design and Site Selection:	January-April 2004
Field Surveys / Data Collection:	May-August 2004
Data Analysis:	September-October 2004
Data Synthesis and Final Report:	November-December 2004

PROJECT JUSTIFICATION

As stated in the introduction, annual economic losses and habitat degradation by invasive plant species in the United States is well documented (Pimentel et al., 2000). Understanding the controls on spatial distribution of invasives in the context of disturbance regime is critical for designing effective watershed conservation and restoration plans. To this end, the proposed project will: (1) provide important baseline data on the dispersion of non-native invasive plant species in western Oregon, (2) establish a strategy for discerning patterns of invasion according to geomorphic and anthropogenic disturbance regime(s), (3) provide a methodology for assessing susceptibility of land areas to invasion based on select comparator species, (4) contribute to a more thorough understanding of the basic biology of a number of invasive plant species in the region, and (5) provide valuable data and recommendations for future conservation projects by community stakeholders in the Luckiamute Watershed.

BUDGET (2004)

Equipment / Supplies	$1000.00	(software licensing / incidental supplies)
Travel / Mileage	$2000.00	(personal vehicle / field transportation / meetings)
Student Stipends	$4000.00	(stipends for 2 students)
Total:	**$7000.00**	

Student stipends include salary and other personnel expenses (OPE) (2 students x $2000 ea). Travel expenses include costs for personal vehicle mileage at rates established by the Oregon University System (currently $0.36 / mi). Travel will include visits to field sites and partial offset of expenses related to meetings and dissemination of results. Equipment and supplies will include partial offset of software licensing expenses and expendable lab / field supplies.

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