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Invasive Plant Species and Their Impact on Stream Health using Macroinvertebrates in the Willamette Valley, Oregon

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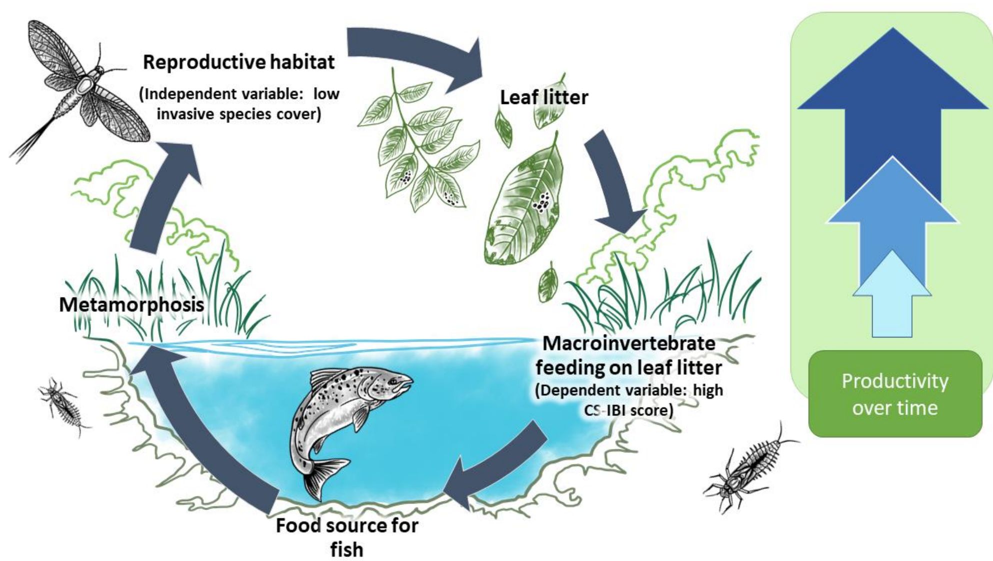
Introduction

Invasive plant species are a significant cause of environmental degradation that affects biodiversity and negatively impacts the economy. Each year, $83 million goes towards managing and eradicating invasive species in Oregon that impact residents with higher costs for agriculture products and other resources (The City of Portland, 2022). The Oregon Statute defines invasive species as "...nonnative organisms that cause economic or environmental harm and are capable of spreading to new areas of the state" (OISC, 2022). Introduced through human actions, they are more resilient to diseases in the ecosystem and experience less predation than native species (USDA, 2022). Because of this, invasive species have a better opportunity to reproduce than currently established species, causing a disturbance in the ecosystem's biodiversity. Some species need to absorb more water from the soil, which takes away from other species (Bansal et al., 2014). Fender's blue butterfly (*Icaricia icarioides fenderi*) is an endangered subspecies that illustrates this process well. They rely primarily on the threatened species Kincaid's lupine (*Lupinus sulphureus*) for reproductive habitat (The City of Portland, 2022). Their decline continues due to aggressive invaders, Himalayan blackberry (*Rubus armeniacus*) and tall oat grass (*Arrhenatherum elatius*) that outcompete soil nutrients and habitat space (The City of Portland, 2022).

Invasive species affect critical habitats known as riparian zones, transitional areas between a waterbody and terrestrial land that sustain biodiversity through habitat and food accessibility. Occupying only 2% of land in the US, they contain 70% of threatened and endangered species (Poff et al., 2014). These zones are high-priority conservation areas in urbanized watersheds. They sustain streambanks from collapsing, preserve water and soil quality, recharge groundwater, suppress wildfires, and reduce damage caused by floods (Kominoski et al., 2013; Wentzel & Hull, 2021). The plants that reside within riparian zones are essential in providing energy through leaf litter for stream ecosystems. Once leaf litter reaches the stream, species of stream insects known as macroinvertebrates, specifically shredders, decompose it (Mutshekwa et al., 2020). They consume the microbes that attach to the leaf, decomposing it in the process (Edwards, 2020). This energy transforms into biomass for the insect, feeding its predators, most notably fish and amphibians (Edwards, 2020; Figure 1). This energy transfer process is known as a transformational link. It is essential to make energy flow within the food web of a stream and terrestrial ecosystem once macroinvertebrates emerge during their adult stage.

Streams and rivers are most affected by invasive species due to their dependence on riparian zones for nutrient input from leaf litter, shade from trees, and channel stability (Kuglerová et al., 2017). In addition, invasive species cause degradation to water quality and weaken the ecosystem's ability to absorb pollutants (EPA, 2022a). In the Pacific Northwest, riparian zones are significant for anadromous salmonids, most of which have been endangered or threatened since the 1990s (Everest & Reeves, 2007). Salmonids carry nutrients from the ocean, including Nitrogen and Phosphorus. By doing so, they supply many freshwater species with the necessary nutrients (Anderson & Connolly, 2022). Previous research found invasive fish species to impact freshwater food webs through excessive predation on native fish species (Havel et al., 2015; Strayer, 2010). These invasions could, in some cases, reduce macroinvertebrate populations, as with Peacock Bass (*Cichla spp.*) in Lake Gatun, Panama (Havel et al., 2015). This research will focus on macroinvertebrates, the primary food source for salmonid populations.

We used macroinvertebrate data to evaluate stream health because they rely on riparian zones and provide a crucial link to the food web in the stream and terrestrial uplands. Certain macroinvertebrate species are sensitive to pollutants in the water, including mayflies (*Ephemeroptera*), stoneflies (*Plecoptera*), and caddisflies (*Trichoptera*). These are indicator species commonly used for biological assessments when monitoring stream health (Hubler et al., 2016). Using this reliable method for collecting stream health data, this study aims to understand the probable effects invasive plant species have on the macroinvertebrate community.



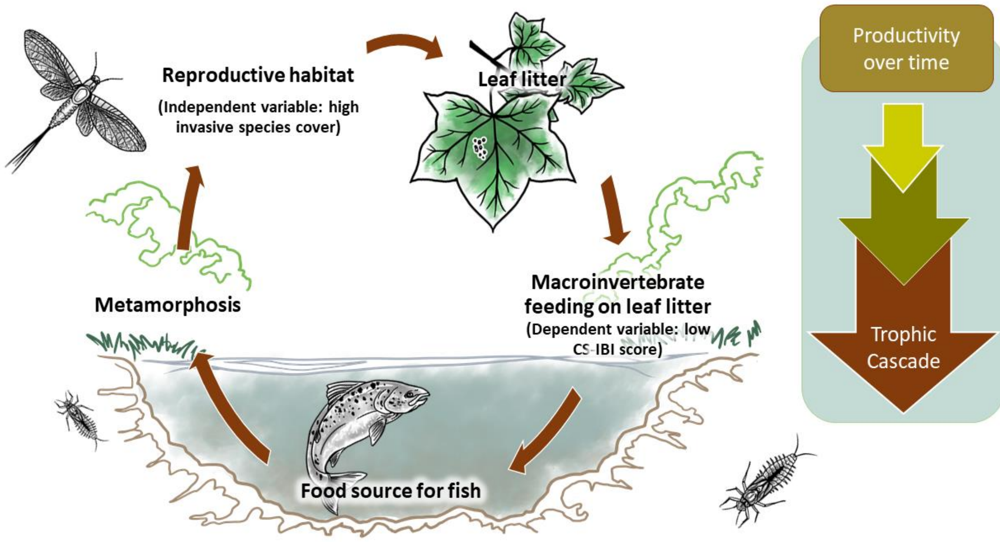


Figure 1. A conceptual model comparing energy flow between native and invasive plants within stream-riparian ecosystems. Invasive species will reduce water quality, directly impacting macroinvertebrate populations. In response, salmon populations will decrease, and over time, the ecosystem becomes unbalanced, leading to a trophic cascade. Arrows signify the amount of energy circulating between each stage.

Figure 1 demonstrates the interconnected relationship between macroinvertebrates and riparian zones and how invasive species could change this dynamic. In a healthy riparian zone, native plants stabilize banks, allow for greater biodiversity, and filters pollutants in the stream. The leaves of these plants serve as reproductive habitat for macroinvertebrates, which bring the eggs back into the stream (Figure 1). In its larval stage, macroinvertebrates feed the fish and predator macroinvertebrate species. Upon metamorphosis, macroinvertebrates become prey to amphibians, birds, and bats that reside within the riparian zone (Edwards, 2020). Over time, this cycle will increase productivity as healthier ecosystems tend to have various feeder types serving different functions (Edwards, 2020). Introducing invasive species can collapse an ecosystem by replacing currently established species and providing less support to these ecosystems. Biodiversity decreases heavily and collapses the ecosystem's food web, also referred to as a trophic cascade (Figure 1). One study in western stream ecosystems found that among 12 invasive species, lower macroinvertebrate assemblages correlated with invasive species presence (Ringold, 2006). Conflicting research has observed higher plant density to increase macroinvertebrates within streams (Schultz & Dibble, 2012). The type of plants, native or invasive, did not affect these results. Another study in coastal British Columbia observed a significant relationship between litter decomposition and species richness of macroinvertebrates when comparing native and invasive tree leaf litter in streams (Kuglerová et al., 2017). Based on the varying results from multiple studies, it is difficult to pinpoint whether invasive species are causing harm to the biota in stream ecosystems.

In addition, this research will investigate what percentage of invasive species coverage are noxious weeds from the Oregon Noxious Weed Profiles. Noxious weeds, unlike invasive species, can be native and non-invasive. However, the governing authority recognizes them as harmful to humans, agriculture, or environmental health (State of Oregon, 2022). Similar to invasive species, noxious weeds are widespread in urbanized areas. Johnson Creek, the most urbanized location, is predicted to have the most noxious weed species. Noxious species, like invasive species, are difficult to manage and typically go unnoticed by people until they are a visible problem. Identifying their effects on stream health is crucial to improving management methods and conserving native and endangered species that are declining as invasive species expand. Based on current published research about the topic, this research would be the first to provide invasive species data specific to riparian zones in Oregon.

Methods

Study locations

This study sampled three streams within the Willamette Basin, Oregon. These streams include Clear Creek, which merges into the Clackamas River at Carver Park, Clear Creek at Metzler Park, and Johnson Creek. Johnson Creek is in Southeast Portland and our most urbanized site per the EPA's stream data, followed by Carver Park and Metzler Park as our least disturbed sites (Figure 2). Clear Creek flows through Carver Park and Metzler Park into the Clackamas River, while Johnson Creek flows into the Willamette River. Metzler Park is our ideal reference site based on available macroinvertebrate data and the least disturbance. Pollution is a significant disturbance factor in streams and correlates to urbanization. Based on Figure 2, EPA assesses Johnson Creek as polluted, with Carver Park having a good result and Metzler Park being an unassessed location. This study chooses stream sites based on available macroinvertebrate data from Dr. Patrick Edwards and citizen scientists. Plant sampling occurs near the end of June when most species are mature enough to be identified based on their features.

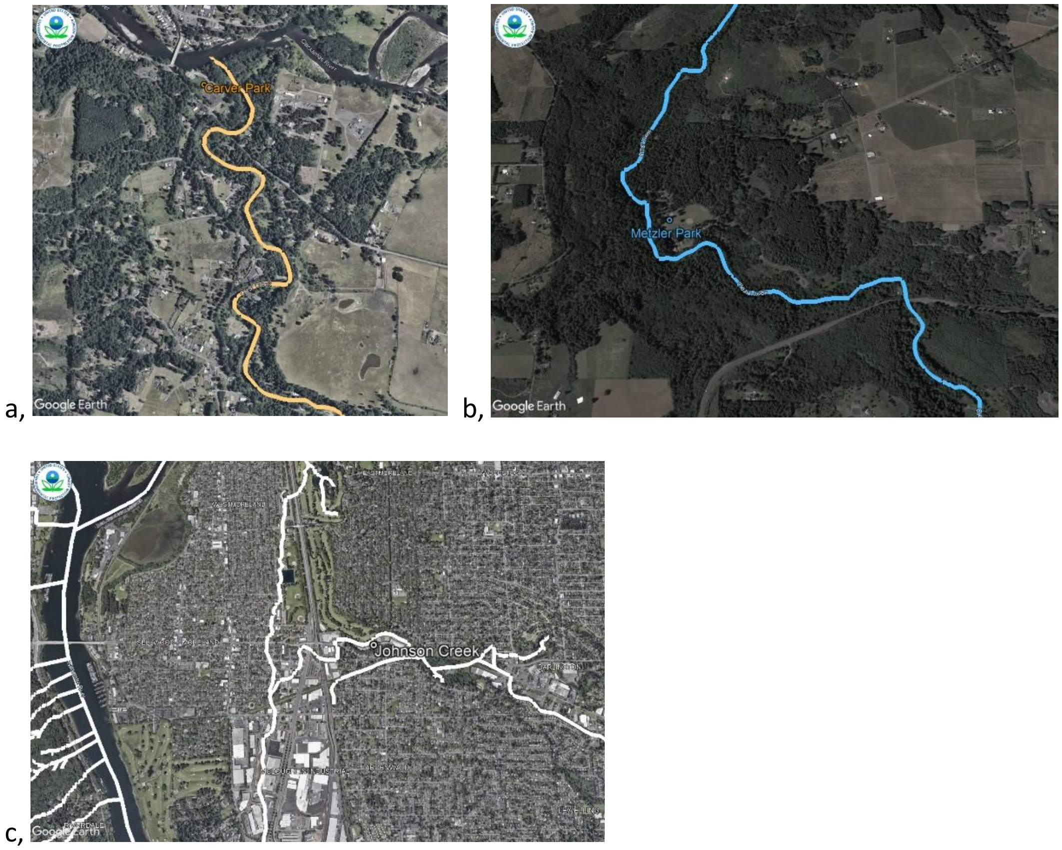


Figure 2. Locations of sampling sites Carver Park (a), Metzler Park (b), and Johnson Creek (c) in their respective order. Using EPA's Watershed Assessment, Tracking, and Environmental Results System (WATER) data, assessed streams are as polluted (white), good (orange), or unassessed (blue). This map does not identify all streams.

Plant sampling procedure

Plant data collection takes place at each site in three locations with clear access to the riparian zone. Accessibility limitations allow sampling to occur only on one side of the stream. A 40 ft transect line is measured inside the riparian zone, preferably closest to the water. We place a 0.50 m^2 folding quadrat starting from the 0 m mark, then every 10 ft alongside the transect for five placements per transect. Identification of all plants inside the quadrat is done at least to their genus level using a dichotomous key from the plant identification book *Plants of The Pacific Northwest Coast* by Paul B. Alaback and the *iNaturalist* identification app. Species coverage only considered plants themselves, disregarding any empty space or non-plant material. Classification of plants as native, nonnative, invasive, or as an Oregon noxious weed is done using *Plants of The Pacific Northwest*

Coast, iNaturalist, Oregon Invasive Species Online Hotline, OregonFlora, Oregon Noxious Weed Profiles, and Google as a last resort.

Macroinvertebrate Sampling Procedure

We use Dr. Patrick Edward's CS-IBI data to complete a biological assessment. Biological assessments collect indicator species like macroinvertebrates to find possible changes in the environment's physical and chemical conditions (Edwards, 2020; EPA, 2022a). Their lack of movement between areas and life span is a valuable way of collecting long-term data in a one-stream system (Edwards, 2020; EPA, 2022b). Macroinvertebrates are especially crucial when identifying disturbances. However, they cannot be evaluated for certain pollutants since they do not always react to the same concentrations (Edwards, 2020). Macroinvertebrates used in this study are collected using citizen scientists with nonlethal sampling methods referred to as the Oregon Index of Biologic Integrity (Edwards, 2020). It uses six metrics to evaluate stream impairment, shown in table 1. Each region has a different rating system for their IBI scores (Teels & Danielson, 2001). Compared to the IBI method professionally used in stream assessments, the CS-IBI completes all data collected in the field without macroinvertebrate preservation or in-depth magnification (Edwards, 2022). Results using this index tend to be lower in species diversity since citizen scientists lack experience in macroinvertebrate identification. However, this method is comparable to professionally collected data and useful in macroinvertebrate surveys among several streams in the Pacific Northwest (Edwards, 2016; Edwards et al., 2018; Blake & Rhanor, 2020).

Metric	**Raw Score**	**5**	**3**	**1**	**Score (circle one)**
Taxa Richness		> 18	10-18	< 10	5 3 1
Mayfly Richness		> 4	2-4	< 2	5 3 1
Stonefly Richness		> 3	1-3	0	5 3 1
Caddisfly Richness		> 4	2-4	< 2	5 3 1
% Diptera		< 15	15-30	> 30	5 3 1
% Dominance		< 30	30-50	> 50	5 3 1
					Sum the Score

Table 1. Oregon Index of Biologic Integrity's six metrics and their scoring system used to find the condition of a stream Image by Oregon Watershed Enhancement Board.

Collection of live samples occurs on each side of the bank and the middle of the stream using a D-net facing upstream (Figure 3). A 1 m^2 plot is visually estimated before the net and physically disturbed for about 90 seconds. Afterward, the net is slowly picked up and cleaned of the substrate and potential insects in a clear tub filled with stream water. The water is randomly spread in a sectioned tray using a turkey baster. Five sections are selected using a randomized number sheet and evaluated for species richness. The EPT index calculates family count, which consists of pollution-sensitive macroinvertebrates mayflies, stoneflies, and caddisflies. Percent True Fly (*Diptera*) is calculated by combining all true fly abundance and dividing it by the total. Percent Dominance divides the top abundant three families by the total. The raw score is our initial result for each metric before it is condensed into one of the scoring categories 5, 3, or 1 (Table 1). The sum of these scoring categories will determine whether the stream is impaired (0-33), moderately impaired (34-66), or unimpaired (67-100).

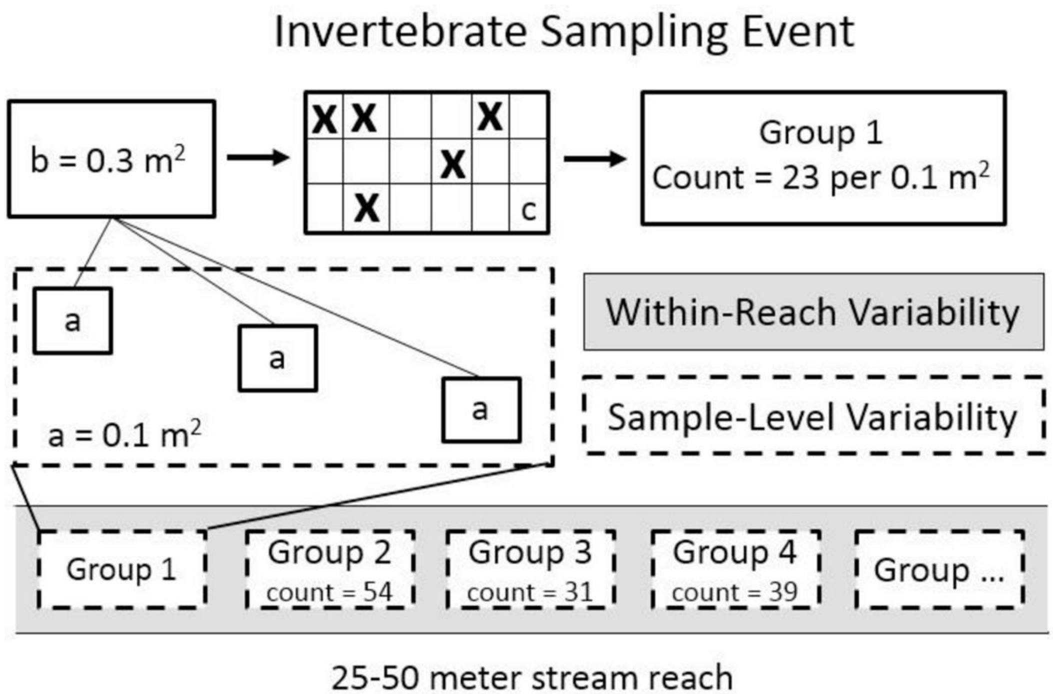


Figure 3. Macroinvertebrate field collection method for calculating the CS-IBI score. Image by Edwards, 2016.

Data Analysis

The IBI scores are calculated by Dr. Patrick Edwards using family-level richness and abundance of macroinvertebrate species. We condense plant data in google sheets, with invasive species having their percentages combined for each quadrat. Each transect has an average for invasive species cover. Figures are created in Excel. Noxious species coverage was calculated by taking the average of each quadrat's percentage. Quadrat placements without noxious species have a label of "0". A regression analysis is run through excel to find the significance between invasive species cover and CS-IBI score using the statistical R^2 and p-value.

Results

Each sampling site has its unique ecosystem, alongside its fair share of human disturbance. Recreational usage is the primary reason people interact with the riparian zone.

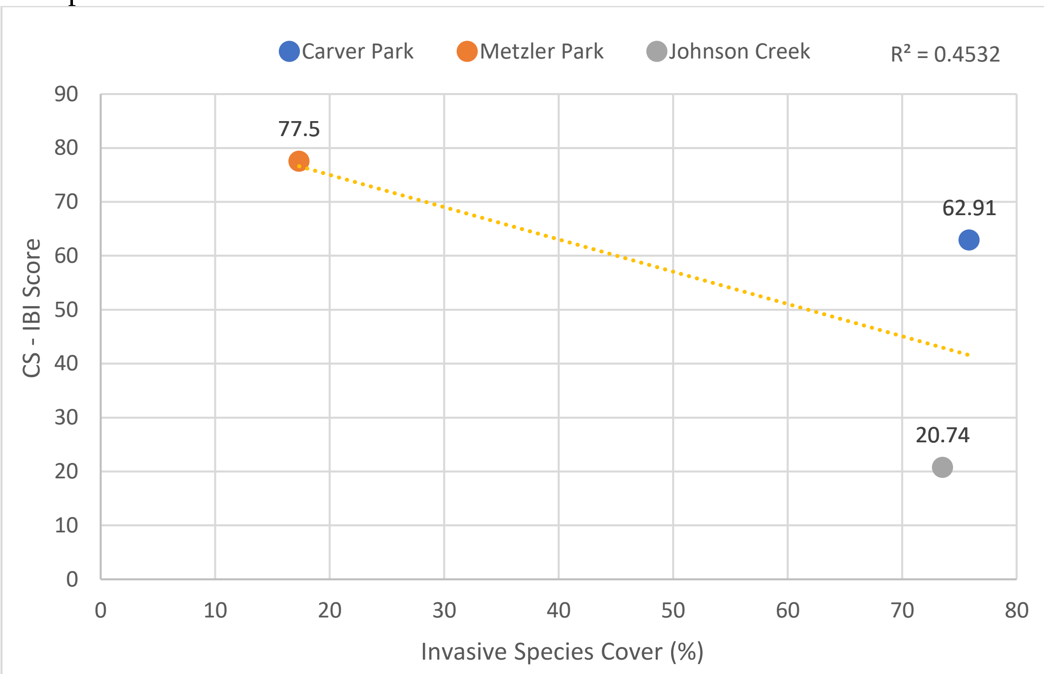


Figure 4. Results portraying the relationship between invasive species cover (%) and averaged CS-IBI Score.

CS-IBI measurements for each stream and each location's average invasive percent cover. Our results show a negative linear relationship between invasive species cover and CS-IBI score (Figure 4). Metzler Park has the highest average CS-IBI of 77.5 and falls into the unimpaired category. In contrast, Johnson Creek has the lowest average CS-IBI score of 20.74, making the stream impaired (Figure 4). Although Carver Park has the highest invasive species cover, it has a much higher CS-IBI score average than Johnson Creek (Figure 4). Regression statistics gave an R^2 value of 0.45 and a p-value of 0.07, which are not statistically significant.

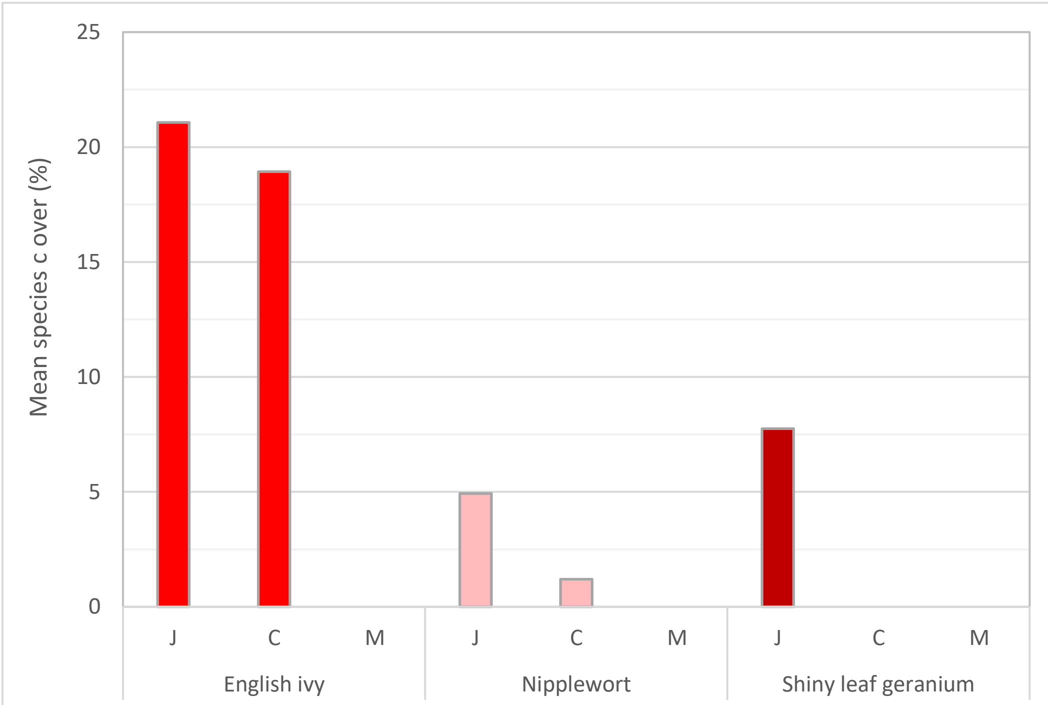


Figure 5. Bar graph comparing each location's percent coverage of the most abundant invasive species. The three sampling locations are divided for each species and abbreviated as Johnson Creek (J), Carver Park (C), and Metzler Park (M). The percentage of invasive species cover compares to the total percent coverage of other species found in the site. The order of locations is set based on urbanization, with Johnson Creek being the most urbanized site and Metzler Park being the least.

Urbanization affects the percentage of noxious species in riparian zones. Johnson Creek has the highest percentage of all three noxious species: English ivy (*Hedera helix*), Nipplewort (*Lapsana communis*), and Shiny leaf geranium (*Geranium lucidum*) (Figure 5). English ivy has the highest percentage of species cover at 21.07% in Johnson Creek (Figure 5). Carver Park has English ivy and Nipplewort present, although English ivy has a higher percentage of species cover at 18.93% compared to Nipplewort at 1.20% (Figure 5). Metzler Park has no observations of any of these invasive species. Shiny leaf geranium is observed only at Johnson Creek, with a percentage of 7.75%.

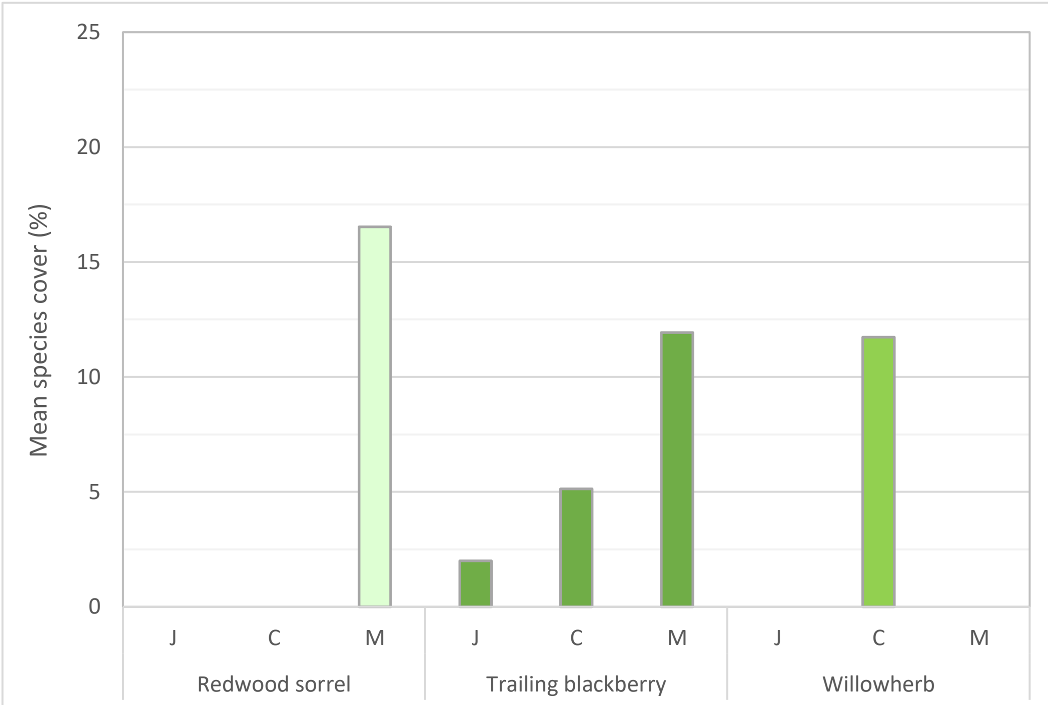
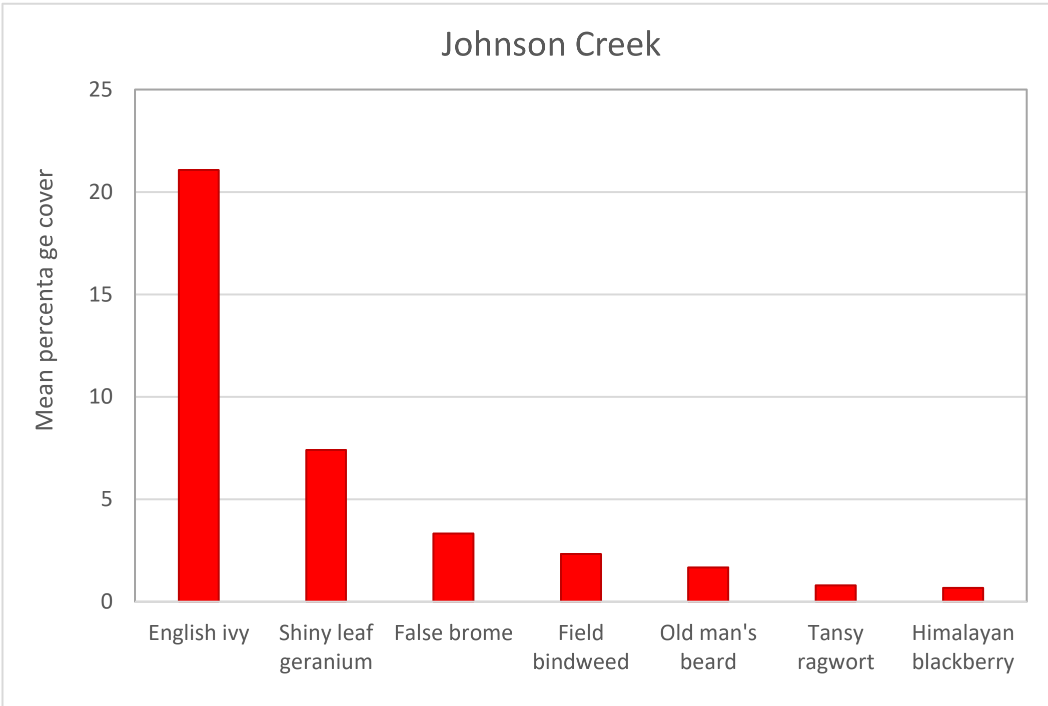
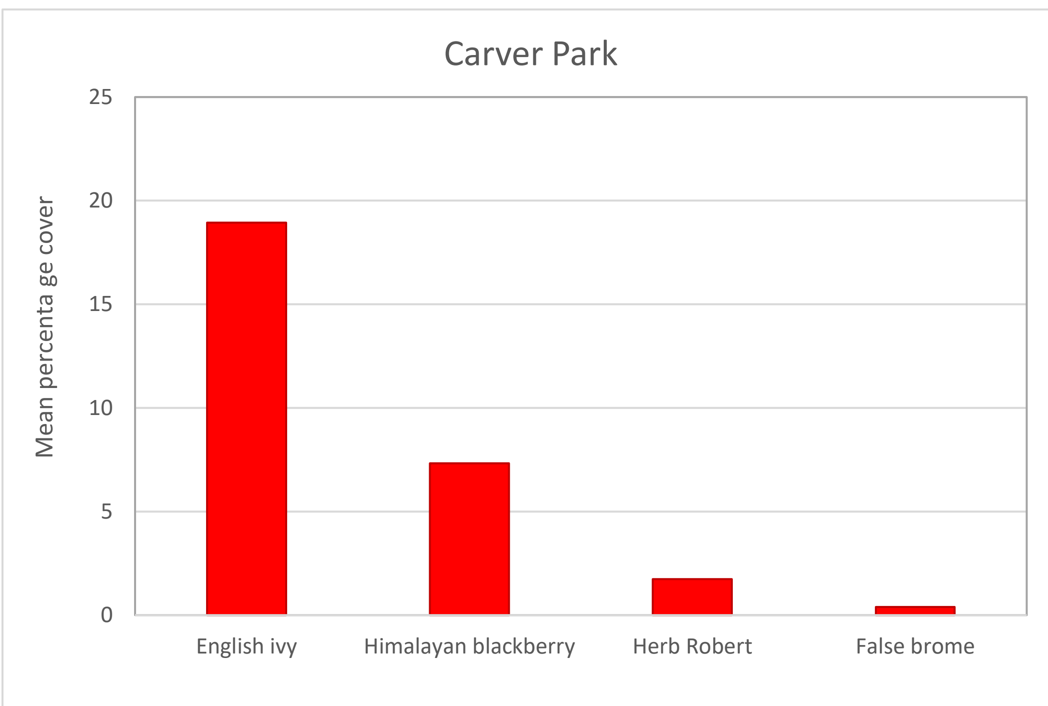


Figure 6. Comparing percent coverage of the top three most abundant native species. Each species divides into three sampling locations: Johnson Creek (J), Carver Park (C), and Metzler Park (M). The order of locations is the same as in Figure 5.

There is a correlation between native species presence and urbanization of the sampling site. Johnson Creek only has one of these top natives, Trailing blackberry (*Rubus ursinus*), present at 2% (Figure 6). Trialing blackberry is present at every location, with Metzler Park having the highest percent over at 11.93% (Figure 6). Based on the results of this research, Redwood sorrel (*Oxalis oregana*) is present only at Metzler Park, with the highest species cover at 16.53% among the three native species (Figure 6). Willowherb (*Epilobium ciliatum*) is only present at Carver Park, with an 11.73% species cover.


Johnson Creek
Mean percenta ge cover
25
20
15
10
5
0
English ivy
Shiny leaf geranium
False brome
Field bindweed
Old man's beard
Tansy ragwort
Himalayan blackberry


Carver Park
Mean percenta ge cover
25
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English ivy
Himalayan blackberry
Herb Robert
False brome

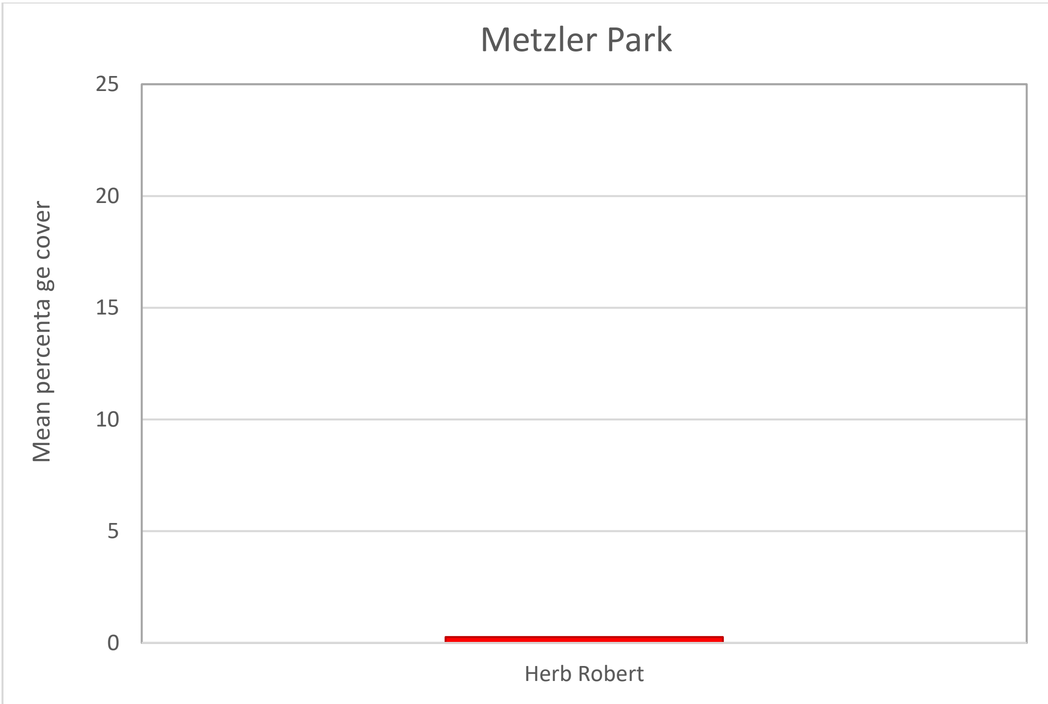


Figure 7. Mean percentage cover of observed Oregon Noxious Weeds at each sampling site.

Our results show invasive species as our only noxious weeds (Figure 7). Each measurement uses averaged percentage cover from all quadrat placements. English ivy has the highest mean percentage cover for Johnson Creek and Carver Park. At both sites, it is present at ~20% percent. Metzler Park has the least invasive species, with a mean percentage cover of 0.27% for Herb Robert (*Geranium robertianum*) (Figure 7). Herb Robert is present in Carver Park at 2% (Figure 7). Himalayan blackberry is Carver Park's second-highest mean percent cover and the lowest percent cover for Johnson Creek (Figure 7). Comparing all sites, Johnson Creek has a higher species richness, with six different noxious species at its site (Figure 7). Carver Park has four different species, and Metzler Park has only one. The Oregon Department of Agriculture classifies noxious weeds in Oregon by the following: A-listed weeds, B-listed weeds, and T-listed weeds. A-listed weeds have small infestations and could threaten neighboring states (ODA, 2022a). B-listed weeds are abundant and dealt with on a case-by-case basis (ODA, 2022a). T-listed weeds are the focus for prevention and control, with ODA implementing a statewide action plan to control them (ODA, 2022a). From our results, most plants are on the B list, with tansy ragwort (*Senecio jacobaea*) being the only exception and placed in both B and T lists (Oregon State Weed Board, 2022).

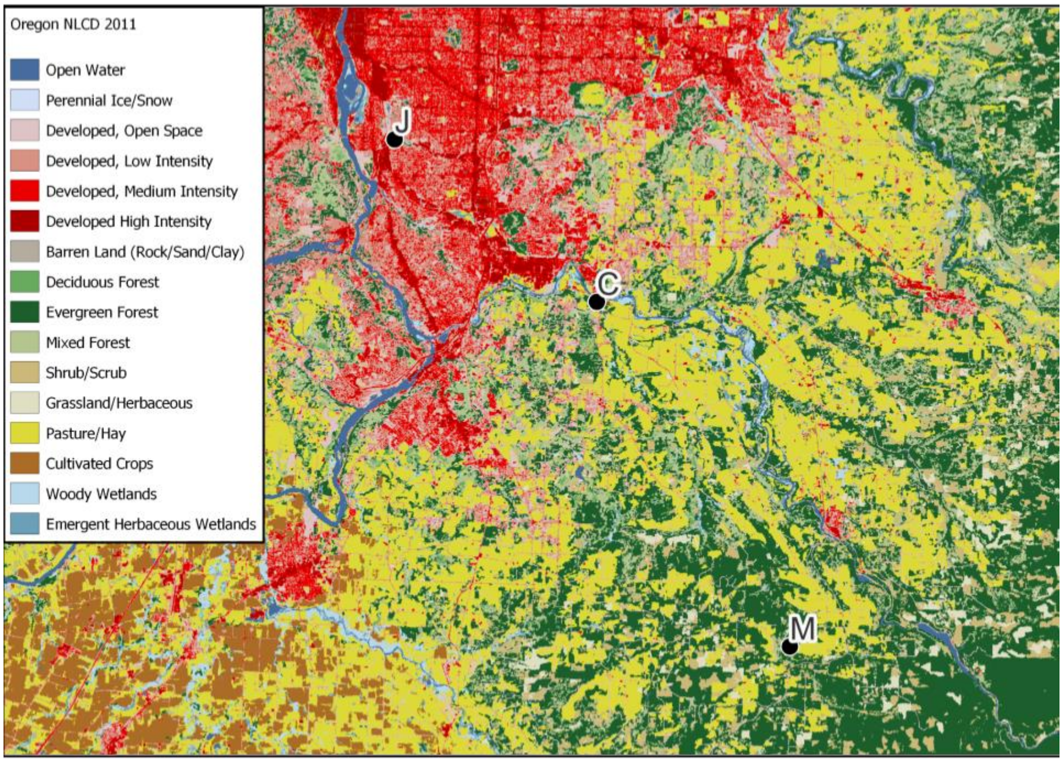
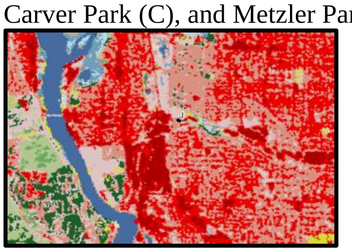
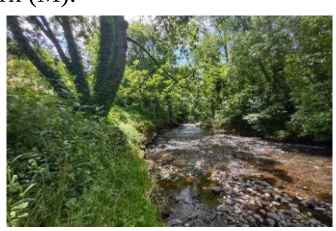


Figure 8a. Sampling sites evaluated for land use with the Oregon National Land Cover 2011 Database (NLCD). The following are abbreviations for sampled streams: Johnson Creek (J), Carver Park (C), and Metzler Park (M).

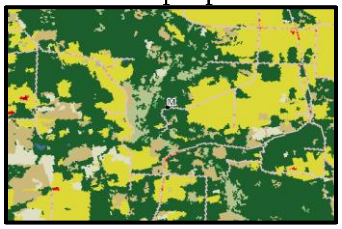

<u>Johnson Creek</u>

Fewer shaded areas compared to its stream width. While taking samples, signs of human and dog activity are visible near the stream. The non-accessible side of the stream is part of a golf course.



<u>Carver Park</u>

Sampling on an off-path trail that many people would use to enter the stream for recreational purposes.



Metzler Park

Recreational activities, including swimming, wading in the water, and camping are prominent. Many visitors chose to walk on off trail paths.

Figure 8b. Close-up of each sampling location from Figure 8a, including site photos and observations.

Urbanization is a covariant in this experiment due to its heavy influence on stream health and biota. The Johnson Creek site comprises developed open space, low, medium, and high intensity, with a small amount of pasture/ hay areas and mixed forest (Figure 8b). Carver Park has a blend of Evergreen Forest, mixed forest, open water, and woody wetlands, and developed low intensity (Figure 8b). Metzler Park primarily has an Evergreen Forest with a small amount of mixed forest, shrub/ scrub, and pasture/hay (Figure 8b). All three sites show a variety in land usage, where Johnson Creek is the most urbanized site and Metzler Park is the least urbanized. Carver creek, our moderately impaired site, has less urbanization than Johnson Creek but more urbanization compared to Metzler Park (Figure 8). The location of these streams plays a significant part in their land usage, where Johnson Creek is in Portland and Metzler Park is furthest from the city (Figure 8a).

Discussion

Our results show that invasive species may negatively impact stream health. While being utterly different stream systems, Johnson Creek and Carver Park has similar invasive species presence (Figure 4). Interestingly, Carver Park has a slightly higher invasive species presence and a higher CS-IBI score than Johnson Creek (Figure 4). Comparing these results to USGS Regional Stream Quality Assessment, Johnson Creek's CS-IBI score of 20.74 is similar to the Macroinvertebrate Multimetric Index (MMI) score of 21.95 collected at Johnson Creek at Circle Ave, OR (USGS, 2015). The MMI uses macroinvertebrate assemblages and disturbance, with a similar scoring metric to CS-IBI, the main difference being that MMI is used professionally whereas CS-IBI is collected by non-professionals (Edward, 2016). Metzler Park is comparable to the USGS data, where its MMI is 74.52 compared to our result of 77.50 (USGS, 2015; Figure 4).

There is a possible link between urbanization of riparian zones and the MMI scores. The riparian conditions for Metzler Park show that 0% of riparian areas are urbanized or used as cropland; Johnson Creek has a score of 38%; Carver Park is 7% (USGS, 2015). From these results it can be speculated that a more urbanized riparian zone leads to higher invasive species presence. Our experiment only took samples from one side of the stream, leaving out many potential invasive species and noxious weeds. In Johnson Creek, there is a visually noticeable difference between each side of the stream's riparian zone in terms of usage. One side of the riparian zone is part of a residential area, and the other is the property of a golf course. Sampling both sides could impact the type of species we would observe in the riparian zone. This consistency is necessary to keep in mind when identifying the possible flaws in this research. These unexpected results could be due to identification mistakes primarily with grass species, most notably invasive annual grasses. In Eastern Oregon, invasive annual grasses, including cheatgrass (*Bromus tectorum*), medusahead (*Taeniatherum caput-medusae*), and ventenata (*Ventenata dubia*), have aggressively invaded and displaced native sagebrush ecosystems (Bansal et al., 2014). These grasses compete for soil moisture and reduce water availability for native species (Bansal et al., 2014). Invasive grasses are difficult to identify and could impair stream health if left to spread. Grass species are present in all sampling locations. However, they were difficult to identify as they looked similar and could have skewed results. In our noxious weeds results, False brome (*Brachypodium sylvaticum*) was the only grass species present, only in Johnson Creek, at 3.33% (Figure 7).

Noxious weeds are most present at Johnson Creek and least at Metzler Park, an expected result considering the difference in urbanization between the sites. English ivy, an aggressive and resilient noxious weed, has the highest percent cover observed in both Johnson Creek and Carver Park. The ODA categorizes English ivy on the B-list and is very costly to remove, up to $3000 per acre (ODA, 2022b). The species most targeted for removal and maintenance is tansy ragwort, which is on the T-list for noxious species (ODA, 2022c). tansy ragwort is present in Johnson Creek at the lowest percentage for noxious species at 6% (Figure 7). The issue with this species is its toxicity towards horses and cattle, alongside its resilient seeds that can last in the soil for 15 years. It is an aggressive spreader in the Portland area (ODA, 2022c). The National Park Service states that tansy ragwort thrives in well-drained soil and has two predators: ragwort flea beetle (*Longitarsus jacobaeae*) and cinnabar moth (*Tyria jacobaeae*) (Reeves, 2016). Its impact on riparian ecosystems has yet to be evaluated but could be studied in future research.

Studies have found a shift in macroinvertebrate communities based on litter decay from invasive species in comparison to native ones (Kennedy &

Sabaawi, 2018). However, there have been instances where invasive species provide similar functions to native species and do not affect macroinvertebrate communities. A study in Idaho comparing native and invasive tree litter over three months observed that Japanese knotweed (*Fallopia japonica Houtt. Ronse Decrane*) decomposed similarly to Alder (*Alnus incana L*.) and Cottonwood (*Populus trichocarpa TORR.* and *GRAY*). Alder has twice the amount of nitrogen in its leaf litter (Braatne et al., 2007). Japanese knotweed is a deep-rooted riparian plant known to outcompete native species by absorbing more water and nutrients. The plant has a sooner growing season, and with this advantage, it can collect more sunlight (Braatne et al., 2007; ODA, 2022). Observations in this research could not find significant differences in macroinvertebrate assemblages between invasive and native plant litter (Braatne et al., 2007). A similar study comparing native and invasive plant litter in South Africa found no significant results between the two groups regarding macroinvertebrate abundance and composition (Mutshekwa et al., 2020). Similarly, a study in British Columbia found macroinvertebrate richness to be higher and density to be ~20% and 40% greater in invasive litter bags compared to native ones (Kuglerová et al., 2017). Invasive species in this study have a faster decomposition rate. Although macroinvertebrates may prefer species whose decomposition is faster, that does not mean that invasive species do not pose indirect threats while living in the ecosystem (Kuglerová et al., 2017). Riparian zones typically form in areas with unstable soil, making them more likely to experience erosion (Everest & Reeves, 2007). Adding invasive species in riparian zones is more likely to escalate erosion, making the stream susceptible to sedimentation and flooding after the plant dies back during the fall and winter (Oorschot et al., 2017).

Our research can improve further by sampling streams within the Willamette Valley primarily affected by the dominant invasive species, English ivy. Focusing on dominant invaders may bring certainty as to whether invasive species in riparian zones affect biota communities inside the stream. Most invasive species research focuses on the current effects a species has on the ecosystem. Current practices to eradicate invasive species lack historical information and consistent management methods, especially in stream ecosystems, allowing an accessible mode of transportation by stream flow. Japanese knotweed, for example, occupies highly disturbed areas and prefers riparian areas because it can disperse its seeds through waterways (Oorschot et al., 2017). The Oregon Invasive Species Council's (OISC) statewide action plan offers prevention strategies, early detection, rapid response, control, management, education, outreach, coordination, and leadership (OISC, 2017). Understanding how invasive species could evolve and become effective invaders is crucial to managing them in the future and present. The best method for eradicating invasions is by preventing their introduction in the first place. According to the US Congress Office of Technology Assessment report in 1993, every dollar spent on prevention practices saves $17 for management expenses in the long run (Sheley et al., 2011). Overall, invasive species threaten a stream ecosystem's well-being, and its interactions with biota in riparian and stream ecosystems must undertake further exploration.

Limitations

In a natural setting, many factors influence stream health directly and indirectly, adding uncertainty to our results. For future research, collecting plant samples from multiple stream sites of differing urbanization may provide a larger sampling pool and better consistency between results. Due to time limitations, we could not evaluate how each species influences the riparian zone, considering that each species poses a different impact or benefit. For example, Water thymes (*Hydrilla verticillata*) did affect macroinvertebrate assemblage but not native species richness (Havel et al., 2015). A similar study evaluates individual invasive species compared to stream conditions using macroinvertebrate MMI (Ringold, 2006). The cause and effect of plant invasions are uncertain. However, researchers of this study infer human activity and reduced stream biotic conditions to be an association (Ringold, 2006). Anthropogenic activity results in the misplacement of invasive species. Unlike native species, invasive species can use their functions in this new environment to their reproductive advantage. Himalayan blackberry, which spreads through roots and seeds, grow as dense, thorny bushes, preventing new vegetation from establishing itself (McQueeney, 2017). They are aggressive invaders and do not provide enough shade compared to native shrubs and trees that help cool streams necessary for macroinvertebrates to thrive (McQueeney, 2017).

The scope of this research only considers invasive plant species in riparian zones that emits invasions inside the stream itself, where macroinvertebrates spend most of their lifespan. An older study observes the invasive plant water-milfoil (*Myriophyllum spicatum*) to form large mats on the water surface, displacing native plants and reducing food sources for macroinvertebrates (Havel et al., 2015). Another study found certain invasive plants to increase biota in streams, although their density prevents predator fish species from being able to forage for food sources including macroinvertebrates (Strayer, 2010). Other invasive plants decrease oxygen availability inside streams, reducing biodiversity due to hypoxia (Strayer, 2010).

While effective, using a quadrat and percentage cover is not representative of the whole plant if it goes outside the quadrat's frame. Conducting plant ID using dichotomous keys and identification apps only considers plants at later stages of their life cycle, making it challenging to identify seedlings and immature plants. In addition, some plant species have many similar features making it difficult to distinguish whether they are native or invasive. The Portland Plant List acknowledged that what people classify as an invasive species may change over time based on the geologic conditions, climate, and the plant's reproductive methods (Anderson & Zehnder, 2016). To correctly distinguish invasive species from native ones, we must first have an updated and accessible record of information. For example, some sources consider trailing blackberry as Oregon's only native blackberry, while others deem it somewhat invasive (Finn & Strik, 2014; McQueeney, 2017). It took much effort to find information about species and their probable effects on the environment, especially if they were lesser known. This uncertainty creates confusion for people taking interest in finding accurate information on how to identify, manage, and remove invasive species that continue to degrade riparian zones that protect stream health.

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