BODY SIZE AND GROWTH RATES OF THE WESTERN POND TURTLE AND RED-EARED SLIDER IN GOLDEN GARDENS PARK, OREGON

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A THESIS

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Peg Boulay, Primary Advisor

Abstract

The conservation of native species has become increasingly important in order to maintain ecosystems in a more sustainable manner. The western pond turtle (*Actinemys marmorata*) is one of the few native turtle species to Oregon and its population sizes have been decreasing. One invasive species that may be affecting population size and health of the western pond turtle is the red-eared slider (*Trachemys scripta elegans*). This species is one of the most predominate invasive species in the world, and has successfully established populations wherever it has been introduced. I studied the two species' populations at Golden Gardens Park in Eugene, Oregon. In order to understand the relationship between the two species, I compared age distributions, as well as carapace length, and weight. I hypothesized that the western pond turtle would have an older and less evenly distributed age distribution, smaller weights per age class, and smaller carapace lengths per age class than the red-eared slider. The red-eared slider had a more even age distribution, larger carapace length per age class, and larger weight per age class than the western pond turtle. The invasive red-eared slider may be negatively affecting the western pond turtle's native population. The red-eared slider has the potential to reach age of first reproduction before, nest earlier and produce more eggs

than the western pond turtle. Additionally, both species compete for similar resources and the increased size of the red-eared slider may be allowing for competitive exclusion from resources for the western pond turtle. Based on my results, I suggest further management strategies to be used in Golden Gardens Park and suggest future project techniques to create a more rigorous project.

Acknowledgements

I would like to thank the City of Eugene and Oregon Department of Fish and Wildlife for providing me with tools, cages, and access to Golden Gardens Park. I would also like to thank Susanna Lim and Tom Titus for helping me revise and stay on track for my thesis. Lauri Holts, the Natural Resources Coordinator for City of Eugene, allowed me to help her collect turtles from traps and shared so much information with me about her own projects. Lauri is also committed to the preservation of the native species, and she often writes grants to repair riparian areas along the pond systems in Eugene. Chris Yee allowed me to conduct my project along with his own work and gave me information and support throughout the project. Chris often works with fish populations, but he also does turtle population studies at Golden Garden and Delta ponds around Eugene. He feels that the invasive red-eared slider population has grown so much that the western pond turtle populations are now in danger of being out-competed. He dedicates much of his free time to studying and trapping each species within the ponds and doing analysis of health features. Finally, I would like to thank Margaret (Peg) Boulay. Peg provided me with the education to write this paper and organize my project; she introduced me to Chris Yee, and continuously provided me with support and guidance throughout the writing process.

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Introduction

Native Western Pond Turtle

Western pond turtle (*Actinemys marmorata*) populations occur along the west coast of North America, ranging from Baja California Norte, Mexico, to the foothills of Puget Sound in Washington (Baird and Gerard 1852; Bury and Germano 2008). In Oregon, the western pond turtle occupies habitats in the Willamette Valley, the western Cascades, the Coast Range (below 4,000 feet), the Columbia River, and southwest Oregon (Rosenberg et al. 2009). This species utilizes aquatic environments for food, escape cover, and hibernation, as well as terrestrial environments for nesting and hibernation. Aquatic environments can be either lentic habitats such as static ponds, swamps, and lakes, or lotic habitats, such as slow-flowing streams (Rathbun et al. 2002).

The western pond turtle currently inhabits 90% of its historic geographic range. The western pond turtle's population sizes are decreasing throughout its range, particularly in urbanized areas (Bury and Germano 2008). Populations of the western pond turtle have declined with increased habitat alteration and fragmentation (Buskirk 2002). Other threats to the western pond turtle include predation of nests or hatchlings by native and non-native species. Raccoons and invasive species, such as the red-eared slider, are primary threats to this species (Bury and Germano 2008).

The western pond turtle is a native turtle species currently included on Oregon's Sensitive-Critical Species List (Rosenberg et al. 2009). This non-regulatory list highlights species that are "facing one or more threats to their populations and/or habitat" (ODFW 2010). The threats that the western pond turtle species are facing must be identified and addressed to prevent the species from becoming a candidate for endangerment listing. As a result of being on the Sensitive-Critical Species List, there was increased research about western pond turtle population numbers and population health threats (Rathbun 2002).

Invasive Red-Eared Slider

The red-eared slider (*Trachemys scripta elegans*) naturally occurs in the central and southeastern United States within large rivers and their tributaries (Conant and Collins 1991; Salzberg 2000). While not native to the western United States, they are now found throughout all of the western states and internationally. They can be found throughout Oregon, and have been found in larger concentrations throughout the Willamette Valley and in Southern Oregon (Rosenberg et al. 2009).

The primary cause for red-eared slider introduction into non-native territories is release by pet owners (Cadi and Joly 2004, Hayes et al. 1999). Red-eared sliders are the most commonly sold species within the pet trade (Cadi and Joly 2004). Although the red-eared slider is illegal to possess and sell in Oregon, people continue to own them because it is not illegal in many other states, even as close as Washington. While these regulations are readily available through the internet outreach has not been effective enough to inform the public of the legal status and ecological impacts caused by the release of this species (ODFW 2009 (a)).

Possible Impact of Invasive Species

The introduction of a non-native species can alter the health of native communities through multiple processes including predation, disease and parasite introduction, and competitive exclusion (Cadi and Joly 2004; Hayes et al. 1999). Often potential impacts are hard to predict and understand, especially when considering an under-studied species, such as the red-eared slider. Any time an invasive species is introduced into an ecosystem there may be repercussions because the native and non-native species do not share a co-evolutionary pathway. These introductions can allow for new selective pressures that affect the habitat usage and fitness of both introduced and native species (Cadi and Joly 2004). Although the influences of non-native species on natives and are hard to determine, it is often expected that if each are using one resource, such as the same food, competition is likely (Cadi and Joly 2004).

For example, a study in France focused on the weight and survival of a native European pond turtle (*Emysorbicularis galloitalica*) and the red-eared slider over a period of time (Cadi and Joly 2004). Researchers concluded that the native species was not able to compete with the rapid reproduction and disease resistance of the red-eared slider. Cadi and Joly (2004) showed that the invasive species was negatively affecting the native species. They suggested that management strategies for banning the importation of exotic species to preserve the natural biota.

Potential Interactions between the Western Pond Turtle and the Red-Eared Slider

Ecology

The western pond turtle and red-eared slider are both ectotherms, and must thermoregulate externally to maintain their body temperatures (Bury and Germano 2008; Meek and Avery 1988; Alvarez 2006). These turtles forage during late afternoon or early evening while basking intermittently throughout the day to maintain an internal body temperature of 24-32 °C (Bury and Germano 2008). To raise their internal temperature, turtles will come out of the water to bask by exposing their shell to direct sunlight (Bury Germano 2008). Because of this, basking structures such as logs or large rocks are important for turtle growth and survival (Cadi and Joly 2003). Turtles generally choose basking structures in areas with low canopy cover to maximize access to direct sunlight.

During prime basking periods, turtle presence on basking structures can continue to increase until structures are crowded (Figure 1). Some turtles will climb on each other, or will become aggressive while basking and push each other off of the basking structure (Polo-Cavia et al. 2009). The red-eared slider may use aggressive behavior to compete with and overpower the western pond turtle. Red-eared sliders have evolved aggressive behavior for interspecific competition in their native range in order to have access to required resources, such as food (Cadi and Joly 2003; Da Silva and Blasco 1995).

In a study on the effects of the introduction of the red-eared slider on native Sonora mud turtles (*Kinosternon sonoriense*), Da Silva and Blasco (1995) evaluated competition for basking structures between the native turtle species and invasive red-eared sliders. The results indicated that the presence of the red-eared slider changed the basking behaviors of the native species and that the red-eared slider spent more time basking than the native mud turtle.

Other than competition for basking sites, the western pond turtle and the red-eared slider might also interact during feeding. Both species are primarily opportunistic omnivores that feed on aquatic invertebrates and some live vegetation, and scavenge on dead plant and animal materials (Rosenberg et al. 2009, Bury 1986). Conditions of slow moving or standing water are needed for turtles to acquire adequate supplies of food and conserve energy (Bury and Germano 2008).

Both species need similar habitats to survive, and because of this, the red-eared slider is thought to negatively impact the western pond turtle because it may be better adapted to changing conditions (Cadi and Joly 2004). Moreover, the western pond turtle is likely more susceptible to disease introduction from an invasive species because it has not been previously introduced to the diseases or parasites to which the red-eared slider has adapted to over time through the habitats it has been introduced to or acquired from being bred in captivity (Cadi and Joly 2004; ODFW 2009).

Other mechanisms that may negatively affect the western pond turtle are exclusion from resources such as nesting sites, food, and basking structure space. Nesting areas consist of soft substrate, a low-inclined terrestrial slope from the water, and high solar radiation (Rosenberg et al. 2009). Exclusion from these areas may be because the red-eared sliders have a predisposition to continual competition in many environments that the western pond turtle has not had in its evolutionary history (Cadi and Joly 2004). Through the adaptability to compete in varying environments the red-eared slider may be less affected by population control factors that native species' populations may be controlled by.

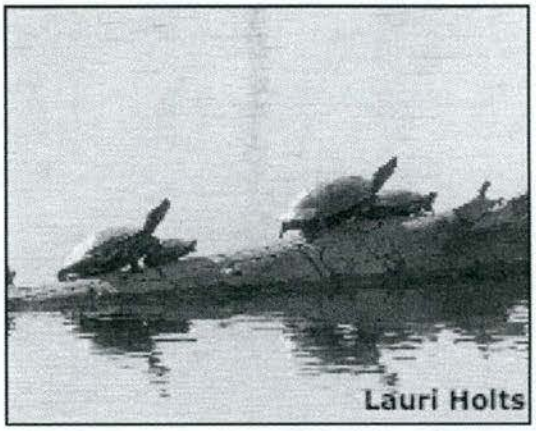

Figure 1. Western pond turtles (forward, right) and red-eared sliders (behind, left) on a basking log. This image shows the difficulty that a smaller western pond turtle might have while trying to bask if basking structures become crowded. The red-eared slider could ultimately over take and push the western pond turtle off of the structure.

Reproduction

Reproduction rates may differ between the red-eared slider and western pond turtle. Red-eared sliders have earlier nesting behavior and an earlier age of first reproduction, and these may allow the red-eared slider to out-compete the western pond turtle. While both species can live up to thirty years, both start reproducing when they reach six inches in length. However, the red-eared slider starts reproducing at a much younger age than the western pond turtle, due to faster growth rates (Tucker 1998). At first age of reproduction for the western pond turtle can take up to 12 years and as little as 3 years for the red-eared slider, although the time varies depending on local climatic temperatures and incubating times (Tucker 1998). For example, in higher temperatures of incubation, eggs are more likely to become female than male.

Additionally, both species can produce single or multiple clutches during a breeding season, but having multiple clutches and is less common for the western pond turtle (Brown et al. 1995; Tucker 1998). Holland and Bury (1998) noted that the western pond turtle might only produce every other year at the northern extent of its range. Moreover, the number of eggs per clutch increases with female age and size. Red-eared sliders reach reproductive age earlier than western pond turtles because of their rapid growth rates (Brown et al. 1995). Because they grow larger, red-eared sliders may have more eggs per clutch than the western pond turtle (Figure 2) (Brown et al. 1995). Red-eared sliders lay their eggs a month earlier than the western pond turtle and may therefore occupy preferred nesting areas (Brown et al. 1995). Earlier nesting by the red-eared sliders may alert predators to the presence of turtle eggs, resulting in increased nest predation rates and decreased hatching rates of western pond turtles (Rosenberg et al. 2009).

In summary, the western pond turtle may be threatened by the presence of red-eared sliders through many mechanisms including nesting, reproduction, basking, and feeding. The red-eared slider has been documented to negatively impact other turtle species outside of its native range (Cadi and Joly 2004). It is crucial to test different factors that can be impacting the native species' population survival and reproduction. When understood, these factors can help to determine mechanisms and potential solutions to minimize impacts from invasive species.

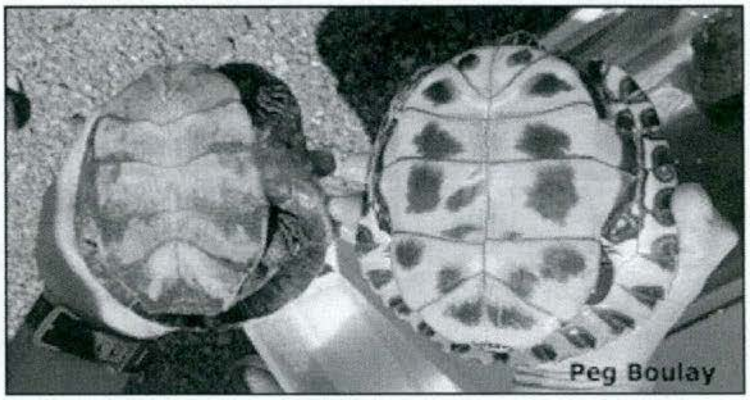

Figure 2. Size differentiation between the western pond turtle (left) and the red-eared slider (right). These turtles are the same age, but the red-eared slider has a much larger shell then the western pond turtle.

Knowledge To Be Gained

The introduction of the red-eared slider into non-native regions and the impacts of invasive species in non-native territories have not been widely studied internationally or in the United States. However, there are studies involving the effects of invasive species on native species. In the case of the western pond turtle, understanding how it responds to varied ecological conditions can, in general, give insight into the plasticity of life histories in turtle species (Bury and Germano 2008). Although turtle species can adjust to polluted waterways, habitat fragmentation and destruction, and competition with invasive species, it is often difficult to assess the impacts of habitat destruction or competition. Turtle presence in disturbed areas does not necessarily indicate a viable population (Bury and Germano 2008).

However, if disturbance from habitat destruction and invasive species are impacting populations of western pond turtles, then there must a change in management strategies in turtle habitat to conserve their native population. In order to inform and promote conservation, management strategies such as monitoring and hypothesis-driven research are helpful in understanding the impacts of invasive species on native species. Research and management attention must be paid to both upland and aquatic habitats in which the species is found (Buskirk 2002). If there is enough evidence of harmful and negative costs effecting native species, then management strategies can be created to reverse the likelihood that a native species will be eradicated (Hayes et al. 1999).

To further understand the health of a population, one can compare the reproductive success between species co-inhabiting a site. In cryptic species, where measuring reproductive success is often difficult, the condition of a population can be determined from the number of individuals that are of reproductive age or size (Bury and Germano 1998). Comparing age classes between turtle species can show whether one species is exhibiting higher reproductive success.

In this study I am aiming to understand the relationship between growth rates, body size, and the age of first reproduction between the western pond turtle and red-eared slider within Golden Gardens Park pond system. If the red-eared slider is reproducing more successfully than the western pond turtle in Oregon, then there can be a significant argument for increased management strategies to prevent the likelihood of further threatening western pond turtle populations.

Methods

Study Site and Project Overview

I did all of my data collection in the Main and South Ponds at Golden Gardens Park in Eugene, Oregon (Figures 3 and 4). Golden Gardens is a 313-acre park located near the intersection of Golden Garden Street and Jessen Drive. It was originally a series of gravel pits that were used in the construction of Beltline Road. When the gravel pits were abandoned, they were filled with water and became ponds. The City of Eugene first acquired the land for Golden Gardens Park from Lane County in 1974. The ponds were not safe for residents living around the area because of steep banks. In addition, ponds overrun with invasive plant and animal species. In recent years, the City of Eugene has improved wildlife habitat and user safety with the help of the Bethel Community surrounding Golden Gardens (City of Eugene 2005).

Golden Gardens has populations of both red-eared sliders and western pond turtles and has been the subject of previous turtle monitoring projects. Chris Yee of Oregon Department of Fish and Wildlife and Lauri Holts of City of Eugene both contributed to a previous and on-going turtle-monitoring project. Lauri helped to rehabilitate Golden Gardens Park to a scenic park and reintroduced native plant species. After these applications Chris and Lauri trapped and marked western pond turtles in the Park. Additionally, Chris removes invasive red-eared sliders while collecting data to compare population numbers of both western pond turtles and red-eared sliders. I gathered my data while helping Chris with the latter monitoring project.

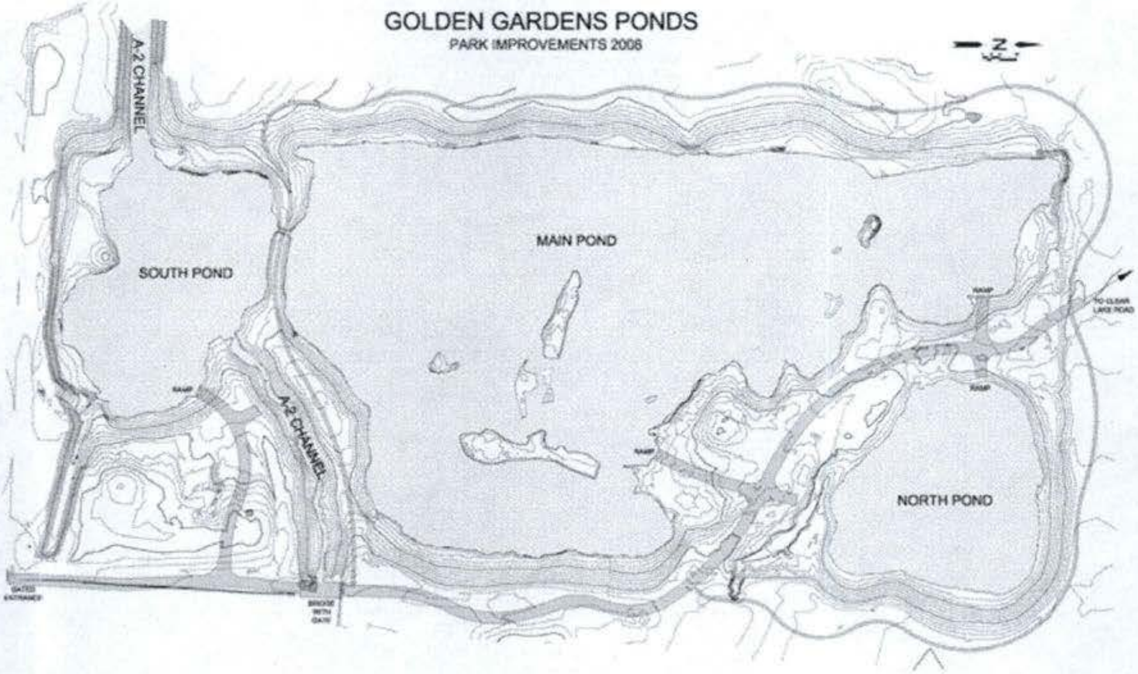

Figure 3. Aerial drawing of Golden Gardens Park in Western Eugene, OR. Source: City of Eugene.

Figure 4. Aerial view of Golden Gardens City Park within the Eugene/Springfield area. Source: Google Earth.

Data Collection

Turtle Traps

We conducted turtle trapping on 25 April – 10 May 2010 and 28 July - 8 August 2010. We used two different types of traps: Casteel wire floating trap cages and basking traps that Chris Yee modified. The Casteel trap consisted of a rectangular cage with two openings on either side that allow turtles to enter but not exit (Figure 5). There were two buoys on either side to keep traps afloat and prevent trapped turtles from drowning (Figure 6).

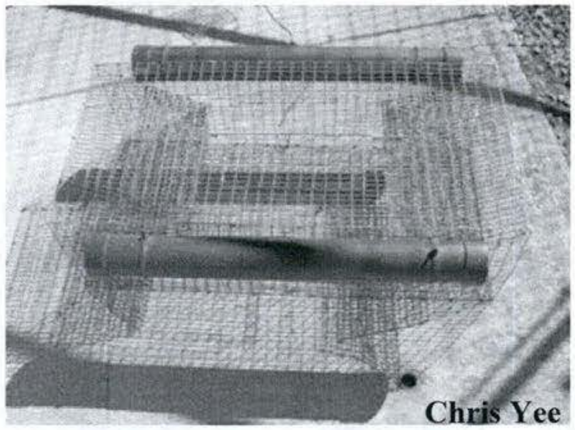

Figure 5. Side view of the Casteel wire floating cage. It consists of two side entrances that do not allow for adult escape.

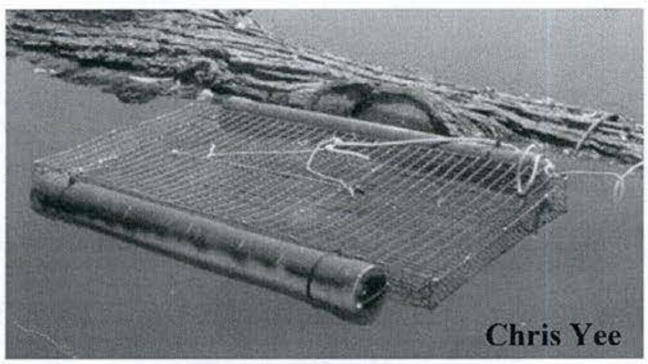

Figure 6. Casteel wire floating cage with the two buoys keeping the cage floating while in the pond.

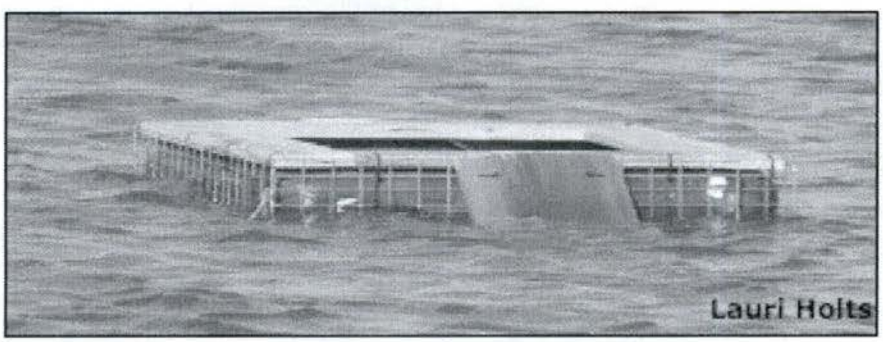

Figure 7. Modified basking trap in a pond. The wooden ramp leads up to a wide wooden ledge for basking.

Modified basking traps had openings on two sides to allow turtles in and included ramps that allowed turtles to climb on top of the traps to bask (Figure 7). The tops of the cages were open in the center to allow turtles to dive into the cage instead of back towards the pond.

We baited traps with meat or fish and left them alone for at least 24 hours before they were checked. We checked the traps for turtles once a day, every day of the study period. We placed traps around vegetation lines in the ponds. We tied the basking traps to basking logs in the ponds.

Turtle Data

We recorded the following information from each captured turtle: gender, carapace (top of shell) length, weight, scute-determined-age, and plastron (bottom of shell) length. We weighed the turtles using a milligram scale and we used a clasping ruler to measure carapace and plastron length. Turtles that were at age of first reproduction were greater than six inches, or 152.4 millimeters.

We determined gender by using distinguishing characteristics between females and males. Female features include a brown colored throat, a convex plastron, and a cloacal vent close to the interior edge of the carapace (Nussbaum et al. 1983). Males have a light or pale yellow throat, a conclave plastron, and the cloacal vent is close to the edge of the carapace (Nussbaum et al. 1983).

We determined scute-determined-age by counting the growth rings (annuli) on the left pectoral scute on the plastron (Bury and Germano 1998; Wilson 2003) (Figure 8). Growth rings are like that of a tree, in which each year a new growth ring is added as the turtle's shell grows throughout the seasons (Bury and Germano 1998). Sometimes turtles are too old or the shells are too worn, and the growth rings cannot be counted. In this situation we would count as many rings as possible. However, often this meant that turtles were over ten years of age. For the purposes of this study, I used the highest recorded age as their determined age, because it indicated the animal's minimum age.

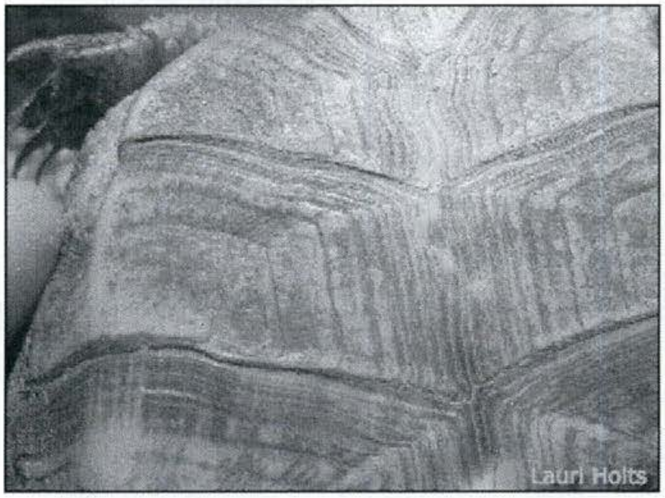

Figure 8. Scute rings on the left pectoral plastron of a western pond turtle. Each ring represents a year for the turtle's age.

Data Analysis

I examined the differences in population structure and body size between the red-eared slider and the western pond turtle. I hypothesized that the red-eared slider would have a larger proportion of younger individuals or a more even distribution of ages than the western pond turtle. I determined age groups and classified captured turtles by age group for both the red-eared slider and the western pond turtle in order to determine distribution proportions. To understand the significance between the two species' age distributions I used a Chi-squared analysis.

Second, I predicted that female red-eared sliders would have larger body sizes per age class, than the western pond turtle. To test the significance of this I compared the mass and length of carapace between the red-eared sliders and western pond turtles through a regression analysis and used one-tailed t-tests. I used a one-tailed t-test because my hypothesis was that the red-eared slider would have a larger mass and longer carapace length than the western pond turtle, based on previous research.

I used only female turtles in my analysis in order to limit potential capture bias. This was because many females might have been more active in spring due to nesting while the males may have been less active during the study season. Furthermore, because my study is focusing on reproduction rates between the species I chose to focus on females because they influence population size through reproduction timing and clutch size.

Results

We caught 14 red-eared sliders, 12 of which were female, and 32 western pond turtles caught, 15 of which were female. Average age for the western pond turtle was ($\bar{x}$ = 8.7 years), and ($\bar{x}$ = 6.75 years) for the red-eared slider (Figure 9). Age distributions between the red-eared slider and the western pond turtle were significantly different with the red-eared slider having more young individuals than the western pond turtle, $P < 0.05$, $X^2 = 40.58$ (Figure 9). Overall, red-eared sliders had significantly larger weights and carapace lengths at each age group than western pond turtle weights and carapace lengths ($t(26) = 0.0309$, $p < 0.05$) and ($t(26) = 0.0148$, $p < 0.05$), (Tables 1 and 2 and Figure 11). Additionally, when a regression line was fitted the red-eared slider had a larger slope for both weight and carapace length than the western pond turtle (Table 1 and Figures 10 and 11). For the red-eared slider age of first reproduction was reached between ages 5 and 6 and for the western pond turtle this occurred at ages 7, 8, and 9 (Table 2).

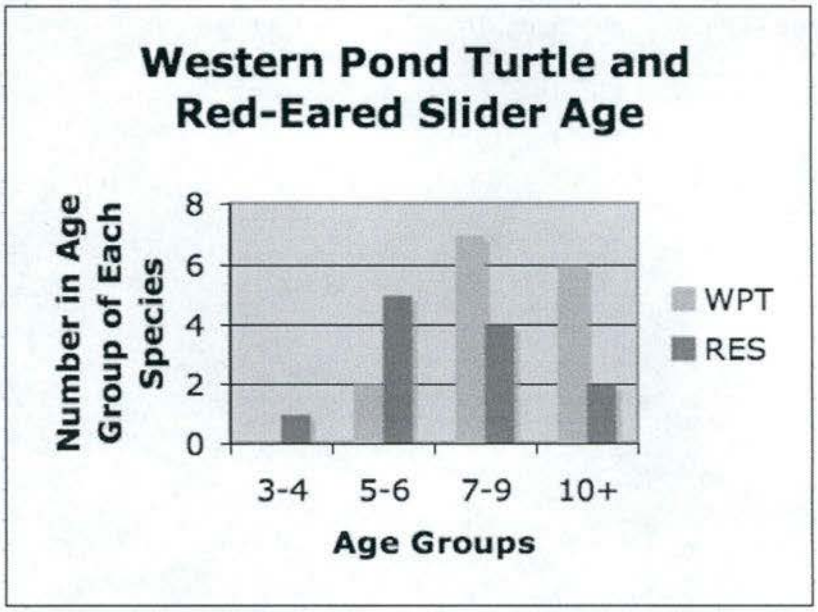

Figure 9. Age distributions of female western pond turtles and female red-eared sliders ($\bar{x}$ = 6.75 yrs for the red-eared slider and $\bar{x}$ = 8.7 yrs for the western pond turtle). The red-eared slider has a younger age structure while the western pond turtle has any older age structure X^2 (14, n=30) = 40.58.

Age Group	Western pond turtle average mass	Red-eared slider average mass
3-4	None Caught	$\bar{x}$ = 163 g
5-6	$\bar{x}$ = 209.5 g	$\bar{x}$ = 753.4 g
7-9	$\bar{x}$ = 581.3 g	$\bar{x}$ = 964.8 g
10+	$\bar{x}$ = 665.67 g	$\bar{x}$ = 1913 g
Total	$\bar{x}$ =565 g	$\bar{x}$ = 968 g

Table 1. Mass in grams between each species in each age class. The red-eared slider has much heavier individuals per age class than the western pond turtle.

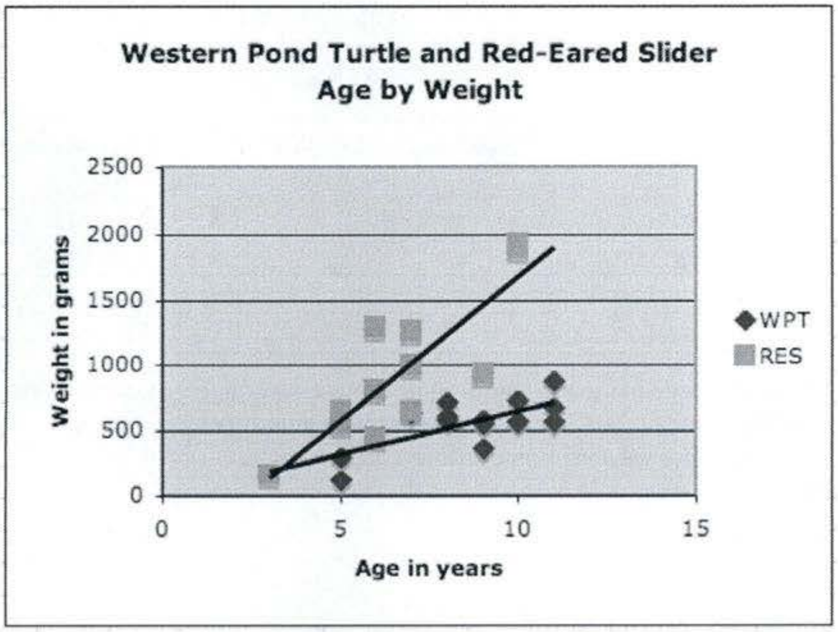

Figure 10. Red-eared slider age as a function of weight ($\bar{x}$ =6.75 years old, 968 grams). Western pond turtle age as a function of weight ($\bar{x}$ =8.7 years old, 565 grams). The red-eared slider had a significantly larger weight per age and larger slope than the western pond turtle t (26)= 0.0148, $p < 0.05$, (western pond turtle slope: y= 66x - 15, red-eared slider slope: y= 221x - 521).

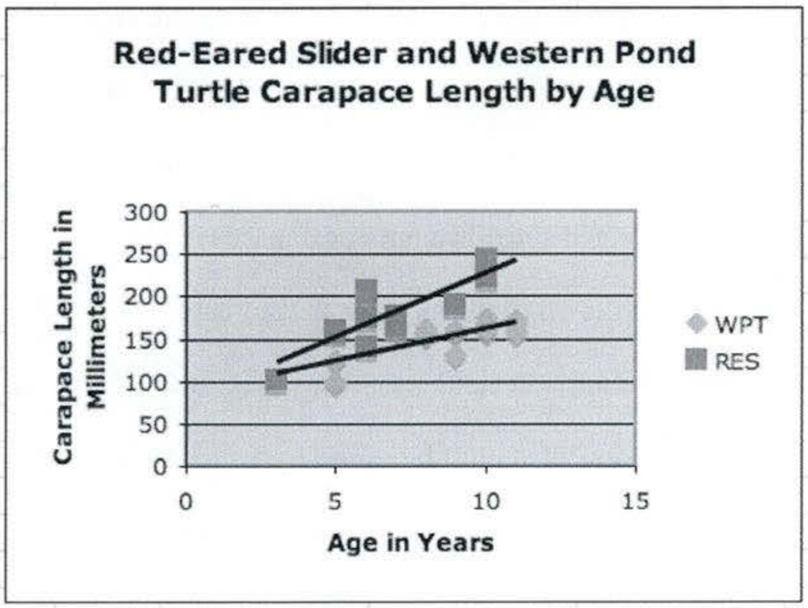

Figure 11. The red-eared slider has a much larger carapace length per age than the western pond turtle (red-eared slider $\bar{x}$ = 178 millimeters, western pond turtle $\bar{x}$ = 154 millimeters). The red-eared slider had a significantly larger carapace length per age and larger slope than the

western pond turtle $t_{(26)} = 0.0309$, $p < 0.05$, (western pond turtle slope: $y = 7.6x + 87$, red-eared slider slope: $y = 15.66x + 72.47$).

Age Group	Western pond turtle AVG carapace length	Red-eared slider AVG carapace length
3-4	None Caught	$\bar{x}$ = 102 mm
5-6	$\bar{x}$ = 104.5 mm	$\bar{x}$ = 173.3 mm
7-9	$\bar{x}$ = 155.4 mm	$\bar{x}$ = 187 mm
10+	$\bar{x}$ = 165.3 mm	$\bar{x}$ = 233 mm

Table 2. Average carapace length in millimeters per age group between the western pond turtle and the red-eared slider. The average carapace length is larger per age group for the red-eared slider than for the western pond turtle.

Discussion

Captured red-eared sliders have a significantly younger age structure than western pond turtles in Golden Gardens Park. This finding indicates that the red-eared slider population may have greater reproductive success than the western pond turtle. Moreover, there were no western pond turtles caught in the three to four year age class, which might signify that the population may not be recruiting new individuals. The western pond turtle average age may be increasing because there are fewer surviving turtles that reproduce and because there is an older population of western pond turtles.

The red-eared slider had larger carapace lengths and heavier weights than the western pond turtle. This indicates that the red-eared slider grows at a faster rate than the western pond turtle in Golden Gardens Park. Because of this larger growth there are certain repercussions that must be considered, such as larger numbers of eggs, higher breeding, and potential competition between the species. More over, the red-eared slider is large enough for age of first reproduction at a much younger age than the western pond turtle. This indicates that its population has the potential to reproduce much more quickly than the western pond turtle and for as much as two years before western pond turtles of the same age. If this is true then not only are there more red-eared sliders reproducing at a younger age, but also, western pond turtles would have to reach a much older age before they can begin to reproduce.

Conversely, there is a chance of capture bias, which would exclude all smaller western pond turtles from sampling because they are too small, often up to age six, to be caught in the wire cages (Rosenberg et al. 2009). To correct for this, smaller cages could be designed and placed around the perimeter of the study site. These shallow areas are where hatchling and juvenile turtles often congregate to remain hidden through potentially deadly stages in their life. The western pond turtle may also stay in a cryptic stage longer than the red-eared slider because it is slower growing, which may result in less western pond turtles being caught.

Future Recommendations for Similar Projects

This project provided me with much more experience in a research-oriented field and allowed me to develop my own hypotheses and findings. However, I was not able to complete all the data analysis that I originally planned on. My sample size for the project was not large enough for a life-table analysis. I wished to compute the likelihood of survival from known age ranges of each species (Cain et al. 2008). In the future, one might perform a backwards regression from a life-table analysis, in order to account for missing age cohorts after sampling a population. This can only be possible if there are even age classes throughout the rest of each species, which there was not in my project (Ambrose and Ambrose 1977).

My project aimed to identify possible ways in which the red-eared slider might be affecting the western pond turtle. I hoped to evaluate what the interactions between the species were and how they affected each other. In order to try to understand if competition is occurring between these species a study could be created in which both species were in a controlled, or at least enclosed, environment. Interactions could then be monitored and individual resource usage, such as food sources and basking areas, could be compared in order to evaluate if one species has been competitively excluded.

Next, counting scute rings in order to determine age has not been the most consistent means to determine the age of individual turtles. Nevertheless, this seems to be the most accurate means of measuring to date (Bury and Germano 1998). These types of studies are relatively new in the scientific field and because of this, there is not a lot of baseline research. However, in the future, mass could be used to estimate the length and age of each species without measurement, if a large enough sample size is caught. This estimation can be used as a proxy for determining age or length of a turtle. For example, a single weight of an individual could be compared to the average weight per age of the same species, which could in turn correlate to an average length of the carapace and average age of the species. However, as with my own study, it would be difficult to have an average weight per age class over the age of ten and so, this estimation technique could only be used up to the age of nine.

Finally, to further increase the rigor of future studies one could follow, mark, and track each species over multiple seasons. Additionally, to understand which species is reaching first age of reproduction and therefore able to reproduce more successfully, one could perform nest site surveys or capture and release population studies. By having a larger sample size over a longer sampling period the potential to find significant results increases. Comparing ages and sizes between the two species may then demonstrate which population is more vigorous in a more statistically significant manner than in my own study.

Management Implications

Competition is one expected repercussion from size and age differences between the red-eared slider and western pond turtle. While my study did not specifically address competition, it is important to address the potential impacts from competition that may result from larger sizes and earlier ages of first reproduction for the red-eared slider. I hope that the information found in my thesis study may ultimately contribute to continued restoration projects or increased efforts in the removal of the red-eared slider throughout Oregon in order to prevent any potential negative impacts for the western pond turtle. Management and recovery strategies can be implemented to decrease the effects of the invasive species and potentially restore habitat to resemble a more native biota, thereby creating an environment that may better benefit the western pond turtle. Habitat enhancement and acquisition is an important factor in protecting native species. This can be done for Golden Gardens Park by acquiring plots for future houses that may come up for sale and additional land acquisition. This allows for an increase in the extent of land restoration in the area, particularly for nesting sites of the western pond turtle (Hayes et al. 1999; Rosenberg et al. 2009).

Next, determining critical characteristics for maintaining a healthy turtle population can be done through surveys of the types of land and park use by community members and by continuing research of native and invasive species in Golden Gardens Park (Rosenberg et al. 2009). Further research on both the red-eared slider and the western pond turtle could be in the form of genetic diversity (Hayes et al. 1999). This could help determine the amount of relatedness between red-eared sliders in the ponds. Additionally, genetic diversity can be used to understand potential impacts of inbreeding in a system dominated by an invasive species. Furthermore, pathology research for disease introduction from red-eared sliders can be studied by collecting bacterial swabs from both the red-eared slider and the western pond turtle (Hayes et al. 1999; Rosenberg et al. 2009). Bacterial swabs between species can show the presence of diseases that may be similar or are differing between the two species. If these diseases are tracked over time, it could possibly show the extent to which either species might by introducing or transmitting pathogens within Golden Gardens Ponds.

Community involvement is one of the most important factors in preserving native biota. Many people do not know that the red-eared slider is illegal to possess in Oregon and in order to increase awareness and reduce the number of red-eared sliders in pet shops and homes, community members must engage in public outreach. Additionally, community involvement is important in preventing the introduction and spread of invasive species. Population movement and urbanization often introduce invasive species to an area and unless the public is aware of the potential damage from this introduction, native species may be extirpated by competitive exclusion.

Bibliography

Alvarez, J. 2006. Use of Artificial Basking Substrate to Detect And Monitor Pacific Pond Turtles (*Emys marmorata*). Western North American Naturalist 66 (1): 129-131.

Baird, S. and C. Girard. 1852. Descriptions of New Species of Reptiles, Collected by the U.S. Exploring Expedition Under the Command of Capt. Charles Wilkes, U.S.N. First Part. - Including the species from the Western coast of America. Proceedings of the Academy of Natural Sciences of Philadelphia 6: 174-177.

Brown, H., B. Bury, D. Darda, L. Diller, C. Peterson, and R. Storm. 1995. Reptiles of Washington and Oregon. Seattle Audubon Society.

Breslow, S. J. 2001. Farmers' Perceptions of Salmon Habitat Restoration Measures: Loss and Contestation. Submitted to The Environmental Protection Agency and The Society for Applied Anthropology: 52.

Bury, B. 1986. Feeding Ecology of the Turtle, *Clemmys marmorata*. Journal of Herpetology 20 (4): 515-521.

Bury, B. and D. Germano. 1998. Annual Deposition of Scute Rings in the Western Pond Turtle, *Clemmys marmorata*. Chelonian Conservation and Biology 3 (1): 108-109.

Bury, B. and D. Germano. 2008. *Actinemys marmorata*--western pond turtle, Pacific pond turtle. Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group. Chelonian Research Foundation, Chelonian Monograph 5: 1.1-1.9.

Buskirk, J. 2002. The Western Pond Turtle, *Emys marmorata*. Radiata 11 (3): 3-30.

Conant, R., and J. T. Collins. 1998. A Field Guide to Reptiles & Amphibians. Eastern and Central North America. Third Edition, Expanded. Houghton Mifflin Company, Boston. 616.

Cadi, A. and P. Joly. 2003. Competition for basking places between the endangered European pond turtle (*Emys orbicularis galloitalica*) and the introduced red-eared slider (*Trachemys scripta elegans*). Can J Zool 81:1392–1398.

Cadi, A. and P. Joly. 2004. Impact of introduction of red-eared slider (*Trachemys scripta elegans*) on survival rates of European pond turtle (*Emys orbicularis*). Biodiversity and Conservation 13: 2511-2518.

City of Eugene. 2005. Available: http://www.eugene-or.gov [Date visited: 11/29/10].

Da Silva, E. and M. Blasco. 1995. *Trachemys scripta elegans* in Southwestern Spain. Herpetological Review 26: 133-134.

Germano, D. and G. Rathbun. 2008. Growth, Population Structure, and Reproduction of Western Pond Turtles (*Actinemys marmorata*) on the Central Coast of California. Chelonian Conservation and Biology 7 (2): 188-194.

Hays, D., K. McAllister, S. Richardson, and D. Stinson. 1999. Washington State Recovery Plan for the Western Pond Turtle. Washington Department of Fish and Wildlife: 66.

Holland, D. C. and R. B. Bury. 1998. *Clemmys marmorata* (Baird and Gerard 1852) Western Pond Turtle. In P.C.H. Prichard and A.G.J. Rhodin (eds.) The Conservation Biology of Freshwater Turtles. Chelonian Research Monographs 2 (2).

Meek, R. and R. A. Avery. 1988. Thermoregulation in chelonians. Journal of Herpetology 1: 253–259.

Nussbaum, R. A., E. D. Brodie, Jr., R. M. Storm. 1983. Amphibians & Reptiles of the Pacific Northwest. University Press of Idaho. 332 pp.

Oregon Department of Fish and Wildlife. 2009 a. Oregon Administrative Rules. Division 56.

Polo-Cavia, N., P. Lopez and J. Martin. 2009. Competitive interactions during basking between native and invasive freshwater turtle species. Biological Invasions 12: 2141-2152.

Prevot-Julliard, A., E. Gousset, C. Archinard, A. Cadi, and M. Girondot. 2007. Pets and Invasion Risks: Is the Slider Turtle Strictly Carnivorous? Amphibia-Reptilia 28 (1): 139-143.

Rathbun, G., N. Scott Jr., and T. Murphey. 2002. Terrestrial habitat use by Pacific pond turtles in a Mediterranean climate. Southwestern Naturalist 47: 225-235.

Rosenberg, D., J. Gervais, D. Vesely, S. Barnes, L. Holts, R. Horn, R. Swift, L. Todd, C. Yee. 2009. Conservation Assessment of the Western Pond Turtle in Oregon *(Actinemys marmorata*). Sponsored by the U.S.D.I., Bureau of Land Management, Fish and Wildlife Service, U.S.D.A. Forest Service Region 6, Oregon Department of Fish and Wildlife, and City of Portland Metro.

Salzberg, A. 2000. The Cage Papers: The Norway Rat of the Turtle World. Reptile & Amphibian Hobbyist 5(8): 84.

Tucker, J. K., G. L. Paukstis and F. J. Janzen. 1998. Annual and Local Variation in Reproduction in the Red-Eared Slider, *Trachemys scripta elegans*. Journal of Herpetology 32 (4): 515-526.

Wilson, D. S., C. R. Tracy, and C. R. Tracy. 2003. Estimating Age of Turtles from Growth Rings: A Critical Evaluation of the Technique. Herpetologica 59 (2): 178-194.