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THESIS APPROVAL

The abstract and thesis of Deborah Jean Frankel for the Master of Science in Environmental Sciences and Resources were presented May 11, 2007, and accepted by the thesis committee and the department.

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ABSTRACT

An abstract of the thesis of Deborah Jean Frankel for the Master of Science in Environmental Sciences and Resources presented May 11, 2007.

Title: The effects of coypu *Myocastor coypus* (nutria) trapping on the water quality of South Johnson Creek, Beaverton, Oregon

Nutria are semi-aquatic rodents, non-native to Oregon. They are an invasive species that damage stream banks with burrowing and cause destruction of native vegetation; activity that may cause deterioration of stream water quality. I hypothesized that my study's duration and pattern of nutria trapping along South Johnson Creek would be sufficient to lead to a significant change in turbidity, dissolved oxygen (DO), total dissolved solids (TDS), total solids (TS), and total suspended solids (TSS).

I selected my study site to be South Johnson Creek, a stream that meanders through suburban housing divisions in Beaverton, Oregon. I chose three ponded sites of comparable size and make up. At each pond I installed five live animal traps. From July 2005 – July 2006 nutria were trapped over a three-day period once a month. Water quality data was collected two ways: from sites upstream and downstream of the ponds immediately before trapping and after trapping (DO and turbidity), and twice a month from a permanent monitoring station, Davis, within the sub-basin

(2004-05 = year before trapping, 2005-06 = year of trapping: DO, turbidity, TS, TSS, and TDS).

Most results showed that water quality did not significantly change due to the trapping of nutria. In analyzing upstream/downstream dissolved oxygen and turbidity data from the three ponds during the dry and wet season, I found no significant differences. However, year of trapping dry season Davis dissolved oxygen levels showed a significant difference (i.e. improvement) over levels from the year before trapping, ($p = 0.018$, $\alpha = 0.05$). Descriptive statistics showed that turbidity, total solids, and total suspended solids increased (i.e. degraded) from the year before trapping to the year of trapping, the solids during the dry season and turbidity during the wet. Due to the nature of this study and to the number of variables present in the basin, identifying the source(s) of the parameter changes was difficult. In order to more accurately determine the effects of nutria trapping on water quality in South Johnson Creek, future studies undertaken need to be long-term (3-5 years) and cover a greater geographical area.

THE EFFECTS OF COYPU *MYOCASTOR COYPUS* (NUTRIA) TRAPPING ON
THE WATER QUALITY OF
SOUTH JOHNSON CREEK, BEAVERTON, OREGON

by

DEBORAH JEAN FRANKEL

A thesis submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE
in
ENVIRONMENTAL SCIENCES AND RESOURCES

Portland State University
2007

DEDICATION

To the memory of the late scientist Darcy Muller (1995-2007).

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INTRODUCTION

Nutria are semi-aquatic rodents indigenous to the Patagonian region of South America. They were brought to North America at the turn of the twentieth century for their fur but were released when fur farming became non-profitable. The combination of suitable wetland and riparian habitat, mild winters, lack of natural predators, and well-established regional populations, has enabled the feral populations to thrive in their novel environment. In Oregon, nutria are considered a non-native, invasive species that damage stream banks with burrowing, cause destruction of native vegetation, damage water control structures, overgraze and cause subsequent loss of marsh, act as reservoirs for wildlife diseases, and displace native fauna such as muskrats and beaver.

Background

The nutria, *Myocastor coypus*, also known as coypu, is a mammal in the Order Rodentia, Family Myocastoridae, Genus *Myocastor*, and Species *Myocastor coypus*. They are native to South America, specifically to Southern Brazil, Bolivia, Paraguay, Uruguay, Argentina, and Chile. Early in the 19th century there was a worldwide demand for the velvet-like under-fur of the nutria; they were caught and kept in breeding farms throughout the U.S. and the world. Due to a soft fur market in the 1930's, nutria were intentionally released, leading to the establishment of feral populations in the U.S. According to the Ramsar Convention on Wetlands, nutria are known as an alien species that "becomes established in natural or semi-natural ecosystems or habitats, is an agent of change, and threatens native biodiversity (species, populations and/or ecosystems)," (Howard, 1971).

In Oregon, an unknown number of nutria were released from a farm in Tillamook County during a flood in 1937 (Verts et al., 1998). These animals established a colony near Garrison Lake and along the Nestucca River in Tillamook County. By 1946, colonies were established in several coastal counties, along the major river systems in the interior valleys, and in the Umatilla and Grande Ronde rivers in northeastern Oregon. Recently, trappers have taken large numbers of nutria from the interior valleys south of Douglas County, in counties along the Pacific Coast south to Coos County, in the Klamath and Harney basins, and in counties that border or include the Columbia, Snake, and Malheur rivers. In addition, regular sightings have been made of nutria in the northern Willamette Valley.

Characteristics

Nutria are rodents which resemble beavers, but with long, thin, somewhat dorsoventrally flattened tails (Bounds, 2000). They have hunched bodies and pentadactyl feet with naked soles. The toes of the hind feet, except for the hallux, are included in a web. The long guard hairs vary in color from dark brown to yellow brown and the dense under-fur is gray. The hind legs are much larger than the forelegs, which have four well-developed clawed toes and one vestigial toe. The nutria's large incisors have an outer surface of orange enamel. The muzzle is frosted with white hairs. Adaptations to an aquatic lifestyle include eyes, ears, and nostrils that are set high on the head; a valvular mouth and nose (which seal out water while swimming, diving, or feeding underwater); and four or five pairs of mammae set high on the sides, which enable young to feed while the female is in the water. Body dimensions for an average Oregon female are: total length, 990 mm; tail length, 440 mm; length of hind foot, 140 mm; and ear length, 30 mm. Average weight for female

nutria in Oregon is 10–18 pounds and for male nutria is 12-20 pounds (Verts et al., 1998).

Breeding

Nutria have a polygamous mating system. Births occur in all months with peaks in January, March, May, and October. Litter sizes range from 1-13, with the average being 4-5. Females have been found to give birth at 12-15 months old. Since the gestation period is only 120-130 days, the production of nearly three litters in a one-year period may be possible. Nutria family groups consist of 2-13 individuals and have a dominant male and female. Adult males can also be found in solitary (Verts et al., 1998).

Young nutria are precocial. Neonates are covered with soft, downy fur; the tail hairs are silky, but are replaced by coarse hairs by one month of age (Verts et al., 1998). After the first day, nutria nurse for 20-30 minute periods at 2-3 hour intervals. Nutria mostly nurse while the maternal female is on land and in a prone position. The young nurse for seven weeks. At birth nutria weigh an average of 7.65 ounces. At sexual maturity males average 6.2 pounds and females 4.2 pounds.

Food

Nutria are mainly herbivorous. They have been observed to most frequently eat: willow (*Salix*), false loosestrife (*Ludwigia palustris*), bur-reed (*Sparganium simplex*), beggar ticks (*Bidens cernua*), spike-rush (*Eleocharis palustris*), common smartweed (*Polygonum hydropiperoides*), and panicgrass (*Panicum capillare*) (Wentz, 1971). Plant species that are not consumed are coarse in texture, seasonal, unpalatable, or rare. Wentz considered nutria responsible for the disappearance of the broadleaf

arrowhead (*Sagittaria latifolia*) and the drastic reduction in already rare cattail (*Typha latifolia*). In some areas of western Oregon, nutria also are known to forage on field crops, fruit and nut trees, as well as deciduous and coniferous forest trees (Verts et al., 1989).

Predators and Mortality

In Oregon, there is no known documented information regarding natural predators taking adult nutria or of nutria mortality. Elsewhere humans, alligators, garfish, bald eagles, and bobcats eat nutria. Studies show nutria to be sensitive to low temperatures with mortality being 80-90% following multiple days of freezing temperatures (Verts et al., 1998). Cold weather is the most effective factor limiting the distribution and abundance of nutria.

Habitat

Nutria are found in a wide range of habitats, including permanent and seasonal wetlands as well as adjacent to rivers, lakes, sloughs, and ponds. These areas support both freshwater and brackish water plant communities. Plants found to be abundant in these areas include false loosestrife (*Ludwigia palustris*), nodding beggar-ticks (*Bidens cernua*), Oregon ash (*Fraxinus latifolia*), creeping spike-rush (*Eleocharis palustris*), simplestem bur-reed (*Sparganium simplex*), bentgrass (*Agrostis palustris*), willow (*Salix*), and speedwell (*Veronica* spp).

Studies have observed nutria in water bodies characterized by low or no spread of water, with stream banks of moderate slope, and with good aquatic cover (De Ciechi et al., 1997). Water serves as a shelter for nutria, who commonly dive into water to escape, whereupon they either remain under water for several minutes or

enter submerged burrow openings (Guichon et al., 2003). In Oregon, nutria construct burrows in the banks of rivers, sloughs, and ponds with 45°- 90° slopes, sometimes causing considerable erosion. Burrows can extend from one to six meters, have an average diameter of 22.1 cm., and have several entrances that are partly above water (Woods et al., 1992). When tunnels become flooded during the winter, nutria will find refuge in blackberry brambles. Nutria also construct resting and feeding platforms of matted vegetation connected by trails.

Habits

Nutria tend to be nocturnal, although individuals may be observed swimming, feeding, or walking along a pond bank during the daylight hours (Gosling, 1979). Feeding, swimming, and grooming are the primary nutria activities. Nutria spend up to 92% of their time at locations less than four meters from water, and rarely will they venture more than ten meters from a pond or stream (D'Adamo et al., 2000). However, Verbeylen (2002) found that nutria usually occupy a small area, less than 400 meters from the burrow, but when food supplies are low they migrate to better places. Nutria have been known to migrate up to 75 km.

Previous Research

Although there are several national and international studies on beaver and water quality, there are no known studies documenting the effects of nutria on water quality in Oregon. There have been many studies documenting the impact of nutria trapping on plant survival as well as studies discussing methods of nutria trapping. Only a few of these studies took place in the Pacific Northwest, including by Davison (2005), Morton (2007), Wentz (1971), and Witner (2007).

Trapping

Studies have shown that nutria cause damage to riparian vegetation (Carter et al., 1999). Theoretically, nutria may then lead to the increasing of water sediment load and turbidity, the increasing of water temperature, and the decreasing of dissolved oxygen. Therefore, the removal of nutria could feasibly improve water quality. The majority of nutria trapping studies utilized mark-recapture to estimate nutria population size, carrying capacity, and to ascertain nutria effects on vegetation. Other studies documented the attempts at eradication, with varying degrees of success.

In a mark-recapture study in Louisiana, Linscombe, Kinler, and Wright (1981) found that a nutria density of approximately 24 nutria per hectare can exceed carrying capacity and temporarily damage vegetation. The damage included the creation of unvegetated areas and a reduction in the amount of three-cornered grass (*Scirpus olneyi*).

There have been several studies documenting large scale nutria trapping. In a review of literature, Carter and Leonard (2002) concluded that in order for eradication efforts to be successful nutria populations need to be isolated to prevent reintroduction, harsh winters are necessary, and intensive trapping efforts must be sustained until the last nutria is removed. It is also important to have pre-trapping ecological studies, sufficient funding, the removal of nutria faster than they can reproduce, and follow-up quarterly monitoring for reinvestigation. Carter and Leonard found eradication efforts met with a range of success. Gosling and Baker (1989) documented the successful British eradication campaign that began in 1981 and took 24 trappers, ten years to complete. Another attempt in East Anglia (Gosling et al., 1988) was unsuccessful in eliminating nutria, partly due to the immigration of new

nutria into the area. In this campaign, trappers worked full time for six years from 1975-1981. In 2005, Washington Department of Fish and Wildlife (WDFW) began a 90-day trapping project in Skagit County after the area's first nutria was sighted (Davison et al., 2005). Thirteen nutria were trapped during this period. This result indicated that nutria had already established family groups in several locations and were successfully reproducing. WDFW then realized that it would require a more widespread and intense effort to successfully remove nutria from Skagit County.

Resource managers in the Chesapeake Bay region began to consider options for controlling or eradicating nutria when numbers jumped substantially in the last part of the twentieth century. In 1968, there were less than 150 nutria in the Blackwater National Wildlife Refuge but by the 1990's there were between 35,000 and 50,000. This led to the creation of the Maryland Nutria Project in 2000. From September 2002 to April 2007 10,124 nutria were killed in an area of 125,000 acres. Today over 95% of the trapped area remains nutria free. This study has also shown how an area can recover. By 2004 most square plots had 80% in vegetation coverage, a change from 50% in 2000. There was also an increase in muskrat activity, a native species to the area. Based on this initial success, in early 2003 President Bush signed the Nutria Eradication and Control Act, which authorized the expenditure of \$20 million over five years for nutria eradication in Maryland (Kendrot et al., 2003). This project is still ongoing.

In 2002, wildlife managers created the Louisiana Coastwide Nutria Control Program. Scientists have been trying to determine the threshold of when an area can sustain a carrying capacity and limit destruction. In 2006-2007 managers collected 375,683 tails (hunters received \$5 per tail). There has been a slow decrease in wetland damage: 82,080 acres in 2002 down to 32,000 acres in 2006-2007. To continue this

reduction in damage, the current goal is to remove 400,000 nutria per year (Mouton, 2007).

To have a higher rate of nutria eradication success, scientists are trying new methods. Gary Witmer, U.S. Department of Agriculture, has studied the disappearance of the Louisiana coastal marsh caused by massive nutria eat-outs (Witmer, 2007). He found that traditional hunting and trapping methods were not sufficient and, as a result, he designed a new type of trap. Multiple capture traps (MCT) can hold several nutria simultaneously. During one 10-day trial, 22 nutria were captured. In addition, forward-looking infra-red units recorded the nutria trapped and those animals, nutria and others, in close proximity to the traps.

Financial restraints as well as the nature of nutria have made eradication of nutria very difficult. As a result, in some places management plans may need to center around reducing nutria populations and limiting damage to certain levels. Carter (2007) claimed that population estimates were often wrong and that each environment differed in respect to a control number at which water quality, for example, would improve. He wrote that there have been too many gaps in knowledge pertaining to per-capita nutria impacts and marsh loss dynamics to set a number. In taking steps to determine carrying capacities for different regions, Carter has modeled the effects of nutria on wetland loss (1999).¹ In his analysis, he found that the model was not sensitive to the density at which loss began but to the amount of biomass destroyed per nutria.

¹ Carter's nutria-biomass-area model is premised on the following:

- a) As the number of nutria increases, the amount of biomass consumed increases. As the biomass is consumed, the density of biomass decreases.
- b) Once biomass decreases below a certain amount, a percentage of marsh is lost. The lower the density, the greater the rate of loss.
- c) As the area of marsh decreases, the total amount of biomass that the marsh can support decreases.
- d) The less biomass, the fewer nutria can be supported.

Nutria Impact on Terrestrial and Aquatic Vegetation

Excavations, also known as eat-outs, are the most common sign of nutria feeding activity in the field. Nutria will reduce the aboveground biomass by foraging on the basal portion of stems and breaking up the root mat by grubbing for roots and rhizomes (Carter et al., 1999). This feeding behavior may leave marshes pitted with digging sites, crisscrossed with runways through vegetation, and fragmented with swim canals.

Numerous studies discuss the effects of nutria on local vegetation. In a two-year exclosure study Fuller et al. (1985) found that herbivory may have long-term effects on species composition of the *Sagittaria* marshes of Louisiana. Foote and Johnson (1992) also studied Louisiana wetlands and concluded that nutria grazing expedited marsh loss. Wentz (1971) found that nutria were responsible for the disappearance of broadleaf arrowhead (*Sagittaria latifolia*) from the William L. Finley National Wildlife Refuge in the Willamette Valley, Oregon. He suggested that nutria can overgraze the more palatable plants and, as a result, allow the more resistant species, sometimes poisonous, the opportunity to become dominant members of the plant community.

Nutria (and Beaver) Impact on Water Quality

A limited number of studies have looked at the relationship between nutria and water quality. Boar et al. (1989) studied the impact of nutria on water quality in England. They found that the extensive loss of reedswamp coincided with the increased grazing of nutria. The reedswamp loss caused an increase in the ratio of nitrogen to potassium in the waterways. In France, Michel et al. (2001) found nutria

to be renal carriers of pathogenic and virulent leptospires, shed in urine. Stevenson (2007) discussed the possibility of nutria in the Pacific Northwest being carriers of diseases such as: tularemia, giardia, “swimmer’s itch”, and leptospirosis. Finally, a 2006 Clean Water Services DNA fingerprinting of bacteria sources in the Tualatin sub-basin found that 16% of bacteria pollution came from rodents (i.e. nutria) (Vaughn, 2007); (Figure 1). Nutria droppings may be found floating in the water, along trails, or at feeding sites.

Figure 1. 2006 Clean Water Services DNA fingerprinting of bacteria sources in the Tualatin basin.

Numerous studies document the varying effects of beaver on stream water quality. Drainage networks with beaver are substantially different in their biogeochemical economies than those without beaver. Large impoundments, with surface water release similar to that of a beaver dam, have shown a decrease in

downstream turbidity, nutrients stored in accumulated sediments, enhanced plankton productivity, an increase in the temperature range, and an increase in dissolved oxygen levels in outflowing waters (Naiman et al., 1986). However, Skinner (1984) concluded that beaver might be a source of pollution by contributing bacteria to streamflow as a result of excretion and by stirring sediments. Maret (1987) collected water samples upstream from, within, and downstream of beaver pond complexes. He found that bank and channel erosion from beaver pond complexes contributed greatly to sediment loads. During summer months, Margolis et al. (2001) saw an increase in pH on streams with beaver impoundments.

Water Quality Parameters Analyzed in this Study

To study the effects of trapping on water quality, I selected the water quality parameters of turbidity, dissolved oxygen (DO), total solids (TS), total dissolved solids (TDS), and total suspended solids (TSS). The above were chosen based on the possibility of seeing immediate (i.e. in one year) effects. By using these reactive parameters, I hoped to detect upstream vs. downstream differences and to track trends over time. In particular, turbidity and dissolved oxygen tests are inexpensive methods that require a low sample number to gain an immediate understanding of the health of an aquatic ecosystem.

Turbidity (NTU – Nephelometric Turbidity Unit)

Turbidity is one of the best measures of stream health – both in the short and long-term (Kapur, 2007). It is suspended particulate matter and is the function of three variables (Brower et al., 1998):

- 1) Dissolved chemicals, such as tannins, acids, and salts.

- 2) Suspended particles such as silt, clay, and organic matter.
- 3) Density of microbiological organisms.

Turbidity is the result of soil erosion, urban run-off, algae blooms, and bottom sediment disturbances, which give water a hazy or cloudy appearance. Turbidity indicates water suitability for biological productivity, fisheries, and drinking as well as industrial and recreational uses. Long-term turbidity monitoring is conducted in order to support a description of water quality, to measure changes in water quality, and to understand how a water system functions. The turbidity standard in Oregon states that there should be no more than a ten percent cumulative increase in natural stream turbidities with exceptions for emergencies (ODEQ, 2006).

Dissolved Oxygen (mg/L)

Oxygen, produced by photosynthesis in the daytime, saturates water. Dissolved oxygen (DO) is the percent of full saturation. The concentration is dependent on temperature, pressure, and salinity. The Tualatin Basin Water Quality Standards 2001 require that grab samples be equal to or greater than 6.6 mg/L. (5 mg/L is needed in order to sustain diversity).

Wastes provide nutrients for microorganisms, which grow and multiply rapidly, consuming oxygen in the process. When the demand for oxygen exceeds the supply, microorganisms and fish start to die. The body of water can no longer purify and anaerobic processes take over. Anaerobic decomposition leads to the formation of sulfides, methane, and ammonia. Reducing conditions, called “anoxic”, lead to a decrease in dissolved oxygen (Radajevic, 1999).

Solids (mg/L)

The term solids refers to the quantity of solid matter remaining in a water sample after drying or igniting at a specific temperature. The solid categories I analyzed included: total, suspended, and dissolved. The main sources of solids in natural waters include water, rain, and wind erosion of stream banks. Solid pollution can also come from domestic wastes, road run-off, and industrial processes. Solids in water are undesirable because they degrade drinking water and reduce the use of water for irrigation. High levels of solids also increase water density, reduce the solubility of gases, and can lead to sludge deposits and anaerobic conditions. The amount of suspended solids increases with the degree of water pollution and is extremely useful in the assessment of polluted waters. The statewide narrative criteria on sedimentation is that the formation of appreciable bottom or sludge deposits or the formation of any organic or inorganic deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry may not be allowed (ODEQ, 2006).

Total Solids (mg/L)

Total solids are dried at 103-105 degrees Celsius. The degree of contamination for total solids is: 300 (weak), 700 (medium), and 1000 (heavy). $\text{Total solids (mg/L)} = \text{Total dissolved solids (mg/L)} + \text{Total suspended solids (mg/L)}$ (Radajevic, 1999).

Total Suspended Solids (mg/L)

Total suspended solids are dried at 104-105 degrees Celsius. The degree of contamination for total suspended solids is: 100 (weak), 200 (medium), and 300 (heavy) (Radajevic, 1999).

Total Dissolved Solids (mg/L)

Total dissolved solids are dried at 180 ± 2 degrees Celsius. The degree of contamination for total dissolved solids is: 200 (weak), 500 (medium), and 700 (heavy) (Radajevic, 1999).

Research Objectives and Hypotheses

Over the last ten years, South Johnson Creek has had water quality issues and a decline in the health of riparian vegetation. A 2001 total maximum daily load report (ODEQ, 2001) for the Tualatin Basin shows that South Johnson Creek (Beaverton Creek) was on the 303(d) list of streams not meeting water quality standards from the mouth to the headwaters for temperature, dissolved oxygen (May 1 – October 31), and bacteria (*E. coli* – all year). Bacteria can be directly deposited into surface waters by animals (e.g. nutria); (See Figure 1). The report indicated that elevated bacteria conditions were most evident in ponds where high temperatures and low velocities existed. In a 2003 Tualatin basin study, Clean Water Services (CWS) observed 20 sites in the Tualatin basin and found a population density of 0.13 to 50.66 nutria per acre. Vegetation was badly degraded and the stream banks were tunneled or collapsed at most of the study sites.

Nutria are abundant in South Johnson Creek and are likely one of the causes of water pollution due to increased waste and stream bank degradation, and a decrease of riparian vegetation. My study sought to determine the degree of nutria impact by looking at the effects of trapping on water quality. I hypothesized that over the period of nutria trapping used in this study, water quality would:

- 1) Improve downstream versus upstream for turbidity and dissolved oxygen (DO).

- 2) Improve for the year of trapping versus the year before trapping for turbidity, dissolved oxygen, total dissolved solids (TDS), total solids (TS), and total suspended solids (TSS).

METHODS

Study Area

This study took place in the South Johnson Creek watershed in Beaverton, Oregon, approximately nine miles southeast of Portland (Figures 2 and 3). Study sites were along South Johnson Creek and two of its upper tributaries. South Johnson Creek flows into Beaverton Creek, a tributary of the Tualatin River. Mean winter air temperatures of the Tualatin River basin range from 32 – 63 °F. Mean summertime air temperatures are between 41- 82.5 °F. The area experiences a Mediterranean climate with prolonged winter rainfall and summer drought. The low flows occur at the end of the summer months due to decreased precipitation and increased agricultural withdrawals. Most of the land in the South Johnson Creek watershed is urban and developed. Over 93% of the land ownership in the sub-basin is private. It is an area where “impacts include fragmentation of the riparian corridor, encroachment of development into riparian and wetland buffers, and loss of structural and species diversity...” (ODEQ, 2001)

Sites

Ponds, trap locations, and water sample sites were selected based on pre study observations. I looked for nutria and signs of their presence, including herbivory. The availability of flow data from an established and regularly maintained gauging station was also important in the selection of sites. In addition, all of the selected sites had long-term (including seasonal) access. Permission was granted by Tualatin Hills Park and Recreation District (THPRD) to set traps and collect water samples for one year at each location. Neighbors in close proximity to the ponds were contacted about the study and signs were set at entrance points to the ponds to notify the general public.

The three selected sites were ponded with inflow and outflow of water, had similar areas and nutria densities, and were within suburban housing developments. Table 1 (and Table 2) shows the three ponds, their areas, and the upstream/downstream water quality test sites. Summercrest Park (Figures 4, 7, 8) and Beacon Hill (Figures 5, 9, 10, 11) are on two separate upstream tributaries of South Johnson Creek. Jaylee (Figures 6, 12, 13) is downstream of the confluence of those two reaches and is north of the Davis monitoring station. Until April 2006, the Davis monitoring station collected automated pump samples.

Pond name (Trapping sites)	Pond length (ft)	Pond area (ft²)	Upstream of Pond Water Quality Test Sites	Downstream of Pond Water Quality Test Sites
Summercrest (Figures 4, 7, 8)	1140	12,929	515001	515002
Beacon Hill (Figures 5, 9, 10, 11)	1031	15,705	3827030 3827031	3827028
Jaylee (Figures 6, 12, 13)	1083	17,821	3827007	3827005

Table 1. Pond name (trapping sites) and upstream/downstream water quality test sites.

Figure 2. Map of the Tualatin River basin with the three nutria trapping ponds: Summercrest, Beacon Hill, and Jaylee.

Figure 3. Map of South Johnson Creek basin with study sites: 1=Summercrest, 2=Beacon Hill, 3=Davis, 4=Jaylee.

Figure 4. **Summercrest Pond** with water test sites and trap locations (black boxes).

Figure 5. **Beacon Hill Pond** with water test sites and trap locations (black boxes).

Figure 6. **Jaylee Pond** with water test sites and trap locations (black boxes).

Figure 7. Summercrest – 515001 (Upstream)

Figure 8. Summercrest – 515002 (Downstream)

Figure 9. Beacon Hill – 3827030 (Upstream)

Figure 10. Beacon Hill – 3827031 (Upstream)

Figure 11. Beacon Hill – 3827028 (Downstream)

Figure 12. Jaylee – 3827007 (Upstream)

Figure 13. Jaylee – 3827005 (Downstream)

Trapping

In Oregon, nutria are classified as unprotected Nongame Wildlife and, as such, may be trapped (cannot be relocated) or shot. As a result, my study was a removal project and not a mark-recapture study. As per a plan decided upon with partner agency Clean Water Services (CWS), five traps were set around each of the three ponds. The traps were numbered and put in consistent locations that had significant evidence of nutria: runs, herbivory, tracks, and feces. The plastic live traps were baited with carrots. Trapping at the three ponds was undertaken simultaneously; thus, traps were all set the same day and reset after captured nutria were removed. Traps were set in the evening and checked early the next morning. A U.S. Department of Agriculture-APHIS (Animal and Plant Health Inspection Service) employee trapped

for three consecutive 24 hour periods, Tuesday – Thursday, and then stopped for three weeks (Table 2). Each day the trapper recorded animals trapped (number and type) and weight in pounds. He repeated this same process for one full year from July 2005 through July 2006.

After a year of trapping, I attempted to determine a population estimate for the three ponds. I used the method of maximum-likelihood, which estimates a population from the rate by which trapping reduces the sizes of successive samples (Southwood, 2000). Since Summercrest was the only site with a decreasing number in each sample, it was the only pond for which I estimated a population. The maximum-likelihood population estimate for N at Summercrest was determined by solving the equations:

$$N = \frac{T}{(1 - q^s)} \quad (1.1)$$

$$\frac{q - \frac{kq^s}{(1-q^s)}}{p} = \frac{\sum_{i=1}^s (i-1)u_i}{T} = R \quad (1.2)$$

N = total population size

p = probability of capture on each sampling occasion

k = number of samples

s = distinct periods of trapping (days)

U_i = the number caught for the first time on each occasion

T = Total catch

$q = 1 - p$

First I calculated R and then used equation 1.2 to solve for q. This value was then used in equation 1.1 to estimate N.

Water Quality Testing (Sample Collection)

For one year, I collected water quality data at seven test sites immediately before and after trapping (26 sampling events over a 13 month period). Test sites were upstream and downstream of each of the ponds. I used a Hach portable meter and a turbidimeter to collect data mid depth and at middle cross section; this being the part of the stream most representative of current conditions. At each site I recorded: date, time, site number, temperature, pH, specific conductivity (SpC), dissolved oxygen (DO), DO%, and turbidity. This data provided an immediate, local picture of water quality.

Every two weeks since 1994 the permanent monitoring site, Davis, has collected automated pump samples. I used data from Davis for the following parameters: dissolved oxygen, turbidity, total solids, total dissolved solids, and total suspended solids. Not only did Davis provide long-term parameter trends but since it is located in the central part of the sub-basin (downstream of Beacon Hill and Summercrest, upstream of Jaylee) it provided a basin view of water quality.

Statistical Analysis

In order to determine whether trapping had an impact on water quality, I used paired t-tests and boxplots to look at monthly dissolved oxygen and turbidity trends for the year of trapping from sites upstream and downstream of the ponds (Tables 1 and 2). In order to take into account seasonal differences with high and low flows, I obtained average seasonal rainfall from the Oregon Climate Service website. Therefore, I only analyzed the dry season - July, August, September - and the wet season - November, December, January.

I used dissolved oxygen, turbidity, total solids, total dissolved solids, and total suspended solids data from the Davis permanent monitoring site to make comparisons between the year before trapping and the year of trapping as well as to analyze long-term (1994-2005) parameter trends (Table 2). I used paired t-tests and boxplots to compare before trapping (2004-2005) and during trapping (2005-2006) water quality data. Again, in order to account for seasonal variability, I only analyzed the dry season (July – September) and the wet season (November – January). I also used time series graphs to look at long-term Davis water quality trends by comparing wet and dry seasons from 1994-2006.

Sample collection source	Sample collection	Site(s)	Dates	Parameters Analyzed	Statistical Analysis/Descriptive Statistics
Davis (permanent gauging station upstream of Jaylee trapping site)	Every two weeks	Davis	7/94-4/06 <u>Notes:</u> No data for 9/97-7/98 due to construction. 4/06 Davis ceased data collection	DO, Turbidity, TS, TDS, TSS	Paired t-tests Time series graphs Boxplots
Summercrest Beacon Hill Jaylee	Sunday before and Saturday after trapping days	515002 515001 3827028 3827030 3827031 3827005 3827007	7/05-7/06 <u>Note:</u> 2/06 turbidimeter broken	DO, Turbidity	Paired t-tests Boxplots
USDA-APHIS trapper	3 continuous days once a month	5 traps at each of the ponds: Summercrest, Beacon Hill, Jaylee	7/05-7/06	Number nutria trapped, weights	Maximum-likelihood method to estimate population

Table 2. Summary of study sites, water quality testing and trapping protocol, and statistical analysis/descriptive statistics.

RESULTS

Trapping

Figure 14 and Table 3 show the trapping results for Summercrest, Beacon Hill, and Jaylee for July 2005-July 2006. During the dry season (July, August, and September) eighteen nutria were trapped at the ponds on the upper tributaries, Summercrest and Beacon Hill. During the wet season, twelve nutria were trapped from all three ponds, including one at Jaylee, the pond furthest downstream. Only at Beacon Hill were nutria trapped through July 2006. At Summercrest 37% of the nutria trapped were juveniles and at Beacon Hill 42%. This trapping information shows that nutria had established family groups, were successfully reproducing, and were present throughout the sub-basin.

Since the method of maximum-likelihood requires the reduction in the size of successive samples, a population estimate could only be made for Summercrest. However, no estimate of nutria population size could be calculated until the 6th trapping “day” or period, December 2005 (Figure 15), when population size was estimated to be 48. From this point the nutria population size decreased until it leveled off in April 2006 at 19, the same as the cumulative number of nutria trapped at Summercrest through January 2006. Since estimates of the population size are based on a proportion of the population captured, the number of nutria trapped equaling the population estimate voids an accurate estimate. An assumption that underlies the accurate application of this method is that of a stable population. My study area was not closed; nutria could migrate out of the sub-basin and the birth rate was greater than the death rate, due to the lack of a natural predator and multiple days of freezing temperatures. The inability to use the method of maximum-likelihood supports Carter and Leonard’s (2002) claim of the difficulty in estimating nutria population size.

Figure 14. Nutria trapped per month at Summercrest, Beacon Hill, and Jaylee.

Site	Adults trapped	Juveniles Trapped (≤ 5 lbs)	Total Nutria Trapped	Average weight (lbs)
Summercrest	12	7	19	5.9
Beacon Hill	14	10	24	7.04
Jaylee	2	0	2	12

Table 3. Number of nutria trapped at each pond and average nutria weights (2005-2006).

Figure 15. Estimated Nutria Population Size for Summercrest Pond.
 (1=July 2005; 2=August 2005; 3=September 2005; 4=October 2005; 5=November 2005; 6=December 2005; 7=January 2006...10=April 2006)

Water Quality

Upstream vs. Downstream Test Sites for 2005-2006: Summercrest, Beacon Hill, Jaylee

No significant results were found for the year of trapping when comparing upstream and downstream dissolved oxygen and turbidity data during the wet and dry seasons. Table 4 and 5 show the calculated p-values. Since no nutria were trapped until October at Jaylee, it was only included in the wet season comparisons.

Table 4. Dissolved oxygen (mg/L) upstream vs. downstream paired t-test results for 2005- 2006.

Month	Pond	Upstream (U)	Downstream (D)	U-D	p
July	1	10.5	14.1	-3.6	0.263883
	2	3.77	5.17	-1.4	
August	1	4.08	9.65	-5.57	0.679132
	2	6.02	4.41	1.61	
September	1	5.58	5.49	0.09	0.262549
	2	4.61	4.38	0.23	
November	1	7.66	8.17	-0.51	0.9220765
	2	7.02	7.42	-0.4	
	3	7.01	5.93	1.08	
December	1	13.53	15.4	-1.87	0.242051
	2	12.78	13.22	-0.44	
	3	12.59	12.82	-0.23	
January	1	11.23	11.78	-0.55	0.2029466
	2	11.04	11.39	-0.35	
	3	11.04	11.04	0	

No values significant at $\alpha = 0.05$. 1 = Summercrest, 2 = Beacon Hill, 3 = Jaylee.

Table 5. Turbidity (NTU) upstream vs. downstream paired t-test results for 2005- 2006.

Month	Pond	Upstream (U)	Downstream (D)	U-D	p
July	1	4.49	8.77	-4.28	0.195385
	2	7.7	9.92	-2.22	
August	1	17.4	9.1	8.3	0.977089
	2	5.88	14.8	-8.92	
September	1	22.3	28.4	-6.1	0.156326
	2	7.39	17.57	-10.18	
November	1	10.92	21.6	-10.68	0.2358325
	2	13.65	15.05	-1.4	
	3	12.57	15.15	-2.58	
December	1	5.72	22.7	-16.98	0.425997
	2	8.33	8.85	-0.52	
	3	18	17.4	0.6	
January	1	29.4	42.95	-13.55	0.4818021
	2	28.33	28.8	-0.47	
	3	27.7	25.95	1.75	

No values significant at $\alpha = 0.05$. 1= Summercrest, 2 = Beacon Hill, 3 = Jaylee.

Figures 16a-b show boxplots with upstream/downstream dissolved oxygen and turbidity differences. Dissolved oxygen (Figure 16a) had a greater range of upstream/downstream differences in the dry season versus in the wet season (4.7 vs. 0.4). However, the upstream/downstream median differences were comparable for the dry season (-0.7) and the wet season (-0.1). The negative medians indicate an increase in dissolved oxygen values from upstream to downstream. An increase in DO is an improvement in water quality.

In comparing upstream/downstream turbidity (Figure 16b), there was a greater range of differences in the wet season versus in the dry (12.2 vs. 9.6). The upstream/downstream median differences varied for the dry season (-5.19) and the wet season (-1.4). The negative medians indicate an increase in turbidity from upstream to downstream. An increase in turbidity is a decline in water quality.

16a.

16b.

Figure 16 a-b. Differences of upstream and downstream values in the dry and wet seasons during the year of trapping. Black lines are medians, upper and lower edges of boxes are quartiles, and whiskers are 5 and 95 percentiles.

Before (2004-2005) vs. During (2005-2006) Trapping: Davis Monitoring Station

In comparing wet and dry seasons for the year before trapping (2004-2005) to the year of trapping (2005-2006), only one pair was significant. (Table 6 shows the paired t-test results for dissolved oxygen, turbidity, total solids, total suspended solids, and total dissolved solids.) Only dissolved oxygen during the dry season showed a significant difference (improvement) between the year before trapping and the year of trapping ($p = 0.018$, $\alpha = 0.05$). Beaver studies (Maret, 1987; Margolis, 2001) found that water chemistry changes due to beaver impoundments were most prevalent in the summer (dry season). This is when there is low flow, higher water temperatures, and an increase in hydrologic residence time (Margolis, 2001). The improvement in DO during the dry season could be a result of nutria trapping and a reduction in wastes,

perhaps from nutria, which provide nutrients to the oxygen consuming microorganisms.

I used boxplots (Figures 17a-e) to illustrate the dry vs. wet season parameter values for the year before trapping compared to the year of trapping. Dissolved oxygen (Figure 17a) medians were higher and comparable during the wet seasons (2004 = 11.6, 2005=12) but differed during the dry (2004=6.6, 2005=8.7). DO medians were higher during the year of trapping for both the wet and dry seasons.

Turbidity (Figure 17b) medians were lower and comparable during the dry season (2004=12, 2005=11.5) but varied during the wet (2004=17, 2005=19.5). The 2005-2006 wet season had a much greater turbidity level range (30.25) due to high levels at Summercrest's downstream site, 515002. Total solids medians (Figure 17c) varied between seasons and years. The year of trapping values were higher than the year before trapping and dry season values (2004=131.5, 2005=139) were higher than wet (2004=111.5, 2005=122.5). Total dissolved solids medians (Figure 17d) were lower and comparable during the wet season (2004=101.5, 2005=102.5) but varied during the dry (2004=121, 2005=118). Total suspended solids medians (Figure 17e) varied between seasons and years. During trapping year dry and wet season medians were higher than medians for the year before trapping (2004 dry=10.6, 2005 dry=21, 2004 wet=9.6, 2005 wet=13).

In summary, only dry season DO change was significant for the year before trapping compared to the year of trapping. This change may have been due to a decrease in the amount of waste, specifically from nutria, in the creek water or could

be attributed to other sources. Boxplots show that dissolved oxygen levels improved during both the dry and wet seasons when I compared the year before trapping to the year of trapping. During the wet and dry seasons, both total solids and total suspended solids showed a decrease in water quality between the year before trapping and the year of trapping (an increase in medians). All but total suspended solids showed a seasonal variability, with either wet (DO and turbidity) or dry (TS and TDS) season medians being higher.

Table 6. Davis permanent monitoring station data. Parameter paired t-test results 2004-2005 vs. 2005-2006 for the dry (July, Aug., Sept.) and wet (Nov., Dec., Jan.) seasons.

Parameter	StDev	SE	p-value
<u>Dissolved Oxygen</u>			
Dry	0.493	0.285	0.018*
Wet	1.044	0.603	0.365
<u>Turbidity</u>			
Dry	3.139	1.812	0.626
Wet	30.04	17.343	0.382
<u>Total Solids</u>			
Dry	20.306	11.724	0.89
Wet	9.76	5.635	0.139
<u>Total Suspended Solids</u>			
Dry	7.915	4.57	0.487
Wet	2.946	1.701	0.072
<u>Total Dissolved Solids</u>			
Dry	19.009	10.974	0.862
Wet	6.764	3.905	0.195

* Values with an asterisk are significant at $\alpha = 0.05$.

Figure 17a.

Figure 17b.

Figure 17c.

Figure 17d.

Figure 17e.

Figures 17a-e. Comparison of dry vs. wet season parameter values for the year before trapping and the year of trapping. Black lines are medians, upper and lower edges of boxes are quartiles, and whiskers are 5 and 95 percentiles.

Historical Parameter Data (1994-2005): Davis Monitoring Station

In order to look at long-term parameter trends, I used time series graphs to compare wet vs. dry seasons for 1994-2005. Dry season dissolved oxygen (Figure 18a) values oscillated but were always lower than wet season levels. Turbidity (Figure 18b) wet and dry season values followed the same pattern over time, with wet season levels higher than dry. Total solids (Figure 18c), total dissolved solids (Figure 18d), and total suspended solids (Figure 18e) all had similar patterns for the wet and dry seasons and all mostly had higher values during the dry season.

Therefore, except for turbidity, historical data for an eleven year period showed that the wet season had improved water quality over the dry season (higher dissolved oxygen and lower levels of all the solids). Turbidity values were higher

during the wet season (poorer water quality) and a dramatic upward spike was evident during the year of trapping, 2005. All parameters but total dissolved solids showed a distinct jump during the dry seasons of the late 1990's, which coincided with extensive construction in the basin.

Figure 18a.

Figure 18b.

Figure 18c.

Figure 18d.

Figure 18e.

Figures 18a-e. Time series graphs comparing wet and dry season trends from 1994-2005 for dissolved oxygen, turbidity, total solids, total dissolved solids, and total suspended solids.

Results of Hypothesis

Hypotheses	Statistical Analysis Result (Significant results)
1) Year of trapping downstream DO levels would improve over upstream.	Not supported.
2) Year of trapping downstream turbidity levels would improve over upstream.	Not supported.
3) During the year of trapping data would improve for all parameters over the year before trapping.	Supported for only dissolved oxygen during the dry season.

Table 7. Results of hypotheses.

DISCUSSION

Contrary to my hypotheses, turbidity and dissolved oxygen did not significantly improve from upstream to downstream during the year of trapping. Nor did turbidity, TDS, TS, or TSS improve between the year before trapping and the year of trapping. Only DO significantly improved in the dry season during the year of trapping. In regards to my study, these results indicate that for the majority of parameters nutria trapping did not have a significant effect on water quality.

However, during my study I saw nutria waste, turbid water, degradation of stream banks, and damaged riparian vegetation at all three ponds. ODEQ's 2001 Tualatin Sub-basin Total Maximum Daily Load report shows the pollutants resulting from nutria behavior cause a decline in water quality. Therefore, nutria trapping could have theoretically improved water quality. Although not significant, I did see changes (improved and degraded) in parameter levels between upstream/downstream and before the year of trapping/year of trapping. In the following sections, I present possible explanations for the water chemistry changes seen and for the lack of significant differences. These explanations are separated into an analysis of parameters, water test site variability, and water quality testing limitations.

Analysis of Parameters

The physical and biological consequences of nonpoint pollution on water chemistry of a creek and associated ponds can differ. The changes in water chemistry at my three study ponds (both improved and degraded) could have been influenced by the trapping of nutria but may have also been due to other sources such as yearly weather changes, construction, urban run-off, animal migration, soil erosion, human

disturbance, and/or burrow construction. DO, turbidity, TS, TSS, and TDS are all strong indicators of water quality but they are also variable and, therefore, to attribute a cause or causes for change (or a lack of significant change) can be challenging.

DO studies differ in their conclusions as to the effects of semi-aquatic mammals on water systems. Serena and Pettigrove (2005) found no significant differences in mean summer concentrations of DO between reaches supporting a medium-density of platypus and reaches lacking a population. However, Smith et al. (1991) wrote that dissolved oxygen concentrations decreased (degraded) through beaver impoundments.

DO is highly variable and is affected by temperature, salinity, respiration, and photosynthesis. In my study, dissolved oxygen levels were higher in the wet season than in the dry, improved from upstream to downstream in both seasons, and significantly improved during the dry season between the year before trapping and the year of trapping. The higher DO levels of the wet season were most likely a result of faster, cooler water versus the water of the dry season with higher temperatures, lower flow, and higher oxygen decay.

The significant change in DO during the year of trapping (dry season) may have been a result of nutria removal or may have been due to other factors. Nutria wastes provide nutrients for microorganisms, which grow and multiply rapidly, consuming oxygen in the process (Radajevic, 1999). Nutria trapping may have eliminated the waste and helped improve DO. The increase in DO levels could also have been due to an increase in riparian vegetation planted by Clean Water Services during the year of trapping. Riparian vegetation improves DO by decreasing water temperature and run-off. The significant change in dry season DO is most likely not a result of a difference in water temperature between the year before trapping and the

year of trapping. The average water temperature for the wet season in the year before trapping was 7.3 °C compared to 7.8 °C in the wet season in the year of trapping. It would be a decrease, not an increase such as found here, in the average wet season water temperatures between the two years that could be a reason for an improvement in DO.

Turbidity is an excellent indicator of short and long-term stream health. Studies show the negative effects of beavers on turbidity and solid levels. Skinner (1984) found that beavers might be a point source of pollution by contributing bacteria to stream flow as a result of excretion and by the stirring of sediments. Beaver impoundments can also increase concentrations of suspended solids in downstream waters (Maret, 1987). Therefore, I had predicted that turbidity would improve (the levels would decrease) as a result of nutria trapping. In my study, turbidity increased downstream and during the year of trapping, both during the wet season. Turbidity is also very variable and can be influenced by storms that introduce large loadings of organics, nutrients, and suspended solids. In addition to other potential factors, the increase in turbidity during the wet season may have been due to a difference in precipitation between the year before trapping and the year of trapping. According to the Oregon Climate Service website, the average wet season precipitation in the year before trapping was 2.8 inches and in the year of trapping was 9.6 inches.

Water Test Site Variability

Figure 19. Trapping and water quality results for Summercrest, Beacon Hill, and Jaylee data collection sites and the Davis permanent monitoring station.

Figure 19 provides a map of the South Johnson Creek sub-basin. The three ponds are represented with darkened ovals and the upstream/downstream water test sites at each pond are indicated with a X. The Davis permanent monitoring site is upstream of Jaylee. Wet and dry season trapping and water quality results are summarized at each site.

The variability in test sites may have contributed to the range in nutria trapped and to the differences (or lack of significant differences) in parameter results. The pond make ups may account for different nutria densities (and, thus, the number of nutria trapped). 96% of trapped nutria came from Summercrest and Beacon Hill, while only two nutria (4%) were trapped at Jaylee. Different nutria densities may have varied the ways that the parameters reacted to nutria trapping. The differences in pond water flow (flowing or stagnant) and vegetation (open or shaded), that may have existed prior to nutria habitation or may have been the result of their presence, could have also played a role in the variation of water quality results. Finally, the location of the ponds in relation to South Johnson Creek could be another factor for the variation in the number of nutria trapped and the different parameter levels. Summercrest and Beacon Hill are on two separate upstream tributaries of South Johnson Creek, the confluence being upstream of Davis. Jaylee is on South Johnson Creek, downstream of Davis.

Water Quality Testing Limitations

Different water quality results could also be associated with the type of data source. The Davis station collected reliable automated pump samples over the long-term. However, it only provided a sub-basin picture of water quality, instead of local reactions to nutria trapping. Since Davis is downstream of two of the study ponds,

parameter levels may have changed between Summercrest/Beacon Hill and Davis. One beaver study found that decreases in DO concentrations had significantly increased 150 and 250 meters downstream of impoundments as outlet waters were reoxygenated (Margolis, 2001).

I also collected grab samples from upstream/downstream test sites around each pond for the year of trapping. However, a single grab sample represented a localized snapshot in time that could have easily misrepresented pollutant loadings. Inaccurate water quality parameter measurements could have resulted from inconsistent data collection, machine fallibility, or insufficient samples. Every effort was made to consistently collect data, however, high water levels and different data collection times did not make this feasible.

Population Estimate Limitations

I intended to estimate nutria population at each of the three ponds in order to determine the sub-basin's nutria carrying capacity, that is to see the impact per nutria at each pond. However, I was unable to estimate populations due to the short duration of trapping, a geographically small study area, and a small number of nutria trapped. Southwood (2000) wrote that for the maximum-likelihood method for population estimate to work the probability of capture must be constant. For example, a trapped species must have a stable population, there cannot be any significant natality, mortality, or migration during the duration of the study. Nutria easily migrated from my study area and because nutria can breed up to three times in a year and have no natural predators the birthrate exceeded the death rate. All of this concurs with Carter (2007) who claimed that it is extremely difficult, if not impossible at this point, to estimate population size or determine carrying capacity.

Suggestions for Further Study

My study could serve as a baseline for measured parameters but due to the limitations in my effort to determine the effects of nutria trapping on water quality, I have several suggestions for future studies. First, along South Johnson Creek, construction was a nonpoint source of water pollution. Spikes in the total solids and total suspended solids graphs (Figure 18c and 18e) in 1998, the year of a large amount of construction in the basin, shows the impact of nonpoint source pollution. Therefore, it would be optimal to have a study in an area with no current or predicted construction.

Due to a lack of virgin streams (no nutria) in the sub-basin, this study did not have a control creek. As a result, it was challenging to judge the effects that nutria trapping had on water quality. In addition to a control, it would be important that future studies be on a larger geographical scale. Margolis (2001) documented the ability of beaver impoundments to alter biogeochemical cycles on large spatial and temporal scales. He also found that beaver induced changes in water chemistry persisted one hundred meters downstream of impoundments during the summer.

Future studies would also need to be longer in duration. One year was too short a time to see consistent change flushed through a watershed. A long-term trapping project, 3-5 years, would lead to a dramatic reduction in the nutria population and to the possibility of seeing improving trends in water quality parameters (Kapur, 2007). Naiman et al. (1986) collected data on the effects of beaver dams on carbon budget for four years. Serena et al. (2005) found that the eight year period she studied the impact of the platypus on water quality to be an appropriate time scale in relation to its lifespan, 21 years in the wild. My one year study covered only 33% of the nutria's average lifespan (three years in the wild), compared to Serena's study that

covered 40% of their subject's lifespan. Long-term observations could also be made regarding stream bank stability and the sustainability of riparian vegetation, two strong indicators of the impact of nutria.

Finally, as mentioned previously, the duration and pattern of trapping, limited geographical area covered, and character of nutria made it impossible to estimate population size and carrying capacity in my study. Carter (2007) claimed that the nutria control number varies for different systems. He is currently working on deciphering these variations. In order to estimate population size and carrying capacity of areas, Carter is working on collecting nutria DNA with the use of hair traps. He is also trying to compare age distribution between fresh and saltwater nutria by examining nutria eyes in order to ascertain a genetic structure of the population. If carrying capacity can be determined, a viable option for certain locations may be to control nutria population as opposed to total eradication.

CONCLUSIONS

Contrary to expectations, the trapping of nutria did not significantly impact DO or turbidity when comparing upstream to downstream sites. Only DO showed a significant improvement during the dry season in comparing the year before trapping to the year of trapping. Several factors could explain why more significant differences were not seen, including the variability of: tested parameters, study sites, and sample collection methods.

In analyzing the results of this study, it is important to understand that despite the lack of significant results the impact of nutria at the ponds is visually evident and that nutria have been sighted all throughout the basin. They are a non native, invasive species that can produce up to 40 offspring a year and who have no natural predators. Their main source of mortality is consecutive days of freezing temperatures, a rarity in the mild Pacific Northwest. A long-term trapping study on a larger geographic scale would allow the possibility of seeing improvements in water quality parameters. Current short-term, reactionary, localized trapping campaigns will not alleviate the nutria population problem or its effect on water quality. According to U.S. Fish and Wildlife (2007), "Rapid immigration coupled with a high reproductive rate makes population control a 'high effort' method of damage control and often ineffective. Exclusion is often the best long-term solution to nutria damage." Long-term trapping programs in Louisiana and on the Blackwater National Wildlife have led to improvements in marsh and wetland health. A large scale campaign is a daunting task yet it is undeniable that nutria are very present in the South Johnson Creek sub-basin and that this invasive species has made itself quite comfortable in its new home.

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