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HABITAT EVALUATION FOR THE MARSH WREN *CISTOTHORUS PALUSTRIS* IN THE BEAR RIVER MIGRATORY BIRD REFUGE

In partial fulfillment of the requirements for the degree of
Masters in Science in Environmental Management
in Conservation and Management of Natural Resources

By
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DEDICATION

To my beloved mother and grandparents,

Because without them my life would be meaningless and

to all who admire and respect the beauty of Mother Earth.

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ABSTRACT

Marsh Wren (*Cistothorus palustris*) is a marsh bird specialist found during the spring and summer time in marshes. This passerine bird is considered to be an important biological indicator of the healthiness of marshes. Although Marsh Wren population has declined in some parts of the United States due to deterioration or modification of their habitat, it is particularly abundant across wetlands in Utah. Bear River Migratory Bird Refuge (BRMBR) is recognized as the most important waterfowl in the whole Western United States, serving more than 200 different species of shorebirds and waterbirds, including Marsh Wren. This study investigates dependence of the Marsh Wren's population on the water level and type of vegetation as two major factors defining their habitat. Data collection was performed along linear transects at BRMBR as the primary study site, and also at two other locations (Bear Lake National Refuge and Salt Creek Waterfowl Management Area) for comparison purposes. The average territory size for all three-study sites was determined (BRMBR – 220 m^2, Bear Lake – 557 m^2 and Salt Creek – 129 m^2). Statistical analysis using ANOVA non-parametric tests (Kruskal-Wallis, Mann-Whitney or Tukey method) showed no significant correlation between the bird density and the water level of their habitat ($p > 0.05$). In two of the study sites (BRMBR, Bear Lake) a statistically significant correlation was however observed between Marsh Wren and type of vegetation. Specifically, Marsh Wren preferentially used bulrush to establish its habitat ($p < 0.05$). Because typical vegetation favored by Marsh Wren is thought to be cattail, these results suggest that due to water fluctuations of the wetlands Marsh Wren might be forced to change the habitat from cattail to bulrush in order to remain in high water level area. Thus, alteration to their primary vegetation preferences seems to affect their habitat selection to the extent that they might not nest until their habitat is restored. This research might be useful for managers of marshes in enhancing their management strategies to improve the conservation of this fragile ecosystem.

CHAPTER I

INTRODUCTION

Background

Wetlands loss is a worldwide trend. It is estimated that 50% of all Earth's wetlands have been destroyed since 1900 (Thompson, 2006). The presence of water is vital in the identification of wetland's ecosystems; their hydric soils create a unique environment for the adaptation of specialized plants and animals (UWIN, 2005).

Major part of Utah is covered in arid habitat, and only one percent (approximately eadows (UWIN, 2005).

The Great Salt Lake Ecosystem represents 75% of all Utah's wetlands (UWIN, 2005). This complex ecosystem is made up by: the Great Salt Lake (the largest inland body of salt water in the Western Hemisphere and one of the most saline in the world), the adjacent wetlands, the Bear River, the Weber River and the Jordan River (Bozniak, 2008). The extensive marshes of the Bear River delta, located near the northern end of the Great Salt Lake, have been known for many years as one of the most important waterfowl areas in the West (Williams & Marshall, 1938). Surrounded by arid desert lands, the Bear River delta has long served as an oasis for migrating birds (USFWS, 2011).

Before 1928, that water usage for irrigational purposes was established (Downard, 2010). The usage of Bear River for irrigation and power generation altered hydrological regime, thus reducing the bird population (Williams & Marshall, 1938). By the 1920s only 2,000 to 3,000 acres of the original 45,000 acres of Bear River marshland remained (USFWS, 2011). In 1928, avian botulism, a fatal disease caused by the bacteria *Clostridium botulinum*, resulted in death of hundreds of thousands of birds (Locke & Friend, 1989). The public's reaction to these deadly epidemic brought action and Congress passed an act to make the Bear River delta a National Wildlife Refuge, known as The Bear River Migratory Bird Refuge (BRMBR) (USFWS, 2011).

Great Salt Lake Ecosystem, which includes BRMBR, is a part of the Intermountain West Region of the Great Basin. The area of the basin (200,000 square miles) (NPS, 2007) falls between the Cascade and Rocky Mountain ranges of Oregon, California, Nevada and Utah (Olson, Lindey & Hirshboeck, 2004). All the precipitation in this region evaporates, sinks underground or flows into some of the most saline lakes (NPS, 2007).

The Great Basin is a temperate desert, hot and dry during summer and cold and snowy during winter (NPS, 2007). Due to the arid to semi-arid climate in this area, wetlands account for only 1% (1.6 million acres) of the surface area, while wetlands in the Midwest region comprise approximately 6% (22.5 million acres) of the total area (Olson, Lindey & Hirshboeck, 2004). Despite its arid temperatures, the Great Basin has wet areas of major importance to waterfowl, shorebirds and marshbirds (Ryser, 1985). Over 48% of North America's waterbird diversity and 63% of shorebirds diversity are found in this region (Olson, Lindey & Hirshboeck, 2004).

Today, the BRMBR covers 74,000 acre of freshwater marsh, open water, uplands and alkali mudflats (USFWS, 2011). Its size and geographical location has influenced the migration of the Central and Pacific flyways, making it a vital stopover for migrating birds that forage in the shallow water, mudflats, marshes and adjacent grasslands (Ven Den Akker & Wilson, 1949). According to the USFWS 2006 Plant List, there are about 162 plant species present in the Refuge. This rich vegetation provides habitat for more than 200 bird species, making it a popular birding hotspot in northern Utah and one of the world's best birding areas (USFWS, 2011).

Problem Statement

Marshes are usually inundated with water, causing the surface water levels to vary from a few inches to two or three feet (UWIN, 2005). In Utah, the average precipitation during the hot dry summers is 34 cm, with the minimum and maximum temperatures of 19°C and 37°C, respectively (Lindvall & Low, 1982). The 50 miles of dikes and 57 water control structures and bridges constructed in the BRMBR allow management of the water level and flow throughout a year in the Refuge, thus creating aquatic habitats for the species prioritized as part of the Refuge Management Plan (USFWS, 2011). Water from the Refuge is also used during irrigation season (USFWS, 2011).

Marsh Wren (*Cistothorus palustris*) (Figure 1) is a common migratory bird found in the BRMBR (USGS, 1995). During the summer it is found in most marshy habitats, where they feed and nest (Gadsden, 2008). Ridout (1998) indicated that male wrens are found in territories with high quality vegetation and rich in insects, both important for attracting females. In some parts of the U.S. and Canada their population has been declining because of the destruction of their habitat (Ridiout, 1998). Additionally, some migrating wrens are killed in collisions with communication towers and other structures (Lesperance, 2001).

Since Marsh Wren requires a healthy ecosystem with plenty of insects, it can be considered as an indicator of healthy marshes (Gadsden, 2008). However Marsh Wren is not considered a priority species in the Refuge and little is known about the effect of fluctuating water levels on the quality and quantity of its habitat (Zimmerman, 2002). Changes in the water level of a marsh can be used for the control of undesirable plants (Rebel, 1962). The fluctuations in water level can radically change the plant composition of a marsh (Rebel, 1955). For example, fluctuations in the water level could affect the coverage of cattail (*Typha latifolia*) and bulrush (*Scirpus spp.*), thus potentially reducing the breeding population of Marsh Wrens (Zimmerman, 2002).

Justification

Although Utah's wildlife has mostly adapted to survive under dry conditions, still 80% of the wildlife requires wetlands habitat for at least part of their life cycle, especially for food, shelter, migratory rest stops and as the prime location for raising young (Thompson, 2006). The presence or absence of shelter may influence whether birds will inhabit a wetland or a nearby upland area (USGS, 2007).

The health of freshwater, as well as coastal and marine water can be evaluated by the presence, variety, condition and number of fish, insects, algae, plants and other aquatic organisms (EPA, 2011). Likewise, the presence of certain wetland-dependent animals can be considered as an indicator of a healthy wetland (Tiner, 1999). Such a healthy wetland is characterized by good quality of water, variety of fish, birds and other wildlife (NCRS, n.d).

Marsh Wren as an example or characteristic habitant of healthy marshes is proposed to be included in an integrated monitoring program as the quality indicator of wetlands (Green et al., n.d). In a study conducted by the Marsh Monitoring Program in Thunder Bay, Ontario, Canada from 1995 to 2002, the Marsh Wren was used as an indicator species for high quality marsh habitat. It was concluded that the low number of wrens indicated that the area was impaired in its capability to support a high diversity of marsh bird species. Sensitivity of Marsh Wren to habitat changes was demonstrated in South Dakota were livestock grazing along shorelines of seasonal wetlands negatively affected Wren's population (Zimmerman, 2002). On the other hand, Marsh Wrens readily colonize newly created or restored wetlands habitats, resulting in increasing population size in some areas (Lesperance, 2001).

Despite Marsh Wren lack of vivid colors and majesty, their personality, song and promiscuous behavior makes them attractive to public (Ridout, 1998). The male Marsh Wren can sing up continuously up to 200 songs during their breeding season; their songs are compared to the sound of a sewing machine (STS, 2008). Their population decline should make the public more aware of the importance of wetlands and of the joy watching their behavior can bring (Ridout, 1998).

Hypothesis

Marsh Wren habitat has been affected by the fluctuation of water levels.

Goal

Determine the habitat preference of the *Cistothorus Palustris* in The Bear River Migratory Bird Refuge.

Objectives

1. Evaluate the effects of water level variations on the habitat of *Cistothorus palustris* in Bear River Migratory Bird Refuge and equivalent locations in northern Utah and southern Idaho.

2. Determine density and territory size of *Cistothorus palustris* and density of vegetation in various plots of Bear River Migratory Bird Refuge and equivalent locations in northern Utah and southern Idaho.

CHAPTER II

LITERATURE REVIEW

Historical Background

At the present there are 14 subspecies of Marsh Wren in North America and one in Mexico (Alderfer, 2006). However, Marsh Wren (*Cistothorus palustris)* is listed in the American Ornithologist's Union (1983) as a single species of another taxon with eastern and western counterparts that meet in the Great Plains (Kroodsma, 1989). The eastern species (Sedge Wren) is known as *platensis* and the western species (Marsh Wren) as *palustris,* but both species are formerly known as Marsh Wren (Alderfer, 2006).

Sedge Wren breeds along the Gulf of Mexico and the Atlantic Ocean north to Nova Scotia and westward to Nebraska and Central Saskatchewan (Canada). Marsh Wren breeds from Nebraska and Central Saskatchewan to the Pacific and south through California (Kroodsma, Doland & Verner, 1997). Morphological differences between Marsh Wren populations are minor but sufficient for delineating a number of subspecies in both eastern and western halves of the continent (Kroodsma, 1989).

Physically Marsh Wren (*Cistothorus palustris*) or the Long-Billed Marsh Wren is a small wren ranging from 10 – 14 cm in total length and weighing between 9 – 14 g. Male is larger than the female. Both sexes have a dull black crown, a black triangular area striped with black on the upper back, cinnamon brown upper parts with faint black barring, whitish underparts, buff coloring on the sides and sometimes breast, a white superciliary stripe, and black or cinnamon barring on the tail (Monfils, 2006) (Figure 1).

The adults molt two times a year in spring and midsummer (Alderfer, 2006). The Sedge Wrens (*Cistothorus platensis)* are somewhat smaller than their western counterparts ranging from 10 - 12 cm in length and 10 - 12 g in weight. Both sexes are similar in appearance, except the male is larger than the female. Their short thin bills give them the name of Short-Billed Marsh Wren. Adults have brown upperparts with a light brown belly, flanks and a white throat and breast and an upturned tail varying in color from brown to gray to buff. The back has pale streaks. They have a dark cap with pale steaks and a faint line over the eye. Similar to Marsh Wren they molt twice a year in early spring and late summer (Alderfer, 2006).

The Marsh Wrens (*Cistothorus palustris)* is a common but elusive passerine bird found during the summer in the Bear River Migratory Bird Refuge (BRMBR) (USGS, 2011). They migration is difficult to detect, but usually they are back on breeding grounds by mid-May and leave between midsummer until early fall (Alderfer, 2006). Marsh Wrens usually winters across southern areas of the States up to Washington on the West Coast and up to New Jersey on the East Coast (Udvardy, 2000).

Male Marsh Wrens are considered one of the most amazing singers among birds (Kroodsma, 2008). Although visually difficult to locate, they are fairly easily recognizable by their characteristic singing with a broad range of frequencies along with sharply broken and repetitive sounds produced by the male (Bump, 1986). These "secretive" birds remain well hidden through a day, only occasionally climbing on a cattail while looking for intruders (Udvardy, 2000).

BMBR is located in the northeast arm of the Great Salt Lake known as the Bear River Bay, which embraces 112,000 acres of the Bear River delta (Olson, Lindey &

Hirshboeck, 2004). This ecosystem is composed of freshwater marshes, river channels and alkali salt flats. Its extensive marshes have been known for many years as one of the most important waterfowl areas in the West (Williams & Marshall, 1938).

Surrounded by arid desert lands, the Bear River delta has long served as an oasis for migrating birds (USFWS, 2011). BRMBR is the largest freshwater part of the Great Salt Lake ecosystem and hordes large population segments of Central and Pacific Flyway waterfowl (Van Den Akker & Wilson, 1949), shorebirds and other waterbirds during their annual cycles (Olson, Lindey & Hirshboeck, 2004). It also provides feeding, resting, wintering or stating area to resident wildlife (USFWS, 1997).

Wetlands in this region are adapted to periodic droughts, but their natural hydrologic cycles and water sources have been significantly altered for human uses (Downard, 2010). In 1847, a large-scale European-style agricultural and industrial colonization began with the arrival of the first Mormon settlers (Bedford, 2010). The Euro-American settlers began to use water from the Bear River for agricultural purposes (USFWS, 2011) and for municipal consumption in the first towns, Salt Lake City and Ogden (Bedford, 2010). By 1920, the 45,000 acres of delta marshes were reduced to 3,000 acres (USFWS, 2011). This had a direct effect on the migratory birds as lack of a flooded wetland habitat can decrease the plant growth and food production, also concentrating more birds in a smaller area thus causing outbreaks of bird's diseases (Downard, 2010). Such losses of marshes and large concentrations of waterfowl flock into the remaining wet acres of the Bear River delta had been correlated in the past with outbreaks of bacterium *Clostridium botulinum* (USFWS, 2011). It is estimated that these outbreaks killed more than 3 million of waterfowl in 1900, 1910 and 1920 (USFWS, 2011). The deaths of the birds caused public concern aimed at conservation policy that would also ensure future-hunting opportunities (USFWS, 2011).

In 1928, the Congress established the BMBR to preserve the Bear River Delta marshes. One year later, the Congress authorized the re-establishment of delta marshes with the construction of over 50 miles of dikes and numerous canals to impound the fresh water of the Bear River excluding the saline water of the Great Salt Lake (Williams & Marshall, 1938). When completed, the system created five impoundments of about 5,000 acres each and a total of 25,000 acres of wetlands, which permitted the growth of the most extensive, nesting vegetation (USFWS, 2011). The visible effects of this construction was seen back in the 1930s were wildlife populations and habitats increased (Downard, 2010). This system continues to be used at present.

In 1983, after several extremely wet winters and cooler than normal summers, the Great Salt Lake began to rise above its traditional shoreline and caused Refuge marshes to be inundated with salt water, destroying the existing vegetation along with the facilities (USGS, 2006). It was not until 1989 that flood water receded and restoration of the dikes, roads and water control structures began to allow flushing of the impoundments with fresh river water. Ironically, in 1997 outbreaks of botulism had occurred, killing 500,000 birds in the BRMBR (USFWS, 2011).

Today, the system involves 96 miles of dikes that divide the complex into 26 units creating more habitat diversity and giving managers the ability to better manage water depth within units (Downard, 2010). The 26 manageable units surrounded by dikes constitute about 40,000 acres of marsh and mudflat habitat (USFWS, 2011).

Conceptual framework

The singing behavior of the *Cistothorus spp.* is very similar; males sing relatively frequently, have a large song-type repertories (over 100 songs in some populations), and sing day and night (Kroodsma, 1999). Barclay, Leonard and Friesen (1985) studied the nocturnal singing behavior of Marsh Wren. They proposed that the reason for this behavior is to attract the females that migrate during the night to the breeding area. Additionally nocturnal singing avoids background noises present during the day, thus facilitating male-male vocal interactions. Consequently authors rejected alternative hypothesis; stimulation of females, aggression by other species and song learning by offspring.

During the early morning, male Wrens tend to sing the optimum number of songs per minute (Welter, 1935). Males sing vigorously until acquiring a mate. As the female is constructing the nest and begins laying the eggs, the male's song activity begins to decline. During the incubation males sing significantly more often but less than during mating and reduce singing again during the nestling period and after the young leave the nest. (Wilson & Bart, 1985).

In a study made between the Sedge Wren and the Marsh Wren showed that the Marsh Wren singing behavior is associated with a neural control pathway based on genetic differences and is not just the result of individuals being raised in different environments (Kroodsma & Canady, 1985). The differences between the two Wren's groups are in the singing behavior of the male (Kroodsma, 1989).

The Sedge Wren has a larger song repertoire than the eastern species because of neuroanatomical differences in the song control nuclei in the forebrain (Devoogd, Krebs, Healy & Purvis, 1993). The Sedge males sing 50 different songs in one repertoire (Kroodsma & Canady, 1985). Compared to the Marsh Wren, the Sedge Wren males sing with great individual variation between neighbors, while the Marsh Wren have nearly identical song type repertories (Kroodsma & Verner, 1978). Brenowitz, Lent, and Kroodsma (1995) demonstrated that the amount of brain space does not influence the song learning experience. In fact, the development of neural systems depends on the interactions between genetics and environmental factors.

Other ecological behavior differences are; Sedge Wrens are sedentary while Marsh Wrens are migratory; Sedge Wrens are more polygamous and defend smaller territories than Marsh Wrens; and finally, Sedge Wrens have a longer breeding season than Marsh Wrens (Kroodsma & Canady, 1985). A very distinctive characteristic is the habitat preference; Sedge Wrens are found in moist uplands meadows rather than the cattail and bulrush marshes favored by the Marsh Wrens (Kroodsma & Verner, 1978).

Marsh Wrens are more prone to occupy fresh to salty marshes, seasonal, semipermanent, or permanent wetlands with dense mixed, or monotypic stands of emergent aquatic vegetation such as cattail (*Typha spp*), hardstem bulrush (*Schoenoplectus acutus*), river bulrush (*Schoenoplectus fluviatillis*), alkali bulrush (*Scirpus maritimus*), hairy sedge (*Carex lacustris*), bur-reed (*Sparganium eurycarpum*), and common reed (*Phragmites autralis)* and less in vegetation that is shorter with a weaker stem such as bluejoint (Calamagrotis *canadensis*) and reed canary grass (*Phalaris arundinacea*) (Zimmerman, 2002).

Male Marsh Wrens are the first to arrive to the marsh nesting territory, followed by females a couple of days later. When male Wrens arrive, their reproductive organs are fully developed in contrast to the females, which have to avoid the males until they fully develop (Welter, 1935). Meanwhile, the male Wrens construct nests known as “false nests or dummy nests” on their territories which collectively comprise the “courting centers” (Metz, 1990). Once the female Wren is in a male’s territory; he begins to fluff his breast feathers, raise his tail, sing, fly around his territories and display the “false nests” (Welter, 1935). Male Marsh Wrens are known for their promiscuous and polygamous behavior (Ridout, 1998). Marshes have a minimum requisite food supply and sufficient variation in available food between territories to favor polygamy (Verner & Wilson, 1966). The number of females varies within population, but the most commons harems are with two or three females (Leonard & Picman, 1987-a).

When a female selects her mate, sometimes she completes the nest by adding the lining (Ridout, 1998). In fact females are the ones that build the actual “breeding nests” in which the eggs are laid (Metz, 1991). At this point females are ready to prepare for the mating act (Welter, 1935). Even after females began to incubate, the male Marsh Wrens continue to build others “dummy nests” in other parts of the territory (Welter, 1935; Verner, 1960; Metz, 1991). Although Marsh Wren is considered as one of the most prolific builders of nests, most of those nests remain uncompleted and known as “dummy nests” (Welter, 1935). In a study made by Verner & Engelsen, (1970) the incomplete nests of bachelor’s Marsh Wrens were found to be higher in bulrush. These results show that there is a possibility that bachelors learned that cattail stalks provides stronger support for nest than bulrush in which nests tend to slip down.

A study conducted by Leonard and Picman (1987a) found that there was no correlation between the number of male’s nests and pairing success over the entire breeding season. However, the authors suggested that the "dummy nests" can serve as decoy reducing the predation on the breeding nests, which would be more effective if the breeding nest were not immediately within the cluster of the "dummy nests". In the same year both authors (Leonard & Picman, 1987b), conducted another study to prove the "anti-predator hypothesis". They observed that the breeding nests found near large areas of the "dummy nests" were more successful than the breeding nests found near smaller groups of "dummy nests". However, another study conducted by Metz (1991) concluded that the "dummy nests" did not appear to attract females or reduce predation in the study area. Additionally, several authors have proposed other possible benefits from this behavior; practice that the male acquires in building nests, setting territory boundaries, burning off the excess energy or utilization of the nests as shelter for adults and newly fledged young. Nevertheless, none of the proposed benefits have been shown up to date to adequately explain this persistent behavior.

The nesting materials that the female Marsh Wrens use for constructing the breeding nest include: Sedge (*Carex sp.),* Bluejoint Reedgrass (*Calamagrostis sp.),* Cattail (Thypha *sp.),* grasses, Duckweed (*Lemna sp.*), feathers from other species of birds, and sometimes mud. The innermost part of the nest is made up by finely shredded pieces of vascular materials of plants from the previous year. "Dummy nests" are not used as basis for the female nest. The breeding nests have an opening or "door-step" that the male nests lack, serving as protection for the eggs and young due to uneven growth of the supporting plants (Welter, 1935). Because of the dome shape and small opening, brood parasitism by Brown-Cowbirds (*Molothrus ater)* is uncommon among the breeding nests (Picman, 1986).

Marsh Wren raises two broods in the season and on each occasion forms a new nest (Audubon, 1840). Nests are dome-shaped structures supported by several stems in tall vegetation over water (Monfils, 2006) or damp ground (Zimmerman, 2002). Cattail stalks provide the strongest support for nests (Verner & Engelsen, 1970). The nests can be constructed in cattail and bulrushes, but cattail is the most preferred nesting vegetation (Welter, 1935) since nests built in bulrushes tend to slip down (Verner & Engelsen, 1970). Males Wrens exploit cattail as long as the cattail still has standing water around the bases of the stalks. Once the cattails dry out, the birds move to bulrush stands for nesting cover as a second choice (Verner and Engelsen (1970).

Welter (1935), observed nests of Marsh Wrens in dead cattail stubs or among the new growth of sedges that were between 6 and 24 inches above the water. Nests built in the cattails were up to 6 feet above water. Zimmerman (2002) described 14 locations of Marsh Wrens' nests adjacent to open water and 31 nests located at water depths from 2 to 36 inches. This indicates a preference of Wrens for water based habitats. The presence of water is vital for the protection of nests from mammals and/or providing food source (Verner & Engelsen, 1970).

Leonard and Picman (1987a) conducted a study comparing two sites; the first site was homogenous cattail (Thypha sp.), while the second site was more heterogeneous with Phragmites (*Phragmites australis*), cattails and bulrush (*Scirpus acutus*). The authors found that both sexes of Marsh Wrens showed a preference for the second site. Nestings were more successful due to the tall, dense vegetation and deep water giving the eggs and young's protection from predators. Ironically, territory quality does not influence female success or choice, although females can make some decision at the habitat level (Leonard

& Picman, 1988). Additionally, there's no significant correlation between the total territory size and male pairing success (Verner & Engelsen, 1970). It was shown in the same study that breeding site fidelity is relatively low, about 10% of male Marsh Wrens return to the first site, and 9% to the second site. Some exceptions were observed when returning males established within 100 meters of their prior territories. Returning rates of yearlings were extremely low. On the other hand, this beneficial behavior due to the ability of individuals to select the best habitat every year thus creates intense population shifts when habitats change (Thornton & Love, 2010).

Marsh Wren's eggs have a regular oval form and deep chocolate color (Audubon, 1840). One egg is daily laid by the female Wrens in the early morning, until the clutch is completed. Only the female incubates and begins this process before the completion of the clutch. The average number of eggs per nest is from 5 to 10, measuring around 16.3 mm by 12 mm. It takes ten to thirteen days for the eggs to hatch. The age of the nestlings determines the type of food brought to the young by the females. (Welter, 1935; Verner, 1965). Females are more responsive than males to intrusion near the breeding nest (Koodsma & Verner, 1997).

The females look for food for their young during morning and evenings. First consist of very small insects such as: mosquitoes and their larvae, larval Tipulids, midges and other delicate forms. As the nestlings grow, their food becomes larger and may include: long-horned beetles, caterpillars, sawflies, and other hymenoptera. The female removes the excreta enclosed in the nest after feedings, and eggshells infertile eggs, and dead nestlings. By the day fourteenth, the young leave their nests but since the wings are not well developed, they spend most of the time on or near the ground. Both parents take care of the young for at least two more weeks. The family group stays together for some time. The juveniles do not remain in their parent's territory; instead they wander in the dense matted and tangled places for protection. Once they develop power to fly, they begin to frequent more open areas near the water. (Welter, 1935; Verner, 1965)

Predation is considered to be one of the most important causes of egg and nestling mortality in Temperate Zone marshes (Leonard & Picman, 1987a). Nest predation can be done by; rice rats (Ozryomyus *palustris*), raccoons (*Procyon lotor*), mink (*Mustela vision*), small mammals; meadow mouse *(Microtus pennsylvanicus*), jumping mouse (*Zapus hudsonicus*), short-tailed weasel (*Mutela ermine cicognani*) and snakes as occasional predators (Kroodsma & Verner, 1997). Water in marshes should prevent terrestrial predators from reaching nest located in the deeper marsh area (Picman, Milks & Leptich, 1993). Nevertheless, in a study made by Rush, Soehren, Stodola, Woodrey and Cooper (2009), Marsh Wrens responded negatively to tidal height. An increase in tidal height decreases the availability of vertical vegetative habitat making the species more visible. The greater the visibility, the more susceptibility to predators, which in turn may influence the bird's singing behavior. Oddly, Marsh Wren can be a predator to other marsh passerine birds in the deep marsh area where they favor to live (Picman, Milks & Leptich, 1993).

Marshes are relatively uniform; the environmental limitations present favor the evolution of interspecific aggression and hence interspecific territoriality as means of reducing in interspecific competition (Picman, 1983). Marsh Wren nest locations and feeding areas are often spatially segregated from other co-occurring passerines (Leonard & Picman, 1986). The great variability in territory size between marshes suggests that an arrangement of grouped neighborhoods better describes the spatial arrangement of a breeding population (Picman, 1980). The diversity of vertical vegetation creates foraging and nesting sites attractive to various bird species, functioning as a segregating mechanism (Weller, 1999).

Yellow-Headed and Red-Winged Blackbirds commonly arrive earlier to the marsh and establish their territory before the arrivals of Marsh Wrens (Leonard & Picman, 1986). Intraspecific aggression of Marsh Wrens among Red-Winged Blackbirds (*Agelaious phoeniceus*), Yellow-Headed Blackbirds (*Xanthocephalus xanthocephalus*), and Swamp Sparrows (*Melaspiza georgiana*) is usually observed. Aggression is occasionally seen with Song Sparrows. (*Melospiza melodia*) (Picman, 1983; Leonard & Picman, 1986). Marsh Wrens are spatially segregated due to the active exclusion of Yellow-headed and Red-Winged Blackbirds (Leonard & Picman, 1986).

However, the attacks on Marsh Wrens are more intense by Yellow-Headed Blackbirds than by Redwings Blackbirds (Bump, 1986). It was observed in at least five cases that Yellow-Head males captured Marsh Wrens and pecked them vigorously (Bump, 1986). Moreover, Yellow-Headed Marsh can destroy Wren's eggs and nests (Leonard & Picman, 1986). This active aggression requires Marsh Wrens and Yellow-Headed Blackbirds to nest at least a few meters apart from each other (Verner, 1975).

Generally, Marsh Wren forage on their own territories and may not compete directly with other Marsh nesting's passerine species, for food, but they are excluded from high quality feeding and nesting protected sites along the water's edge (Leonard & Picman, 1986). Nests sites protected from predators are usually located in the deeper central portion of the marshes and may be limited due to the presence of Yellow-Headed and Red-Winged Blackbirds (Leonard & Picman, 1986). Redwing (Picman, 1983) and Yellow-Headed birds (Leonard & Picman, 1986) restrict the distribution of Marsh Wrens until they finish nesting and leave the marsh. At this point, Marsh Wrens begin to nest in these territories. In cases of limited insect availability, Marsh Wrens and Yellow-Headed may compete for food supply (Bump, 1986).

Marsh Wrens of all ages peck and destroy eggs of their own species and other species (Kroodsma & Verner, 1997). Male Marsh Wrens sing while puncturing the eggs (Bump, 1986). Egg pecking has evolved primarily as a mean of reducing competition and not for obtaining food (Leonard & Picman, 1986). Marsh Wrens feed only on invertebrates by scavenging in dense patches of shrubs or along the base of cattail stalks or other marsh vegetation, or near the ground or water surface (Ayers & Armacost, 2010). They feed almost exclusively on insects and spiders found in the marsh grasses, primarily beetles (*Coleoptera),* flies (Diptera), bugs (*Hemiptera),* and dragonflies and damselflies (Odnata) (Thornton & Love, 2010). Aquatic invertebrates are also a major part of the Wren's diet (Verner & Engelsen, 1970). Ayers and Armacost, (2010) observed Marsh Wrens catching and eating small fishes that may be mosquito fish (Gumbusia *affinis*). Wrens that live in salt or estuarine marshes do not drink salty water thus; they obtain all the water from the morning dew on vegetation or from eating highly succulent food (Kroodsma & Verner, 1997).

Singing Male Wrens can discriminate between birds that chase them and birds that are not aggressive towards them (Picman, 1983). Picman (1982) suggests that Red-Winged Blackbirds affect the singing of Male Marsh Wrens by forcing them to sing in the lower perches on cattail from where they apparently cannot efficiently announce their territory. Additionally, Marsh Wrens cease singing whenever a Red-Winged Blackbirds approach them. This in turn can negatively affect Wrens mating status, nest-building activities and the nesting stage of their females.

Occasionally, Marsh Wrens attack young nesting of Red-Winged Blackbirds and Yellow-Headed Blackbird (Bump, 1986) which is a major cause of Red-Winged Blackbirds nesting mortality in some marshes (Picman, 1980). Red-Winged Blackbirds are aggressive to Marsh Wren in response for their nest-destroying behavior (Picman, 1983). Those species that successfully exclude Marsh Wren from the area of their own nests may experience reduced egg loss (Bump, 1986). Redwings and Marsh Wrens degree of spatial segregation depends on the vegetation structure (Picman 1980). Therefore, the denser homogeneous stands of cattail, the less pronounced segregation of nesting site between these two species.

In a study made by Linz, Blitxt, Bergman and Bleier (1996) Redwings Blackbirds, Yellow-heads Blackbirds and Marsh Wrens were used as indicator species due of their dependence on emergent vegetation for nesting. They found that breeding Blackbirds and Marsh Wrens preferred to nest in green vegetation and avoided wetlands with larger amounts of dead vegetation. Marsh Wrens used dense vegetation to reduce the impact of Blackbirds aggression. The authors concluded that reducing cattail coverage in semi-permanent wetlands might temporarily decrease local breeding population of Marsh Wrens and Yellow-Heads but not Redwings, which are more flexible in a nest site selection.

Management Strategies

The Comprehensive Management Plan for the BRMBR stipulates the management's directions for each portion of the Refuge by classifying groups of wildlife and their associated habitats to be emphasized in the management (Olsen, Lindsey & Hirschboeck, 2004). The following operational plans were identified in order to achieve the Refuge objectives within the next 15 years: water grassland management, hunting and predator management, fire management, integrated pest management, swan management and fishery management (USFWS, 2011).

The Habitat Management Plan for the BRMBR is a step-down plan of the Comprehensive Management Plan and the Environmental Assessment for the Restoration and Enhancement of the Refuge. In order to contribute to the conservation and preservation of the biological integrity, diversity and environmental health, the Refuge staff developed a long-term (10 years) Habitat Management Plan (Olsen, Lindsy & Hirschboeck, 2004). The Plan objectives are to create different strategies to manage the habitat's necessities of the priority species. It establishes various management strategies that seek to maintain the most freshwater wetland habitat possible. Each year, the Plan strategies are modified based on the response of the birds to the previous year vegetation. Since the Marsh Wren is not considered a priority species, habitat changes can affect its population.

The Habitat Management Plan establishes the wetlands units to be filled with water after the ice melts and before the peak of spring runoff. As stream discharge declines, managers let non-priority units dry naturally, and manipulate any inflow into higher priority units. Thus, the 26 units are refilled by priority when waters become available during the fall (Olson, 2009). The system ensures that the units will not stay waterless for long periods during the summers. During these months the wetland is about 75% dry (Downard, 2010).

Because *Phragmites* is present in all 26 wetland management units of the BRMBR managers created the Control Plan for the *Phragmites*. The goal is to reduce the extent of monotypic stands, by reducing the plant to less than 10% of total area in each wetland management and less than 5% along the water delivery canals and wetland dikes by 2015. The control strategies include herbicide application of 2% Glyphosate in the fall period that has been found very effective since it stops the stem growth and transports the nutrients to the rhizomes. (Olsen, 2007).

Phragmites is considered an invasive plant due to its ability to easily colonize plots, forming soil-disturbing monocultures (Olsen, 2007). These communities decrease habitat quality for some avifauna, other wetland species (Kulmatiski, Beard, Meyerson, Gibson & Mock, 2010) and plant communities (Olsen, 2007). In the Refuge *Phragmites* can compete with aquatic plants such as alkali bulrush and *Schoenoplectus maritimus* (Olsen, 2007). Marsh Wrens along with Red-winged Blackbird can dominate the *Phragmites* communities in marshes (Benoit & Askins, 1999).

A study made by Benoit and Askins (1990), concluded that Marsh Wrens and Swamp Sparrow were found in high densities at sites with more *Phragmites* or cattail vegetation. Though, wetlands with 50% or more monocultures of *Phragmites australis* were significantly lower in species of birds and vegetation than in short-grass marshes. Whereby, if *Phragmites* exists in stable, discrete patches in brackish meadows or as narrow bands around the perimeter of salt marshes, it may increase the diversity of the vegetation, therefore, enhancing bird species richness. Hence, the mere presence of this plant does not seem to affect the bird diversity. Thus, the complete extermination of *Phragmites* is not recommendable since the plant may contribute to habitat heterogeneity and bird species richness.

Wetland dependent birds can provide a source of information about wetland status and trend due to their dependence on the physical, chemical and biological health of their habitats (Jørgensen, Costanza & Xu, 2005). Marsh birds, by nature of the habitat in which they choose to live, serve as excellent indicators of these ecosystems (Thornton & Love, 2010). Marsh Wrens establish rapidly once a wetland has been restored (Zimmerman, 2002). Since they are a wetland-dependent species, they could be at risk because of the continuing loss and degradation of their habitats (Jorgensen, Costanza & Xu, 2005).

In Pennsylvania around 1956 and 1979, the Marsh Wren was listed by the state as "vulnerable species" due to the loss of 40% of wetlands in the state (Kroodsma & Verner, 1997). Most recently, the North America Breeding Bird Survey (BBS) data indicates that Marsh Wrens abundance appeared to annually drop by 5.25% for the eastern BBS region from 1980 to 2005 (Monfils, 2006). In summary, this specie is an indicator of wetlands healthiness. Therefore, it is critical to study Marsh Wren in the refuge for conservational purposes.

Study Cases

Little is known about the effects of prescribed burning in wetlands on birds during migration. The prescribed fires represent a management strategy conducted in wetlands by the USFWS, to reduce the occurrence of late successional and introduced vegetation, thus providing optimal feeding and loafing habitats for migratory waterfowl, whooping cranes and shorebirds. Brenan, Smith, Haukos & LaGrange (2005) conducted a study to evaluate the effects on prescribed fires in wetlands habitats for migratory birds. The analysis was conducted in the Rain Water Basin wetlands (RWB), Nebraska. The objective of the study was to determine the immediate effects of prescribed burning on abundance, species richness, and composition of wetland birds during spring migration in the RWB regions. The authors hypothesized that burned wetlands might increase abundance and species richness of avian communities relative to unburned wetlands.

The study examined 19 wetlands burned in spring 2002-2004; 10 in 2002, two in 2003 and seven in 2004; burn dates ranged from March 12 to May 2. The target vegetation for the burning was; cattail (*Typha spp.*), river bulrush (*Schoenplectus fluvialitis*), common reed (*Phragmites autralis*) and reed canary grass (*Phalaris arundinacea*). All burned wetland had water but none were 100% full relative to the extent of hydric soils. The growing vegetation in the water was not altered by prescription burning.

In the methodology, the authors made a surveyed of the birds in each wetland within seven days before and following burning to estimate the avian richness and abundance. The vegetation cover was based on the proportion of open water to emergent vegetation. The total number of wetlands birds was visually estimated within the wetland boundary, recorded and further used to estimate number of each species. The Mallard (*Anas platyrhynchos*) were the most abundant and frequent species occurring in 59 of 76 surveys. Other abundant species in both areas were the northern pintails (*Anas acuta*) and green-winged (*Anas crecca*). Also there were cases when: for both burned and reference wetlands, three species were present during initial surveys that were absent from post burned surveys; six species were only present in burned wetlands post-burn and not in the initial survey; in reference wetlands, four species were present in post-burn surveys that were not seen in the initial surveys. There were no difference in the percent change and Sørenson's similarity index in relative abundance and richness in species between burned and reference wetlands.

The prescribed burning had little short-term effect on relative abundance, species richness or community composition of migratory wetland birds. Still, natural fires and management practices differ in the seasonal burning. Spring burns frequently fail to produce sufficient heat to alter rhizome efficiency and shoot viability, thus, rarely change long-term vegetation patterns of persistent emergent. Also, the hydrology is the principal element affecting vegetation in wetlands. The changes in the surrounding vegetation did not alter the avian microclimate in the wetland. The authors conclude that this management strategy alone does not improve wetland habitat quality for birds during spring migration within the RWB. Fires without hydrologic changes often have little influence on emergent plant composition due to temporary changes.

The author's management suggestion is that the USFWS should evaluate the effectiveness of prescribed burnings over the long term given that it does not seem to have a negative impact on avian use of wetlands during spring migration. Therefore, wetland managers should consider incorporating prescribed burning in combination with other management practices into their long-term management strategies. Moreover, they recommend the use of the funds to reestablish wetlands to their original hydrologic regime due to the improvement of vegetation structure and communities for migratory wetland birds.

Wintering birds are one of several groups of species most likely to be influenced by ecological management activities of second-growth forest. Haveri and Carey (2000) conducted a three-year study designed to accelerate development of late-serial characteristics in 16 second-growth Douglas-fir (Pseudotsuga menziesii) stands in order to determine effects of different management strategies on richness of wintering bird species, their abundance and consistency. Two management strategies were used in the study: 1) legacy retention strategy conserving biological components (e.g., old live, dead, and fallen trees) from the previous forests, and 2) variable-density thinning (VDT) strategy to produce high-quality timber and to stimulate understory development by multiple thinning and removal of defective trees.

The study area was designated on the 6,000 ha Rainier Training Area of Ft. Lewis Military Reservation in Thurston County, Washington. Four large management compartments were chosen based on homogeneity, history of treatment, and isolation from old-growth forests to be used as blocks within a randomized blocks experiment. Two compartments with no previous management other than protection were assigned as legacy stands. The other two compartments, clearcut in 1927 and commercially thinned twice, were assigned as thinned stands. Within each compartment 4 stands were designated (total 16 stands). Two randomly selected stands were treated with variable-density thinning (VDT), while the other two served as controls.

Bird counts were conducted at 9 point-count stations/stands located at least 80 m apart from each other and the edge of the stand. In 1996, 8 VDT stands were randomly selected and surveyed; while in 1997 and 1998 all 16 stands were surveyed. The bird count was performed only once in 8-minute sessions on all birds seen or heard. Counts were made in January and February during daylight hours, unless foggy, rainy, or snowy conditions occurred. In 1996, 6 stands were surveyed 3 times each and 2 stands twice each. In 1997 and 1998, 16 stands were surveyed. Total of 1350 visits were made to 144 count stations in 16 stands.

During the period of study 7455 birds representing 28 species were recorded. The thinned control stands were found to contain 1.4 times more birds compared to legacy control stands, while 1.2 times more birds were observed in legacy VDT than in legacy controls. Similar number of birds was recorded in thinned VDT and thinned controls. Birds belonging to eight species accounted for 88% of all counted birds and included: golden-crowned kinglet (*Regulus satrapa*), winter wren (*Troglodytes troglodytes*), black-capped chickadee (*Poecile atricapillus*), chestnut-backed chickadee (*P. rufescens*), varied thrush (*Ixoreus naevius*), red-breasted nuthatch (*Sitta canadensis*), song sparrow (*Melospiza melodia*), and brown creeper (*Certhia americana*). Species richness increased more in thinned control stands (16.2±1.4) compared to legacy controls (12.2±1.0) on average across years. Species richness also differed between strategies, however not greater than differences in richness among years. Proportion of area used and species richness increased with experimental thinnings. Two of the 8 most common winter species increased their use of experimentally thinned stands. No species exhibited greater use of unthinned, competitive-exclusion-stage stands over thinned stands.

Comparison of two management strategies used in the study clearly indicated that variable-density thinning strategy supported more winter birds and more species of winter birds than legacy retention. This finding was somewhat surprising considering that legacy retention is often implemented to provide habitat for overwintering, cavity-using birds, while conventional thinning was often used to reduce decadence in overstory trees and therefore reduces utility to cavity users. However, a limited use of large, old snags by cavity-using wildlife was found in the legacy stands. In fact, two species (winter wrens and song sparrows) exhibited greater use of thinned stands than of legacy stands.

Although species richness was clearly increased in legacy VDT stands compared to legacy controls, the mechanism of this action was not clear. One possibility is that understory development (with concomitant foliage, fruit, seed, and associated insect production), changed microclimates (patches of direct sunlight and sun flecks that might help raise local temperatures without in- creasing windflow), and increased vigor of overstory trees. Experimental VDT had less effect on diversity in the thinned stands, suggesting that thinning in general has positive effects on winter bird communities and that the spatial component of VDT had not had an effect.

The authors concluded that variable-density thinning, in conjunction with other conservation measures (legacy retention, decadence management, and long rotations), should provide habitat for abundant and diverse birds. This study has important forest management implications, suggesting that variable-density thinning can accelerate the development of understory and midstory structure in overstocked closed-canopy forests to create conditions, which support more diverse and abundant wintering bird communities. Variable-density thinning strategy is a valuable adjunct to legacy retention and holds promise as an important tool to manage biodiversity and multiple forest values. Also, VDT may be viable economically for many management applications.

Area and isolation are known to affect avian species richness on islands by altering the equilibrium between extinction and colonization rates. Although these two factors seem to be important in determining bird species richness in freshwater marshes, very little experimental evidence exists to support this hypothesis. Brown and Dinsmore (1986) conducted study aimed to determine if area and isolation influence the number of species of marsh birds and, if so, to show how this information may be applied in managing wetlands. The 30 Iowa marshes chosen for the study were located throughout northwestern and north central Iowa, and ranged in size from 0.2 to 182 ha. All were similar in general water and weather regimes, dominant vegetation types, and open water: cover ratios. The authors focused only on two factors (marsh size and isolation) and did not consider other variables (size and dispersion of open-water areas, water levels, vegetative heterogeneity, and species ranges).

Field study was performed in months of May and June 1983 and 1984. Data was collected between sunrise and 1000 hours 3 times a year. All seen or heard birds were counted within fixed-radius (18 m), circular plots (area = 0.1 ha) during 6-minute observation periods. In the last 2 minutes of each count period, tape recordings of secretive birds were played in an afford to elicit a response. All birds or nests were also included in the species richness estimate as the researchers moved between the plots. After the count period, the area within 13 m of the same observation point (area = 0.05 ha) was searched for nests. The number of plots on a site ranged from 2 to 7, with a total of 95 in 1983 and 91 in 1984. Areal coverage varied from nearly 100% at small sites to

<1% at large sites. The lower areal coverage at large sites was compensated for by increased detection of birds and nests as we moved among plots; large sites had more plots and hence greater effective coverage. A species was classified as breeding if an active nest, flightless young or adults were observed during 2 of 3 visits. Marsh areas were measured from aerial photographs. Each May, average water depths were determined on 1-4 transects across each site, measuring depth every 10 m. The proportion of marsh in open water was estimated visually. Relationships between species richness and independent variables were tested with a log-log (power) model. This model is commonly used for species-area studies. A stepwise multiple regression procedure was used to obtain a multiple-regression model predicting species richness. The independent variables considered were area, water depth, and isolation. The 0.05 significance level was used for all statistical tests.

Total of twenty-five breeding species were observed in the 30 marshes. These results were in agreement to those previously published. There was a significant log-log relationship between species richness and marsh area in 1983 and 1984. Neither the slopes nor the intercepts for the regressions differed between those years. The combined year's model was: log Species = log 6.0 + 0.23 log Area ($r2 = 0.68$). Marsh habitat characteristics were found to be as important to upland-nesting waterfowl as they are to over-water-nesting species. A significant correlation was observed between the number of nesting waterfowl species and marsh size. The species-area slope for the 6 upland nesters was similar to the slope for the 4 over-water nesting waterfowl (0.38 vs. 0.46). In Iowa marshes, the increase in species richness with increasing area is significant, however the rate of increase (slope) decreases as the marshes become larger. The species-area relationship was significant for the 14 smallest sites (0.2-5.5 ha) but it was non-significant for the 14 largest sites (8.3-182.0 ha). Additionally, the largest sites were not the richest in species. The 3 richest sites (f = 16 species) were significantly smaller (14, 19, and 28 ha) than the 3 largest sites (84, 123, and 182 ha; f= 13 species). Water depth (46.7 cm in 1983 and 54.4 cm in 1984) and species richness were significantly related in 1984, but not in 1983. The multiple-regression analysis resulted in a 2-variable model that contained area and isolation but not water depth. The model was significant both years, and there was no significant difference between the models for each year.

The authors calculated the minimum marsh size necessary to support 24 species using three methods. The method of extrapolation of the species-area equation estimated a marsh size of 379 ha. The second method in which species lists of study sites are combined until the desired number of species is obtained predicted a 236 ha marsh (60% of the extrapolation estimate). When marshes were selectively picked during the two-year study (3rd method) the average of 90 ha of marshland supporting 24 species was calculated. Thus, the first two methods over-estimated the area required to hold all 24 species compared to the results of the author's study.

The authors concluded that some marsh species are area sensitive and that species richness decreases as marsh area decreases. In future management decisions it is recommended that the effects of size and isolation of marshes should be considered. Presented data indicated that marshes in the 20-30-ha size class were more efficient in preserving bird species than larger marshes (up to 180 ha). It is possible that smaller wetlands with their reduced resources have lower productivity. Even though, one large marsh may be less expensive to manage, a refuge consisting of a cluster of smaller marshes increases habitat heterogeneity and lessens the risk of disease or problems caused by introductions. In considering species richness, the best strategy recommended by authors is to increase existing marsh complexes by small size additions. Finally, although species richness is important other factors like preservation of unique sites or species, acquisition costs, and management costs must be also considered.

Legal Framework

Each state is allowed to adopt its own system of water law as long as certain paramount federal powers are not affected (Milliman, 1959). The National Environmental Policy Act of 1969 (NEPA) (42 U.S.C. 4321-4347) requires the federal government to use all practicable means to create harmony between man and nature. Nonetheless, it requires that federal agencies integrate environmental consideration in their planning and decision-making through a systematic interdisciplinary approach. The Environmental Protection Agency (EPA), U.S Fish and Wildlife and the U.S Army of Corps of Engineers are the principal agencies to regulate the wetlands in Utah.

In 1928, BRMBR was established by Presidential Proclamation as a "suitable refuge, feeding and breeding grounds for migratory wild fowl". The establishment of the Refuge was approved by the State of Utah. Several Public Land Orders were removed from all appropriation laws. Though, mineral grant laws relevant to drilling are applicable if there is an existence of geological resources such as oil and gas. (USFWS, 2011).

In 1929, the state legislation (Utah Code Ann. 23-21-6 (1)), stated that the U.S Fish Wildlife Service (USFWS) has to provide a management plan for the BRMBR

(Olson, Lindsey & Hirshboeck, 2004). Therefore, the United State laws and policies are primarily responsible for implementing wildlife management programs on the States, but effective implementation depends on Congressional monetary support (Sutter et at., 2005). Thus, the Secretary of Interior has to fix the price(s) in which such areas may be purchased or rented. The USFWS acquired lands with funds provided by the Migratory Bird Conservation Fund established by the Department of the Interior. The Migratory Bird Hunting and Conservation Stamp Act (1934), Wetland Loan Act (1961) and Emergency Resources Act (1986) are the major source of money for the Fund. Also the Refuge has to follow international laws. The Migratory Bird Treaty Act of 1918 was implemented by the United States and Canada, Mexico, Japan and Russia to protect migratory birds. The Act states that is prohibited to hunt, pursue, take, capture, kill or sell birds or its parts including feathers, eggs or nest in the migratory bird list.

The Fish and Wildlife Act (1956) as amended (16 U.S.C. 742a) authorizes the acquisition of additions to the National Wildlife Refuge System for the development, management, advancement, conservation, and protection of fish and wildlife resources by buying or exchanging land and water or interest within. The Refuge Recreation Act approved in 1962 and amended (16 U.S.C 460), authorized the Secretary of the Interior to administer refuges, hatcheries and other conservation areas for recreational use, when such uses do not interfere with the area's primary purposes. The National Wildlife Refuge System Administration Act enacted in 1966 provides guidelines and directives for administration and management of all areas in the system including "wildlife refuges, areas for the protection and conservation of fish and wildlife that are threatened with extinction, wildlife ranges, game ranges, wildlife management areas or waterfowl production areas". The Refuge Improvement Act (1997) is an amendment to the 1966 Refuge System Administration Act; and establishes a singular conservation mission for the National Wildlife Refuge System. The amendment was established "To administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitat within the United States for the benefit of present and future generations of Americans".

The Secretary of Interior authorized to construct, at Bear River Bay and vicinity, dikes, ditches, spillways, buildings and improvements as be necessary in his judgment for the establishment of a suitable refuge and feeding and breeding grounds for migratory wild fowl. Following the Federal Power Act (1920) (33 U.S.C. 1413) as amended, allows the Federal Energy Regulatory Agency to issue license for the construction and the operation and maintenance of dams, water conduits, reservoirs, powerhouses, transmissions lines and other physical structure of a hydropower project. In cases, section 404 of the Clean Water Act (1972) will be applied if it involves the discharge of dredged or fill material into the U.S waters. Moreover, Section 7(a) of the Wild and Scenic Rivers Act (1968) specifies that no department of agency of the United States shall assist in economical or permit the construction of any water resource project that would directly and negatively affect the value of the river. Later, the Fish and Wildlife Service acquired the lands of the National Refuge stated under the Land and Water Conservation Fund Act (1965) as amended (16 U.S.C. 460l). Likewise, under the Reorganization Plan No.4 (1970) and the Fish and Wildlife Coordination Act, any federal agency that proposes to control or modify any body of water must first consult the USFWS or the National Marine Fisheries Services as the appropriate State agencies.

In 1972, the Congress enacted the first comprehensive national clean water legislation known as the Clean Water Act (33 U.S.C. 1344) or CWA. This Act is the foundation of surface water quality protection in the United States. Its main purpose is to restore and maintain the chemical, physical and biological integrity of the nation's waters. The main sections under the Act that applied to wetlands are; (401) requires any applicant for a federal license of permit to conduct any activity that may result in a discharge of a pollutant into water of the United States.

In addition, the discharge has to fulfill with the pertinent waste limitation and Water Quality Standards; (402) authorizes the EPA to issue permits under procedure to implement the National Pollutant Discharge Elimination System Program; and (404) establishes the program by the EPA to regulate the discharged of dredged or fill material in waters of the United States including wetlands. Also, under this Section the U.S Army Corps of Engineers established the regulations and permits. The U.S Army Corps of Engineers also approves statutes provided for fish and wildlife conservation projects, navigation, flood control, rivers and harbors.

Water use and protection is necessary for management. Thus, the water rights of the Bear River are presently adjudicated by the State of Utah. (USFWS, 1997). Water law began in Utah with the settlement of the pioneers in 1874. In order to settle the Salt Lake Valley and begin growing crops, the available water had to be moved from surface streams to settlement locations. The law that subsequently grew to rule the use of water in Utah was understandably grounded in the need to move and use water in order to survive. (Crowther, n.d.).

Therefore, a principle was established for those who first made beneficial use of water should be permitted to continue use in preference to those who came later. This fundamental principal was later approved in a law known as the Doctrine of Prior Appropriation. Whoever, has the first water right is entitled to receive entire allocation of water previous to any junior appropriator receiving any water or “First in time first in right”. (UDWR, 2005). This becomes significant during drought season when a junior water right holder may not receive any water (Smith, 2008). The Doctrine also states that, once a water right has been taken, the right to use the water exists continuously until the beneficial use ends. In other words, “use it or lose it”. (UDWR, 2005).

The main objective of the Doctrine is to take all available water for beneficial use, thus promoting economic growth. But the “seniority” right may affect the doctrine’s main purpose because a junior holder may have better beneficial use than the rightful holder, thus making this doctrine goal irrelevant. (Fornataro, 2008). Nevertheless, the Doctrine proposes that all water that is not already appropriated or used is available for use by any person for a beneficial “purpose”, since the appropriator does not own water but holds the right of usage. Still, the doctrine’s “use it or lose it” promotes the waste of water. If the water rightful holder fails to use water beneficially for a period of five years, the water rights revert back to public ownership. (Smith, 2008).

Through history the beneficial use has been inferred as a practice that encourages economic growth. In recent years, this standard definition has expanded to incorporate ecological benefits such as in stream flows that enhance fish, wildlife and recreation. (UDWR, 2005). However, only the Division of Wildlife Resources and State Parks may perfect an in-stream flow in the State of Utah (Smith, 2008).

The water allocation system was in effect until 1880, when a statute providing for county water commissioners replaced it. In 1897, the Office of the State Engineer was created to administer the water rights. Changing its name in 1963 to the Division of Water Rights, the Office established a complete “water code” that was legislated in 1903 and revised and reformed in 1919. (UDWR, 2005). Today’s with succeeding complete reenactments and amendments is known as Utah Code, Title 73 or Water and Irrigation Law (Smith, 2008). This Code states that all waters in Utah whether above or below the ground are hereby declared public property to all existing rights to the use thereof. The Legislature shall govern the use of public water for beneficial purpose, assimilated by constitutional protections for private property. The right of the public to use public water for recreational purpose is governed by Chapter 29, Public Waters Access Act.

The Utah Code, Title 73-2-1.1 creates the Division of Water Rights within the Utah Department of Natural Resources (UDNR) under the supervision of the executive director of the Department. The Division is the authority for regulating the appropriation and distribution of water rights, including the operation of a stream alteration-permitting program. The program focuses on the regulation of alterations to natural stream channels that may include associated fringe wetlands within 30 feet of a stream. (Anonymous, 2008).

Utah Code (73-2-1) also states the terms, powers, and duties of a State Engineer. The Code divided Utah into seven regions with regional engineers overseeing each region (Smith, 2008). Since 1903, for surface and 1935 groundwater, water right in Utah may only be acquired by application and permit from the State Engineer. The process and right to appropriate water (either surface or ground) is governed by statue, administrative rule, and policy.

The rights held by other water users on the Bear River are important in determining the water supply at the Bear River Migratory Bird Refuge. Because it was established in 1928 when most Bear River water development had occurred prior to that time, the refuge's foundational right is junior to all the large senior agricultural rights on the river during the irrigation season. (Downard, 2010).

CHAPTER III

METHODS

Introduction

Undoubtedly, the Great Salt Lake stands out as the most important inland shorebird site in North America (Olson, Lindey & Hirshboeck, 2004). Stewart and Kantrud (1971) classified the marsh found in this unique ecosystem as class IV (semi-permanent ponds or lakes), D (brackish), and cover type 4 (open water or bare soil on 95% of the wetland area). The predominant plants are; narrowleaf cattail *(Typha augustifolia*), alkali bulrushes *(Scirpus acutus* and *S. paludosus*), saltgrass (*Distichlis stricta*), and pondweed (*Potamogeton sp.*) (Lindvall & Low,1982). The Marsh Wren is a marsh specialist that prefers many types of tall, emergent plant species, where they build their nests high above the marsh surface (Benoit & Askins, 1999). Vegetation found in the Bear River Migratory Bird Refuge supports the population of Marsh Wrens (Citourus palustri). The complex of levels and channels create various sized and shaped habitat patches. These patches contain *Scirpus*, *Phragmites,* and *Typha* vegetation, separately or in mixtures. Along some levees this vegetation appears in a narrow strip, approximately 1-4m wide, along the water's edge. Bounding these strips of emergent vegetation is low grass and forbs or bare ground on one side, and open water on the other. These strips appear to be sufficiently wide to provide Marsh Wren's nesting habitat, but are too narrow to support other species (e.g., red-winged and yellow-headed blackbirds). For this reason, the BRMBR represents a very suitable research field for studying Marsh Wrens. The following objectives will be addressed in this thesis to test the hypothesis;

1. Evaluate the effects of water level variations on Cistothorus *palustris* habitat in Bear River Migratory Bird Refuge and equivalent locations in northern Utah and southern Idaho.

2. Estimate the *Cistothorus palustris* numbers and density in various plots of Bear River Migratory Bird Refuge and equivalent locations in northern Utah and southern Idaho.

Study area

The research was performed in the following places; Bear River Migratory Bird Refuge, Bear Lake National Refuge and Salt Creek Waterfowl Management Area (Compton's Knoll) (Figure 1).

Bear River Migratory Bird Refuge (41-27'51"N 112-15'47"W) is located 15 miles west of Brigham City (Utah) at the elevation of 4,205 feet above the sea level and covers nearly 74,000 acres of marshes, uplands and open water. Salt Creek Waterfowl Management Area (41-38'42" N 112-15'13"W) is situated 10 miles northwest of Corinne (Utah) at the elevation of 4,255 feet. The 5,254-acre area is characterized by open water, mud flats, uplands and emergent marshland habitat. The Bear Lake National Refuge (42-09'48" N 111-18'45" W) is positioned in southeast Idaho, seven miles south of Montpelier. The 19,000-acre refuge lies in Bear Lake Valley with the elevation ranging from 5,925 feet on the marsh to 6,800 feet on the rocky slopes of Merkley Mountain. The marsh is mostly composed of bulrush, open water and flooded meadows of sedges, rushes and grasses. Additionally, parts of the refuge include scattered grasslands and brush covered slopes.

Study Period

Several visits in different times of the day to each place were made to establish the possible plots and the optimum hours for data collection. The Bear River Migratory Bird Refuge was closed until the end of July, since the river had outgrown flooding the roads and making them inaccessible. Counting of the birds was performed from August 21st to August 26th between the hours 0730 and 1100 (Central Standard Time). Singing and other non-foraging activity of Marsh Wrens are mostly performed during early morning hours (Verner, 1965). At night, Male Wrens usually perch upon the flags in the dense growth (Welter, 1935).

The foraging activity and their calls were much evident at mornings than at other time of the day. Thus, the low, early sun made visual identification of the Marsh Wren easier. According to Emlen & DeJong (1981) the temperature, relative humidity, fog and particularly wind can influence the propagation characteristics of sound waves through a habitat, and hence, the distance at which songs can be heard. Therefore days of strong wind, rain or fog were avoided.

Methodological Design

The methodology used is based on the unpublished report by Dr. John Shaw (1998-2003). The method consists of the visual or acoustic identification of Marsh Wrens from a slow-moving vehicle. The vehicle acts as an effective blind. Three different locations were chosen for the study; BRMBR, Bear Lake National Refuge and Salt Creek Waterfowl Management Area. Each of the sites was divided into plots defined as horizontal strips of vegetation directly adjacent to the road and 4m in width. Location of a plot and its length were selected randomly. While driving along each plot, a counter meter was used to measure the exact length of the vegetation and open water. Singing Wrens when approached could be directly observed from the vehicle. At each spot were a Marsh Wren was observed or heard singing, the vehicle was stopped and the number of birds was recorded on a data sheet along with the type of vegetation and the water level.

Data Analysis

Total vegetation area was calculated from the total length of each plot (minus open water area) converted to meters and multiplied by its width (4m). Density of vegetation was calculated from the vegetation area (covered by a specific type of vegetation) divided by the total vegetation area covered by all the vegetation in the plot. Density of vegetation was expressed in units of square meters per hectare (m^2/ha) to avoid small numbers. Accordingly, density of Marsh Wren was calculated from the number of birds recorded at specific plots divided by the total vegetation area of these plots and express in units of bird count/ha. In order to calculate density of birds per type of vegetation, the number of birds was instead divided by the area of the specific type of vegetation. Units of bird's density (count/ha) remain the same. It is worth noting at this point that the total vegetation area used for the mentioned calculations represent the "available" area for establishing the habitat and differs from the total plot area, which is a sum of the "available" area and the area covered by open water ("unavailable"). The following correlations were statistically analyzed: type of vegetation per water level, density of birds per water level and density of birds per type of vegetation. All data was subjected to ANOVA non-parametric test using Kruskal-Wallis method. Additionally, Mann-Whitney method was used to test a directional hypothesis of vegetation dependence on high water level.

Average territory size of Marsh Wren was calculated from the "available" wren-nesting habitat by subtracting "unsuitable" habitat (e.g. open water) from total plot size and divided by the number of birds at the particular plot. Mean of the territory size is the average of all territory sizes at the specific study site. Differences between territory sizes are expressed by standard deviation.

CHAPTER IV

Results and Discussion

The study was performed at three different locations: Bear River Migratory Bird Refuge, Bear Lake and Salt Creek. Three different parameters were recorded: vegetation, water level and the number of birds. The following types of vegetation were considered in the study: bulrush, cattail, phragmites and mix (a combination of any two or three of the above). Any other type of vegetation was combined in a one group designated as others. Each of the study area was divided into several plots, wherein along which data collection was performed. Different types of vegetation were recorded with respect to the water level (high or low) along different plots (Appendix A).

Distribution of vegetation in respect to water level at BRMBR is summarized in Table 1 (expressed in units of square meters) and Table 2 (expressed as density of the vegetation in square meters per total area of the plot in hectares). Distribution of vegetation at BRMBR is graphically displayed in Figure 5 for comparison purposes. Bulrush was found to be the most abundant type of vegetation (63%), followed by cattail (18%) and mixed (11%). Most of the mixed vegetation consisted of bulrush and cattail (68 %). The least represented vegetation was phragmites (1%). The majority of the vegetation was found at high water level (73%), out of which bulrush was the most predominant (75% of all high water vegetation) followed by mixed and cattail (11% each). Cattail was found to be evenly distributed between high and low water level.

The distribution of all recorded types of vegetation was individually analyzed using the Kruskal-Wallis Test. The results presented in Tables 3-4, showed that only the distribution of bulrush against water level was statistically significant at both BRMBR and Bear Lake (p-value of 0.045 and 0.012, respectively). Other types of vegetation showed p-values ranging from 0.142 to 0.963, thus indicating insignificant correlation between the distribution and water level. Similarly, no significance was observed for any type of vegetation at Salt Creek (p-values ranged from 0.103 to 0.317).

Interestingly, Kruskal–Wallis analysis for the density of all vegetation in high water at BRMBR (Table 3) presented statistical significance (p-value = 0.009), unlike the analogous analysis for the density of vegetation in low water level (p-value = 0.415). The overall p-value for the combined low and high water level density of vegetation is 0.020. Similar analysis for Bear Lake vegetation showed p-values < 0.05 for all types of vegetation at both water levels as well as all combined data (Table 4). On the other hand, distribution of vegetation at Salt Creek was founded insignificant across the entire set of data.

Additionally, Mann-Whitney analysis was performed to test a directional hypothesis that specific type of vegetation (e.g., bulrush, cattail) is more abundant at high water level. This hypothesis was found to be statically significant only in case of bulrush (p-value = 0.025) at BRMBR (Table 3). The reverse correlation, namely that the specific type of vegetation is less abundant at high water level, was found significant with the same p-value of 0.007 for bulrush at Bear Lake (Table 4) and Salt Creek (Table 5).

Dependence of Marsh Wren's density on the water level was analyzed at the same study sites. The results are summarized in Tables 7-9 and represented Figure 10. The highest density of Marsh Wren in BRMBR associated with high water level was 216 birds/ha (plot 5) (Table 7). In contrast, the highest density of Marsh Wren at Bear Lake (63 birds/ha at plot 6) (Table 8) and Salt Creek (62 birds/ha at plot 2) (Table 9) was found in plots with low water level. By means of comparison the similar correlation holds for the average density of the mentioned study sites. Specifically the highest average density of Marsh Wren at BRMBR was also found at high water level (69 birds/ha), whereas the highest average density at Bear Lake (22 birds/ha) and Salt Creek (56 birds/ha) was found in low water level (Table 10). Comparison of the results from BRMBR reveals 3-fold higher average density of birds at high water level as compared to low water level. The reverse trend is observed for Bear Lake and Salt Creek, where the average density is 2 and 3 times respectively higher at low water level.

Kruskal-Wallis analysis of data presented in Table 11 reveals no significant correlation between Marsh Wrens and water level. However, in case of BRMBR this insignificance is marginal as the p-value is 0.072 and thus closes to the cut off value 0.05. Moreover, Mann-Whitney test on association of high water level with high bird density confirms significance of this correlation displaying p-value of 0.03 (Table 13).

Data analysis of density of Marsh Wren with respect of vegetation reveals that the density of birds at BRMBR is similar between bulrush and mixed vegetation (84 birds/ha and 89 birds/ha, respectively) (Table 6, Figure 9). The Marsh Wren density found in cattail is much lower displaying value of 31 birds/ha (Table 6). It is worth reminding at this point that mixed vegetation at BRMBR is composed primary of bulrush in combination with cattail (Figure 6). This further reinforces preferences of Marsh Wren for bulrush at this site. Additionally, bulrush was present in places characterized by high water level. For this reason, it is difficult to distinguish which of the two parameters represents priority for establishing marsh wren habitat.

A very similar correlation was found at Bear Lake where Marsh Wren habitat was only found in bulrush and mixed vegetation, which was also composed mostly of bulrush and cattail (Figure 9). The average density of Marsh Wrens in bulrush was likely higher than in mixed vegetation (21 birds/ha vs. 13 birds/ha, respectively). However, in contrast to BRMBR these types of vegetation were mainly found in low water level (Table 6).

In Salt Creek, the tendency is markedly different in respect to the type of vegetation preferred by Marsh Wren. The highest density of birds was found in cattail (91 birds/ha) followed by bulrush and mixed vegetation with similar values (49 birds/ha and 47 birds/ha, respectively). The mixed vegetation in this case consisted of bulrush and cattail). Similar to Bear Lake, the mentioned vegetation was mostly present in areas of low water (Table 6).

Statistical analysis by Kruskall-Wallis method shows strong correlation between type of vegetation and the density of bird for BRMBR and Bear Lake with p-values of 0.010 and 0.011, respectively. Conversely, Salt Creek data revels no statistical significance in the same analysis with a p-value of 0.300 (Table 12).

The average territory size determined for BRMBR was 220 m^2 with standard deviation of 276 m^2, for Bear Lake was 557 m^2 with standard deviation of 470 m^2 and for Salt Creek was 129 m^2 standard deviation of 57 m^2.

CHAPTER VI

CONCLUSIONS

The major goal of the presented study was to elucidate a preference of Marsh Wren in establishing its habitat based on two ecological factors, namely water level and type of vegetation. Although Marsh Wren is generally known for its preference for high water level habitats, results of this investigation failed to prove such a correlation. The largest study site, BRMBR, showed over three-fold higher density of birds in high water level habitat, while Bear Lake and Salt Creek revealed a reversed correlation. Even when analyzed individually neither of the surveyed sites showed statistical significance for the density of Marsh Wren as a function of the water level. In contrast, some degree of correlation between Marsh Wren habitat and type of vegetation was found in two of the study sites (BRMBR, Bear Lake), as determined by low p-value of Kruskal-Wallies test ($p < 0.05$). Specifically, birds were predominantly found in areas covered by bulrush, whereas typical vegetation preferred by Marsh Wren, according to the Habitat Suitability Index Models: Marsh Wren (Gutzwiller & Anderson, 1987) is thought to be cattail. Although unexpected, this behavior is not completely unheard of as shown in few other similar studies. One of the possible explanations is based on the assumption that Marsh Wren in fact prefers high water level habitats. Because bulrush is mostly found in higher water than cattail and water level in marshes tends to fluctuate over the breeding season, it is plausible that Marsh Wren might be forced to change the vegetation type in order to remain in high water level area.

In a study made by Verner & Engelsen (1970) it was observed that the vegetation preference exhibited by Marsh Wren depended on the water level. Authors demonstrated that low water level after May (1968) enforced males to exploit stands almost exclusively covered by bulrush. The given reason was that bulrush grows in deeper water than cattail, thus providing a richer source of food (mostly consisting of aquatic invertebrates) and better protection from possible predators.

Another explanation for somewhat unexpected results emerging from this study might be the fact that data for this research was collected at the end of the breeding season when a significant number of offspring was present and very active. For this reason interpretation of the presented data should be done with special caution.

The significance of this study stems from its potential implications in improving current management strategies of marshes. Since the primary vegetation of the BRMBR is bulrush and that preferred by Marsh Wren is cattail, the managers should adjust the water level in the refuge to facilitate better growth of cattail, thus providing the most preferred habitat for Marsh Wren. However, this practice needs to be very carefully monitored since cattail can behave aggressive by growing in dense monoculture (Apelbaum, n.d). Collectively, the best habitat recommended for Marsh Wren is the one of mix stands of bulrush and cattail.

Finally, dense vegetation and water depth play an essential role in the survival of Marsh Wrens by providing hiding places protecting them from predators, such as owls, hawks and small mammals (meadow mice, jumping mice and Bonaparte weasel) which otherwise destroy their eggs and young's (Cleveland, 1948).

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TABLES

Table 1.

Bear River Migratory Bird Refuge distribution of vegetation in respect to water level (in unit of m^2)

Plot	Water	Bulrush	Cattail	Phragmites	Other	Mix	Total veg.	Open Water	Total
1	High	247	79	0	0	250	577	262	
	Low	3046	845	0	657	143	4690	0	
2	High	1170	69	169	162	0	1572	55	
	Low	384	0	0	846	0	1230	0	
3	High	2420	99	279	171	1980	4949	2855	
	Low	0	0	0	0	0	0	0	
4	High	1718	595	0	0	198	2510	707	
	Low	119	0	0	0	501	621	0	
5	High	163	34	0	0	34	232	116	
	Low	0	0	0	0	646	646	0	
6	High	0	0	0	0	0	0	1024	
	Low	33	112	139	450	207	941	0	
7	High	88	138	0	345	0	571	906	
	Low	90	3575	0	0	56	3721	0	
8	High	16092	2487	0	0	1025	19605	13846	
	Low	0	0	0	0	0	0	0	
9	High	2363	61	0	0	0	2424	307	
	Low	0	0	0	0	0	0	0	
Total		**27934**	**8094**	**588**	**2631**	**5040**	**44287**	**20079**	**108654**
Total [%]		63.1	18.3	1.3	5.9	11.4	100.0	18.5	
	Total High	24262	3563	449	678	3487	32438		
	Total Low	3672	4532	139	1953	1553	11849		
	Total High %	86.9	44.0	76.3	25.8	69.2	73.2		
	Total Low %	13.1	56.0	23.7	74.2	30.8	26.8		
[%] of all	H %	55.8	9.7	4.3	6.5	23.6	100.0		
[%] of all	L %	31.0	38.2	1.2	16.5	13.1	100.0		

Table 2.

Bear River Migratory Bird Refuge *density of vegetation in respect to water level*

Plot #	Water	Bulrush [m^2/ha]	Cattail [m^2/ha]	Phragmites [m^2/ha]	Other [m^2/ha]	Mix [m^2/ha]	Total veg. [Ha]
1	High	470	150	0	0	475	0.5267
	Low	5782	1604	0	1248	271	
2	High	4178	248	605	579	0	0.2802
	Low	1371	0	0	3020	0	
3	High	4890	200	564	345	4001	0.4949
	Low	0	0	0	0	0	
4	High	5487	1900	0	0	631	0.3131
	Low	382	0	0	0	1600	
5	High	1861	389	0	0	389	0.0878
	Low	0	0	0	0	7361	
6	High	0	0	0	0	0	0.0941
	Low	350	1192	1477	4780	2202	
7	High	205	321	0	804	0	0.4292
	Low	210	8330	0	0	131	
8	High	8208	1269	0	0	523	1.9605
	Low	0	0	0	0	0	
9	High	9748	252	0	0	0	0.2424
	Low	0	0	0	0	0	
Avg.	High	2896	762	141	463	874	
Avg.	Low	1933	991	152	724	1072	
Avg.	**Total**	**2423.0**	**874.5**	**146.7**	**591.5**	**971.5**	

Table 3.

Bear River Migratory Bird Refuge - vegetation vs. water level statistical analysis

	Kruskal- Wallis Test			Mann-Whitney
Vegetation type	Chi-Squared	df	p-value	p-value
Bulrush	4.031	1	0.045	0.025 (High>low)
Cattail	1.508	1	0.219	0.119
Phragmites	0.226	1	0.634	0.342
Other	0.224	1	0.636	0.701
Mix	0.002	1	0.963	0.537
Veg. at high water	13.641	4	0.009	
Veg. at low water	3.935	4	0.415	
Total vegetation	**19.679**	**9**	**0.020**	

Table 4.

Bear Lake National Wildlife Refuge - vegetation vs. water level statistical analysis

	Kruskal- Wallis Test			Mann-Whitney
Vegetation type	Chi-Squared	df	p-value	p-value
Bulrush	6.2632	1	0.012	0.007 (High<Low)
Cattail	0.011	1	0.917	
Phragmites	NA	1	NA	
Other	2.1538	1	0.142	
Mix	0.377	1	0.539	
Veg. at high water	10.715	4	0.030	
Veg. at low water	23.099	4	0.001	
Total vegetation	**37.537**	**9**	**0.001**	

Table 5.

Salt Creek Waterfowl Management Area - vegetation vs. water level statistical analysis

Kruskal- Wallis Test			
Vegetation type	Chi-Squared	df	p-value
Bulrush	2.4	1	0.1213
Cattail	2.4	1	0.1213
Phragmites	NA	1	NA
Other	1	1	0.3173
Mix	2.667	1	0.1025
Veg. at high water	2.642	4	0.6194
Veg. at low water	7.432	4	0.1147
Total vegetation	**15.132**	**9**	**0.0874**

Table 6.

Distribution of average bird's density among different vegetation

	Bird density [count/ha]/ vegetation type									
	Bulrush	std.dev	Cattail	std.dev	Phragmites	std.dev	Others	std.dev	Mix	std.dev
Bear River	84	78	31	52	11	22	3	10	89	112
Bear Lake	21	28	0	0	0	0	0	0	13	18
Salt Creek	49	70	91	35	0	0	0	0	47	67
Avg	52	32	41	46	4	6	1	2	50	38

Table 7.

Bear River Migratory Bird Refuge - bird's density dependence on water level (density of birds/water level)

Plot	**Birds #**		**Area [m2]**		**Area [ha]**		**Density [birds/ha]**	
Water	High	Low	High	Low	High	Low	High	Low
1	7	51	577	4690	0.0577	0.4690	121.38	108.74
2	4	4	1572	1230	0.1572	0.1230	25.45	32.52
3	21	0	4949	0	0.4949	0.0000	42.44	0.00
4	10	2	2510	621	0.2510	0.0621	39.84	32.23
5	5	0	232	646	0.0232	0.0646	215.84	0.00
6	3	0	0	941	0.0000	0.0941	0.00	0.00
8	21	0	19605	0	1.9605	0.0000	10.71	0.00
9	23	0	2424	0	0.2424	0.0000	94.89	0.00
Total	**94**	**57**	**31867**	**8128**	**3.1867**	**0.8128**	**Avg. 68.82**	**Avg. 21.68**

Table 8.

Bear Lake National Wildlife Refuge - bird's density dependence on water level (Density of birds/water level)

Plot	Birds #		Area [m2]		Area [ha]		Density [birds/ha]	
Water	High	Low	High	Low	High	Low	High	Low
1	0	1	0	797	0.0000	0.0797	0.00	12.54
2	0	1	0	1189	0.0000	0.1189	0.00	8.41
3	0	7	134	1530	0.0134	0.1530	0.00	45.75
4	5	0	1138	407	0.1138	0.0407	43.96	0.00
5	1	7	379	3249	0.0379	0.3249	26.37	21.54
6	0	7	0	1105	0.0000	0.1105	0.00	63.37
7	1	0	1161	569	0.1161	0.0569	8.62	0.00
Total	**7**	**23**	**2811**	**8847**	**0.2811**	**0.8847**	**Avg. 11.28**	**Avg. 21.66**

Table 9.

Salt Creek Waterfowl Management Area - bird's density dependence on water level (Density of birds/water level)

Plot	Birds #		Area [m2]		Area [ha]		Density [birds/ha]	
Water	High	Low	High	Low	High	Low	High	Low
1	0	4	0	784	0.0000	0.0784	0.00	51.02
2	1	5	278	808	0.0278	0.0808	35.97	61.86
Total	**1**	**9**	**278**	**1592**	**0.0278**	**0.1592**	**Avg.**	**Avg.**
							17.99	**56.44**

Table 10.

Density of Marsh Wren as a function of water level at Bear River, Bear Lake and Salt Creek

	Average Density [birds/ha]	
	High	Low
Bear River	68.82	21.68
Bear Lake	11.28	21.66
Salt Creek	17.99	56.44
Total Avg.	**32.6966**	**32.5933**

Table 11.

Marsh Wren vs. water level statistical analysis

	Kruskal-Wallis Test		
	Chi-Squared	df	P-Value
Bear River	3.246	1	0.072
Bear Lake	0.441	1	0.507
Salt Creek	2.400	1	0.121
All	8.375	4	0.079

Table 12.

Marsh Wren vs. vegetation statistical analysis

	Chi-Squared	df	P-Value
Bear River	13.329	4	0.010
Bear Lake	13.075	4	0.011
Salt Creek	4.881	4	0.300
All	**26.177**	**8**	**0.001**

Table 13.

Marsh Wren vs. water level statistical analysis.

	Kruskal-Wallis test			Mann-Whitney Test	
	Chi-Squared	**df**	**P-Value**	**P-Value**	**P-Value**
				High>Low	High<Low
Bear River	3.246	1	0.0716	0.0396	0.9677
Bear Lake	0.441	1	0.5066	0.9149	0.1035
Salt Creek	2.4	1	0.1213	1	0.1667
All			0.0788		

FIGURE

Figure 1. Study sites - Bear River Migratory Bird Refuge, Bear Lake National Refuge and Salt Creek Waterfowl Management Area

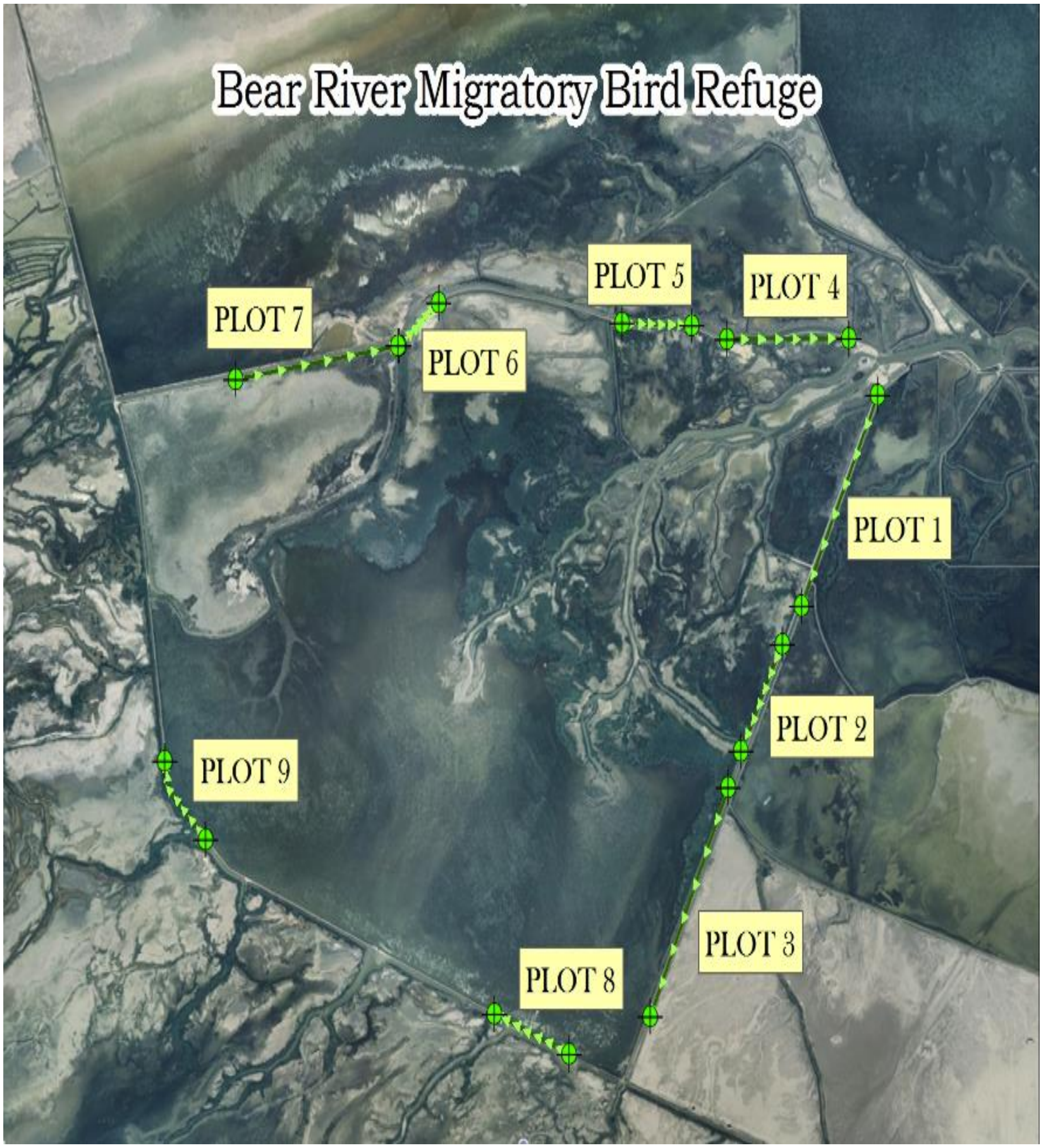

Figure 2. Organization of data collection plots at Bear River Migratory Bird Refuge

Figure 3. Organization of data collection plots at Bear Lake National Refuge

Figure 4. Organization of data collection plots at Salt Creek Waterfowl Management Area

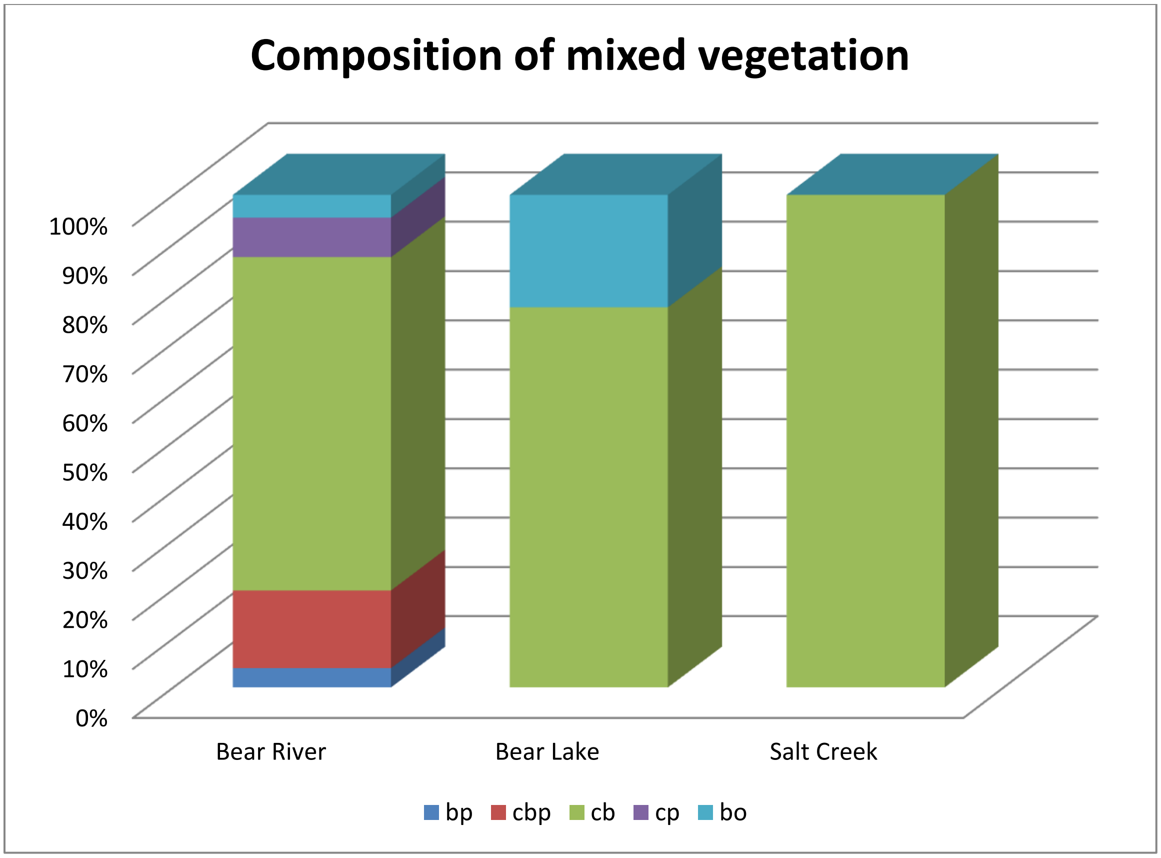

Figure 5. Graphical representation of the different mixed vegetation found in the different study places.

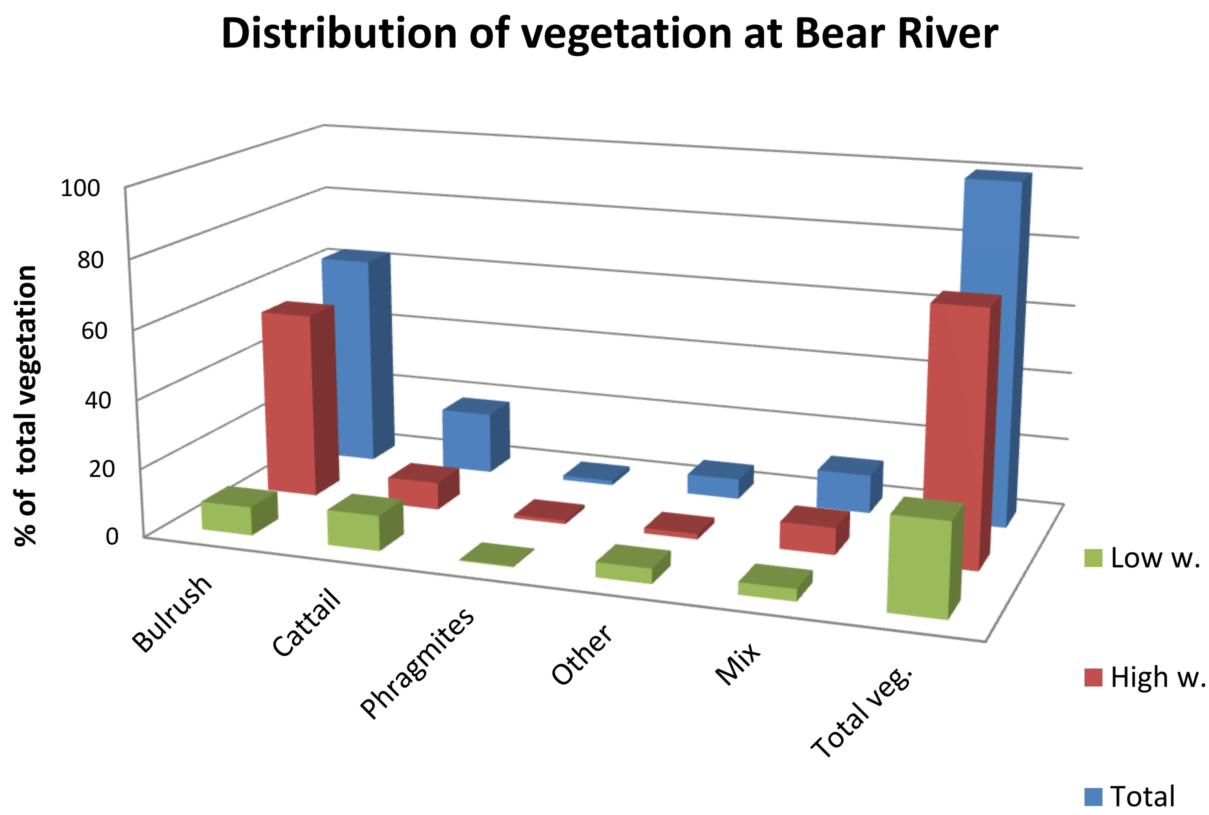

Figure 6. Graphical depiction of the distribution of vegetation in low and high water level at Bear River Migratory Bird Refuge as a percentage of the total vegetation in given water level.

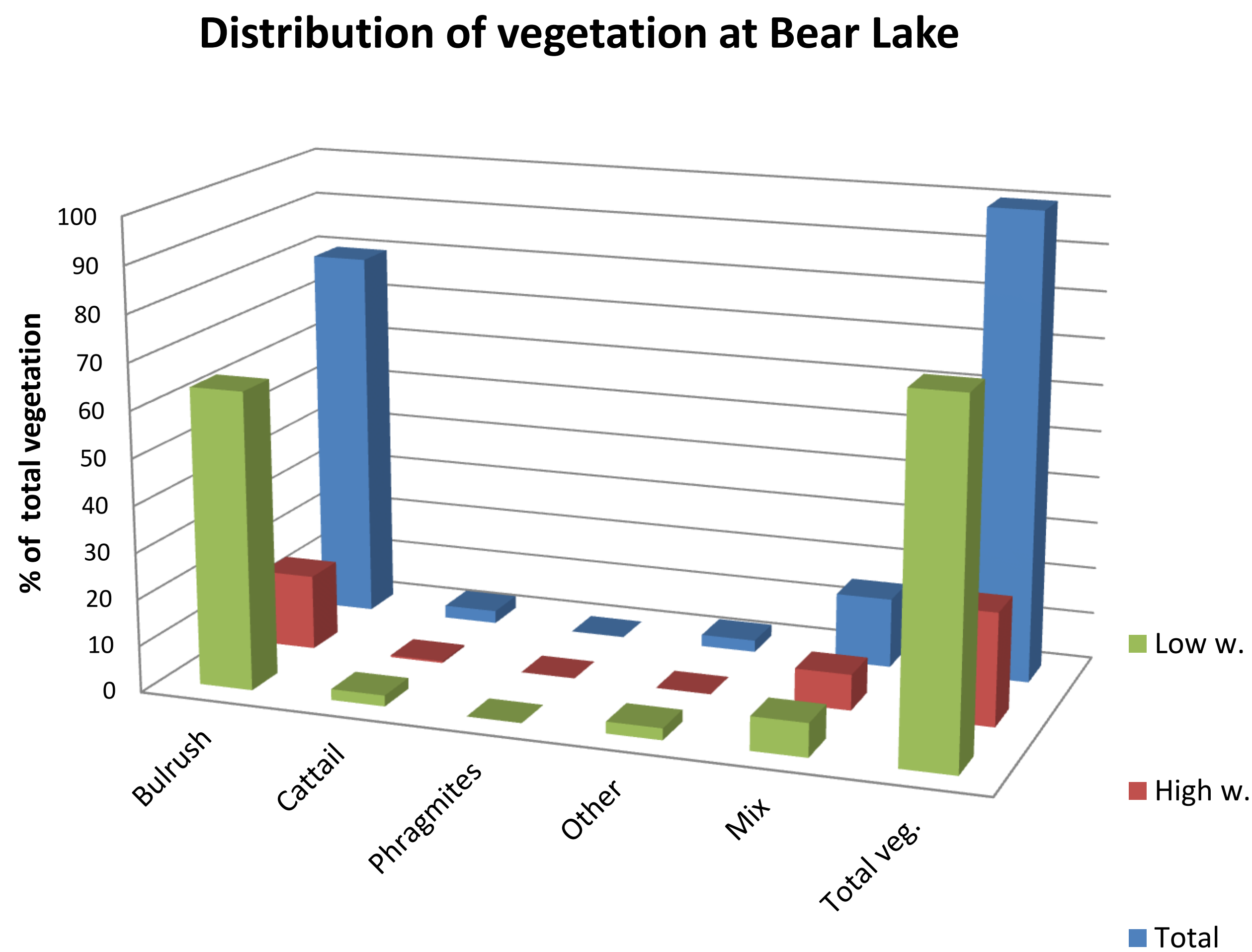

Figure 7. Graphical depiction of the distribution of vegetation in low and high water level at Bear Lake National Refuge as a percentage of the total vegetation in given water level

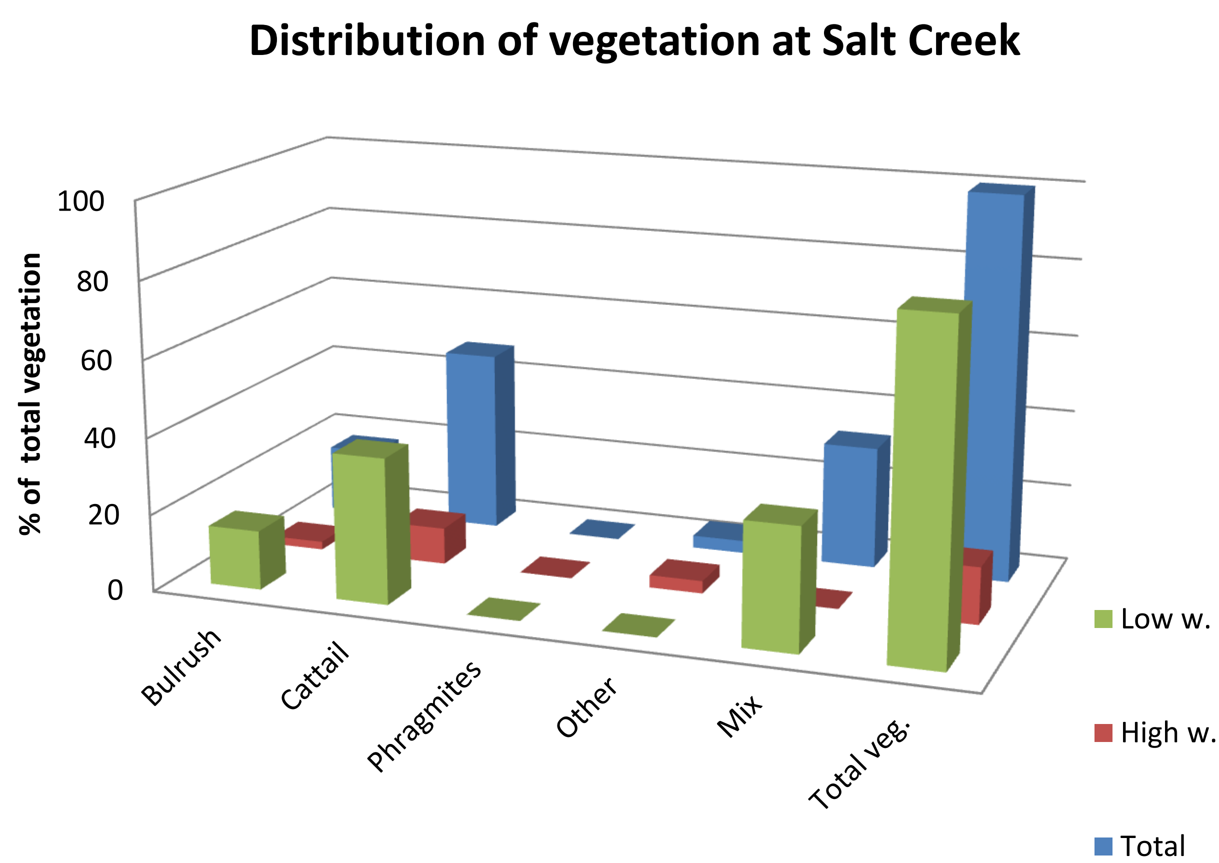

Figure 8. Graphical depiction of the distribution of vegetation in low and high water level at Salt Creek Waterfowl Management as a percentage of the total vegetation in given water level.

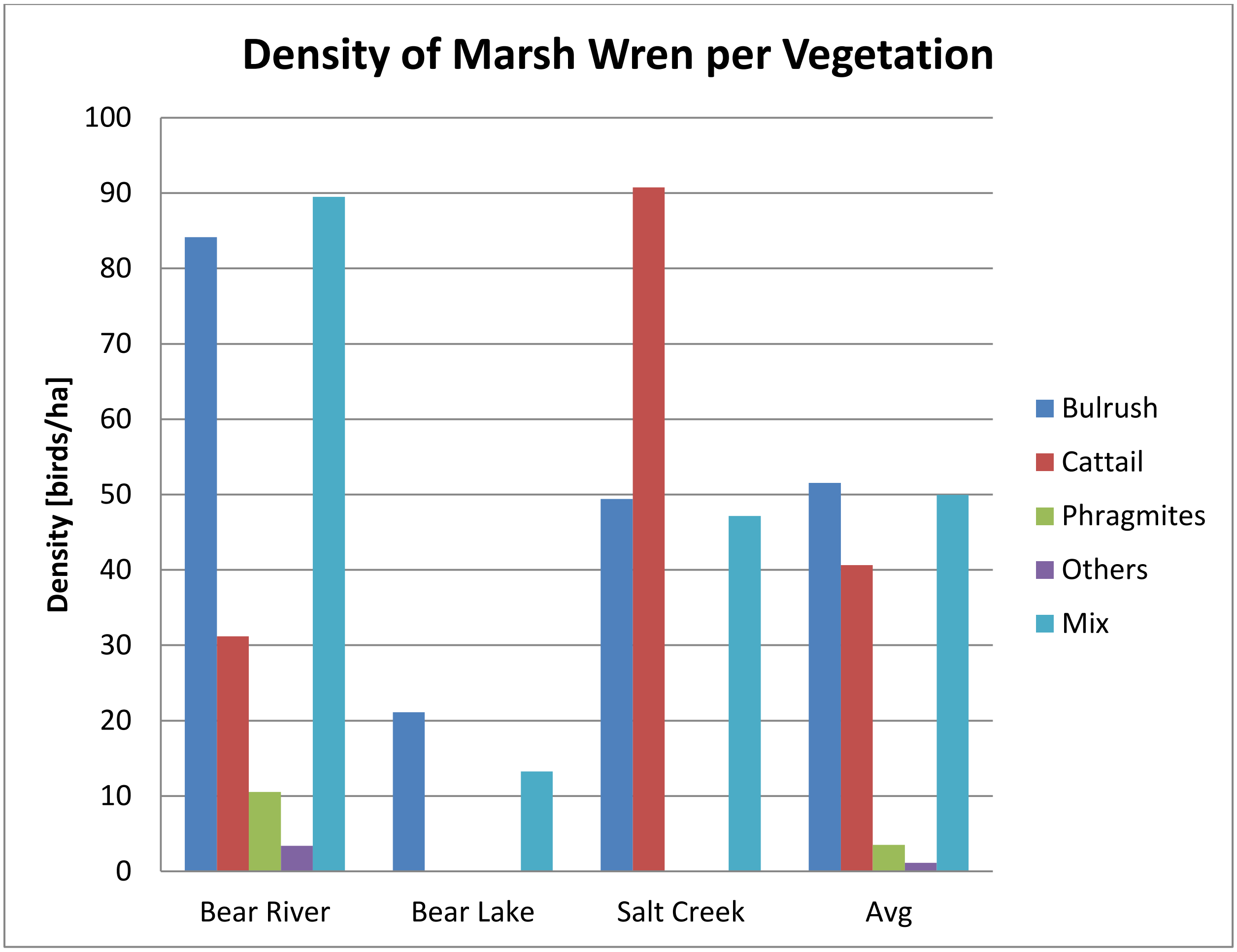

Figure 9. Graphical depiction of the distribution of the total of Marsh Wrens per type of vegetation in the different study places

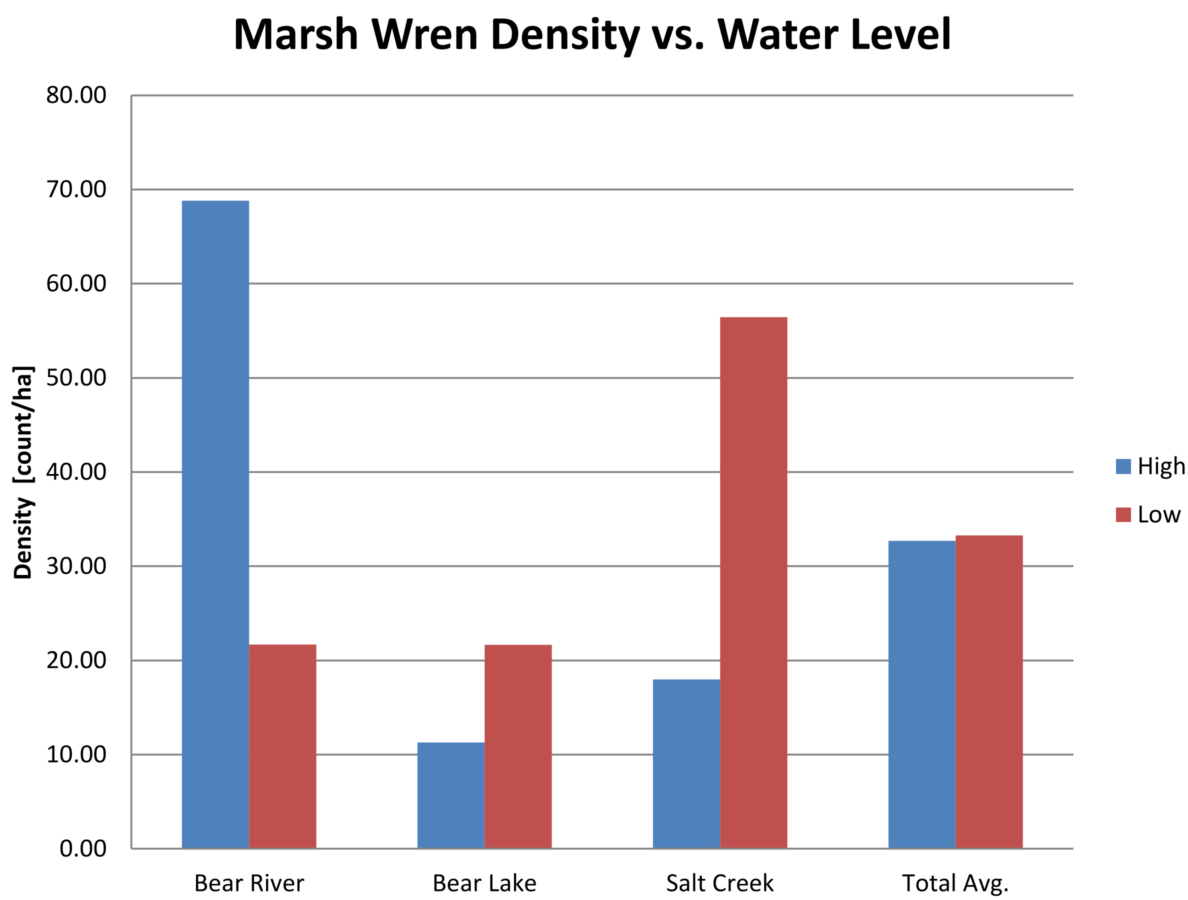

Figure 10. Graphical depiction of the distribution of the total of Marsh Wrens per water in the different study places

APPENDIX

Data Sheet

Location: ________________________________ Plot: _____

Date: _________________ Start Time: ___________ End Time: ___________

Weather: __________________ Wind: _________________

Distance	Vegetation Type				Marsh Wren			Water Level		Comments
	C	B	P	Other	M	N	C	H	L	

Legend:

Wind:	**Vegetation Type:**	**Marsh Wren:**	**Water Level:**
No wind	C- Cattail	M- Visually	H- High
Moderated	B-Bulrush	N- Nest	L- Low
Windy	P- Phragmites	C- Call	
	O- Others		