Combined Annual Habitat Work Plans, 2010-12
Fish Springs NWR

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Introduction

This combined AHWP provides a report on habitat management activities for years 2010-12 and it provides a transitional step toward use of the HMP as the foundation for AHWP writing in 2013 and future years. Reporting for years 2010-12 follows CCP objectives within sections II Habitat Objectives, III Habitat Response, and IV Wildlife Response of this AHWP, whereas planned management strategies for year 2013 (section VII) transition to use of HMP objectives.

From 1988 to 2004, a Marsh Management Plan (MMP, initiated 1988, finalized 1990, last updated Feb.1991) provided direction in wetland habitat management, including goals, objectives and strategies. Beginning in 2004, an approved CCP provided new general guidance involving substantial changes in priorities for habitat management, including wetlands. There is an overall goal for providing habitat for maximizing wildlife diversity. However, the goal is not compliant with Service policy and official amendment of the goal was pursued during the HMP development process.

Additionally, water management direction to accomplish the newly mandated habitat conditions of the CCP were left to the development of a more detailed HMP. Only general descriptions of minor changes in water management to diversify habitats are provided in the CCP; more specific water management remains unchanged from the MMP, which is designed for waterfowl production.

The CCP's timeline for completion of the HMP was 2009, but not until 2010 was HMP development initiated. In 2011, the newly established zone biologist for the I&M program visited the station and began his involvement in HMP development. A contract was awarded to CardnoNew to help facilitate the process. During 2012, HMP development moved forward under a planning team consisting of the refuge manager, I&M zone biologist, I&M GIS manager, and the contractor (CardnoNew). Initially, the regional I&M coordinator was also directly involved.

By November 2012, a draft-draft of the HMP had been completed with the services of the contractor before the end of the contractual period. A final draft of the HMP (to be prepared by Fish Springs staff and the zone I&M biologist) has a completion target for the end of calendar year 2013 or shortly thereafter.

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I. Relationship to the HMP.

The AHWP is an annual work plan that details incremental (or annual) tasks in support of goals and objectives. This combined AHWP for years 2010-12 represents a transitional step from use of the CCP for overall direction in habitat management, and the MMP to guide water management, to full implementation of the HMP. However, the process of detailing annual tasks in support of the CCP is problematic, due in part to policy compliance issues with CCP direction (see below and Appendix A).

The CCP established an "overall goal" to provide habitat for maximum wildlife diversity. This stated "substantive shift in management practices" (see rationale pg. 30 of the CCP), as described in Chapter 4 (pg. 28), was to be the new focus of Refuge management. "Habitat needs for species other than migratory birds that have not been adequately addressed in past management efforts will be fully integrated into management efforts." "[F]ull efforts to understand and meet the habitat requirements"... for "the full complements of flora and fauna historically represented on the Refuge" ... will be a priority."

However, managing habitat for maximum wildlife diversity is not compliant with the Service's Biological Integrity, Diversity, and Ecological Health (BIDEH) policy (see Appendix A). Additionally, by Service policy, refuge purpose/s (in this case migratory bird management) has the highest priority. Other System mission mandates, such as BIDEH, are to be secondary and complimentary. In terms of BIDEH, we are to maintain existing levels and to restore where deemed appropriate. We are to select priority Resources of Concern (ROC) to focus our habitat management activities. Selections of priority ROC are directed by policy guidance, including established refuge purposes (first and foremost), as complimented by other System mission mandates. Migratory bird management as focused on priority ROC is our primary mandate for Fish Springs NWR, not maximizing wildlife diversity. (See Appendix A for detailed references to policy).

II. Habitat Objectives.

In this section, we are to identify management strategies outlined in the CCP and HMP to be completed within the plan year. Since HMP strategies were not available to be completed during 2010-12, CCP objectives and strategies were used, and water management continued to be guided largely by the MMP. Since CCP objectives are written more like strategies than objectives, we identified both CCP objectives and strategies for incremental task completion during the years 2010-12.

During the HMP development process, in addition to goal amendment, modification of CCP objectives was necessary to transition them to "SMART" objectives that provide measurable biological outcomes as part of a Strategic Habitat Conservation / Adaptive Management approach that focuses on the ability of the landscape to sustain priority Resources of Concern.

The following CCP objectives and strategies completed or worked on during 2010-12 have been placed into general categories to improve organization and ease of reporting relative to our efforts in HMP development.

CCP Strategies for HMP development including I&M chapter:

1) *Develop a Habitat Management Plan.*
    a. *Specific characterization of the existing biological conditions.*
    b. *Descriptions of existing ecological structure and functions.*
    c. *Detailed objectives and strategies and the rationale to support the strategies.*
    d. *Detailed description of the expected outcome of habitat management strategies.*
    e. *Detailed methods and management tools to be used to meet objectives.*
    f. *Detailed inventory and monitoring surveys to evaluate the success of selected strategies.*

2) *Rewrite the Marsh Management Plan.*
    a. *Develop a GIS based vegetation database.*

3) *Assess the status of native biodiversity on the Refuge.*
    a. *Continue bimonthly bird counts.*

4) *Continually inventory, monitor and protect habitat for threatened, endangered and sensitive wildlife species.*
    a. *Continually monitor spring data.*

CCP Strategies for Water and Habitat Management:

5) *Provide nesting and brood rearing habitat for waterfowl, shorebirds and water birds by maintaining diverse aquatic habitat, adequate food resources, stable water levels during nesting, and enhancing colonial wading bird nesting habitat.*
    a. *Draw down two units each year to maintain an adequate invertebrate supply as a food source and to recycle nutrients through decomposition and prescribed burning.*
    b. *Bring five to six units to optimal stable water levels by mid-April when waterfowl, shorebirds, and water birds are selecting nest sites.*
    c. *Maintain stable water levels through mid-June for shorebirds and water birds in five to six units to prevent flooding and drying of nests.*
    d. *Maintain stable water levels through mid-July for waterfowl in three to four designated units to prevent flooding and drying of nests.*

6) *Provide spring and fall migration foraging habitat for waterfowl, shorebirds, and water birds. This involves providing a variety of habitat in each marsh unit, including shallowly flooded (# 4 inches) and sub-irrigated saltgrass for shorebirds, and emergent vegetation in water 4 to 12 inches deep for water birds.*

a. *Draw down two units each year to maintain an adequate invertebrate supply as a food source and to recycle nutrients through decomposition and prescribed burning.*
b. *Partially drawdown water in some units and increase water in other units during the early spring (March) to exploit resources not normally available.*
c. *Delay impoundment drawdowns until March 15 or later in those units scheduled for full drawdown but not scheduled for prescribed burning.*
d. *Cut off water to three to four units after mid-July when waterfowl nesting is completed . . . to create mudflats in late summer and into fall.*
e. *Allow water to drop in three to four other units after mid-July when waterfowl nesting is completed until mid-September.*

CCP strategies for management of invasive and pest plant species:

7) Determine the effects of management practices on the spread of Phragmites australis.

8) Reduce whitetop by 60 percent and squarrose knapweed by 60 percent within 3 years, tamarisk by 90 percent within 15 years, and cattail stand density by 50 percent within 15 years.

a. *Develop GIS-based vegetation database showing current distribution as a baseline. Update database as necessary.*
b. *Treat invasive species with appropriate chemical control agents and mechanical methods.*

CCP strategies for partnering:

9) Re-establish the least chub, a candidate species, in North, Deadman, Walter, House, and Percy Springs over the next 10 years.

10) Achieve a nesting success rate of 40 percent for snowy plovers nesting on the Refuge.

11) Participate in local partnering opportunities over the next 15 years that will benefit the Refuge by increasing knowledge of Refuge resources or accomplishing specific tasks.

12) Renew participation in existing national and international partnerships at the regional level.

III. Habitat Response

This section is intended to evaluate progress toward achieving the habitat objective(s) from the present management strategies and prescriptions. These are to be a descriptive response of the habitat to the management strategies and prescriptions. We are also to provide an analysis of results.

CCP Strategies for HMP development including I&M chapter:

Beginning in 2010, we started pursuing HMP development, included initiating and developing baseline information needs, both wildlife and habitat. One of the first steps to be taken was to initiate and develop the use of Refuge Lands GIS (RLGIS). For a more detailed account of RLGIS set up, see the combined 2010-12 Annual Narrative Report. For wildlife strategies, see section IV Wildlife Response below.

Water monitoring:
Spring water discharge monitoring was continued, and we also reinstated measures of water quality, similar to what had been done at times in the past. Additionally, we reinstated water level, flow, and quality monitoring in the managed impoundment units. This had been done historically for all years except for about the last decade. Extensive reporting for 2010, 2011 and 2012 water use is available in separate water use reports.

Phragmites study plot:
The spread and control of *Phragmites* has been of management concern on the Refuge since its establishment in 1959. A number of studies have been conducted on the Refuge to assess the effectiveness of control methods. However, widespread control efforts had not been pursued. Beginning in September 2009, a study plot was set up in Acocet unit to help assess response to new chemical control methods. Phragmites study plot results are in located Appendix C. For Phragmites control activities refer to the subsection below on CCP strategies for invasive and pest plants.

2010 Phragmites and hardstem bulrush mapping:
The presence and spatial distribution of *Phragmites* began being mapped with use of RLGIS in 2010. Curlew, Egret and Ibis units were completed (see strategies for invasive and pest plants, below). We also began mapping hardstem bulrush, due to its limited abundance and importance to colonial nesting wading birds and many other water birds. Hardstem bulrush mapping was completed for Pintail slough. Results included 5.406 acres of dense growth and 0.0903 acres of sparse growth for a total of 5.4963 acres. Maps for both species are available in Appendix B (Phragmites) and D (hardstem bulrush).

NVCS habitat mapping:
In 2011, we expanded our vegetation mapping efforts to mapping all vegetation using the National Vegetation Classification System (NVCS) and RLGIS. The full extent of the Refuge was to be mapped to the Alliance level (dominant species). By the fall of 2012, approximately 90 percent of the area of Refuge was mapped. Remaining areas to be

mapped and verification of all mapping will be completed in 2013. A detailed report of the NVCS mapping effort is provided in the combined 2010-12 Annual Narrative Report.

Additionally, JoAnn Dullum, I&M GIS manager, began geo-rectifying and digitizing a hard-copy 1959 vegetation map (dominant species) by Tietjen. Completion of the digitized map, including verification of polygon attribution, is expected to be completed in 2013. The two mapping efforts will allow for quantitative historical comparisons of the vegetative community at the Alliance level (dominant species).

CCP Strategies for water and habitat management:

At Fish Springs NWR, habitat management is primarily accomplished by how we apply water to the landscape to sustain priority Resources of Concern. However, implementing water and habitat management as directed by the CCP is problematic.

First, priority ROC are not established by the CCP and there is an overall goal to provide habitat for maximum wildlife diversity. Habitat needs for species other than migratory birds that have not been addressed adequately in past management efforts are to be fully integrated into management efforts. This direction is the opposite of our policy guidance to narrow and focus our management efforts to support priority ROC. Given the purposes of the Refuge and policy guidance, migratory birds are our first and foremost priority, not maximum wildlife diversity. Also, provided that wetland resources for migratory birds are highly limited in the greater area around the Refuge, or regionally, and that wetlands make up the vast majority of acres on the Refuge, the highest value of the Refuge is managing wetland habitats to benefit wetland-dependent migratory birds, not other migratory birds.

Second, water management direction in the CCP is general, inconsistent, and in conflict. There is to be a "substantive shift" in management focus from providing habitat for migratory birds to providing habitat for maximum wildlife diversity. However, this "substantive shift" is to be accomplished by minor modifications to water management to provide diverse habitats. However, water management outlined in the CCP is otherwise unchanged from the MMP, which is designed for waterfowl production. The CCP even states elsewhere that water management will be maintained to create optimum conditions for waterfowl production. Various CCP strategies are provided for the minor changes, but there are several conflicts among them. If one strategy were to be done, then others could not. They are not compatible or complimentary.

Given the troubled direction of the CCP, we selected strategies to be accomplished that supported wetland-dependent migratory bird species, as guided by water management in the MMP. It should also be noted that under MMP water management, northern units will go dry or mostly dry each year, due high rates of evapotranspiration (ET) loss, regardless of the drawdown rotation schedule. Only a limited number of pools can be maintained at "optimum pool level" during summer. Those four pools include Avocet, Mallard, Shoveler, and South Curlew, where one of these pools is scheduled to be drawn down each year given the prescribed drawdown rotation. Thus, Avocet, Mallard, Shoveler, and

South Curlew pools function as semi-permanent wetlands and the remaining northern pools provide seasonal wetlands.

Semi-permanently flooded wetlands:

During 2010-12, we managed Avocet, Mallard, Shoveler, and South Curlew pools on a rotational basis (per the MMP with minor modification) to be maintained at "optimum pool" water levels. This area, as well as West Curlew supports stands of tall persistent emergent plants, namely Olney's three-square bulrush, hardstem bulrush, cattail, and limited sites of alkali bulrush. There are also extensive stands of Baltic rush and Phragmites on shorelines or adjacent wet meadows. See the following section for our strategies employed to control Phragmites in this area. The MMP water management for these sites is specifically designed to best support waterfowl (duck) production, although uses by a variety of other water birds are realized.

In 2010, South Curlew (along with the full Curlew Unit) was drawn down per the MMP/CCP rotation schedule. Ibis (see below) was also drawn down as part of the rotation schedule. Egret Unit (see below) was drawn down along with Egret and Curlew (North and South) to facilitate Phragmites control and infrastructural repairs to the water delivery system. In 2012, the same areas were drawn down to further facilitate Phragmites control and infrastructure maintenance. In 2011, Shoveler and Pintail units (see below) were drawn down per the MMP/CCP rotation. Phragmites and infrastructural repairs were also performed when drawn down.

These actions involved full drawdowns, however we experimentally pulled the water down much more slowly than is prescribed in the MMP. This was done to attract and prolong migratory bird uses. See wildlife response below.

Seasonally-flooded wetlands:

Seasonally flooded wetlands included 6 main pool sites: Pintail, North Curlew, Egret, Harrison and Gadwall. Although not identified in the CCP, since 1994 Gadwall pool has been managed using a partial drawdown prescription to support snowy plover use and to discourage nesting Canada geese. The other 5 pools are maintained at "optimum pool" water levels when water is available (winter and spring) before drying in summer due to ET loss. One of the 5 pools is scheduled for full drawdown each year. This water management is by design for the 5 pools to support waterfowl production, primarily nesting Canada geese (see MMP). However, this prescription also supports a variety of water bird uses, especially when drying down.

The 4 northernmost pools (Pintail, Ibis, Harrison and Gadwall) are large, shallow (up to 3 feet) bathtub-like bodies of water lined primarily by saltgrass, some alkali bulrush, or iodine bush. The pools produce stands of SAV when flooded, but that is lost when the pools dry down in summer. Reduced pool areas create mudflat shoreline habitat, with recognized value to shorebirds in the MMP. Major alterations to pool management, such as that done in Gadwall, provide great potential to improve site conditions for shorebird uses.

North Curlew, to the west, supports braided wetlands with islands bounded by bulrush, Baltic rush, Phragmites and saltgrass. The main pool area of North Curlew to the east is dominated by expansive stands of saltgrass that are flooded by shallow water when at "optimum pool." Egret to the west, has native water channel braids that are lined by bulrush, Baltic rush, Phragmites and saltgrass. The main pool area to the east is dominated by expansive stands of saltgrass that are shallowly flooded when at "optimum pool."

The large expansive saltgrass stands within the main pool areas of Egret and Curlew provide opportunity for minor water level adjustments to support migratory bird species other than waterfowl (noted in the CCP) as departing from the "optimum pool" levels of the MMP that are designed to support waterfowl production.

In 2010, Ibis, Egret and North Curlew were planned to be fully drawn down along with South Curlew (see above). This was repeated in 2012 (see above). In 2011, Pintail was to be fully drawn down along with Shoveler (see above). As planned, Shoveler, Curlew (North and South), and Egret were fully drawn down on the noted years, but the full drawdown was executed over a protracted period to extend water use by birds during the spring migration season. Due to clogged outlet channels for Ibis and Pintail pools, they could not be fully drawn down. Instead, they were only partially drawn down on the noted years, similar to the special prescription for Gadwall pool.

In addition to water management prescriptions, other habitat management strategies included scheduled prescribed burns per the MMP/CCP, control of non-native invasives species and Phragmites, and some experimental cattail control. Prescribed burns are coordinated with and follow the drawdown rotation. Units scheduled for drawdown are also burned in late winter or early spring (mid to late March) after water levels have dropped and vegetation has sufficiently dried. Burn dates are not extended beyond that time in order to limit impacts to nesting birds. In 2010 and 2011, prescribed burns were carried out in all units that were drawn down. In 2012, prescribed burns could not be conducted, due to the Fire Plan needing required revision. The Rocky Basin Fire District FMO was tasked with completing all Fire Plan updates within the zone. Other refuges had been prioritized over Fish Springs. There were efforts made to acquire plan writing assistance for the FMO. We are hopeful to be back burning on schedule in 2013 or 2014. For strategies involving control of non-native invasive plants, Phragmites and cattail, see the following section.

CCP strategies for management of invasive and pest plant species:

Phragmites on the Refuge is best known to be native. Samples were tested by Cornell in the past and again in 2010 by Dr. Karin Kettenring at Utah State University. Being native and biologically invasive, our native Phragmites is not considered an "invasive plant" by Service definition. Invasive plants include non-native only. However, since its spread is of management concern to be controlled, by Service definition native Phragmites is a management pest plant.

As mentioned above, the spread of Phragmites has been of management concern since the establishment of the Refuge. A number of past studies have been conducted on the Refuge to assess the effectiveness of control. The CCP establishes an objective for further assessment in successful control. However, there is a wealth of information available in the literature regarding successful chemical control techniques for Phragmites. Further, the UDWR has been actively controlling Phragmites within wetlands of Utah and that information is available. Additionally, the current Fish Springs refuge manager has past experience with successful chemical control of Phragmites in Oregon and Washington.

From 2010-12, we began a large-scale Phragmites control program. Our intention was to provide sufficient information regarding its longer term feasibility and effectiveness. After 3-5 years of implementation, we hoped to be able to develop a highly effective management objective and control strategies for use in the HMP.

Control efforts were coordinated with the scheduled water drawdown rotation per the MMP/CCP, since a ground application with a farm tractor would be used. In 2010, Curlew and Ibis units were targeted. We also additionally drew down Egret Unit as an alteration to the schedule for that year. In 2011, Shoveler and Pintail units were targeted per the normal rotation schedule. In 2012, Mallard and Gadwall were scheduled for drawdown per the MMP/CCP. However, we altered the schedule by delaying the drawdown of Mallard that year to be done the following year. Gadwall did not factor in as it had not been managed by that rotation since 1994, but rather has had a special partial drawdown every year. In lieu of drawing down Mallard in 2012, we drew down Curlew, Egret and Ibis to support a second chemical application following the initial application in 2010. In 2013, Mallard, Shoveler and Pintail will be drawn down. The second chemical application will be completed for Shoveler and Pintail, and Mallard will be initially treated.

Phragmites control areas by year (*denotes altered drawdown rotation):

2010 – Curlew, *Egret, Ibis
2011 – Shoveler, Pintail
2012 – *Curlew, *Egret, *Ibis

The targeted time for chemical application was after full bloom and before dormancy, which is generally from late August to late September. Glyphosate was used at three quarts per acre, with LI-700 at 1 quart per 100 gallons of solution to serve as the surfactant and acidifying agent. Peak efficacy of glyphosate is obtained when the chemical solution is at a pH between 3 and 5. We monitored our pH with our water quality test instrument. We also tested in limited areas a tank solution of glyphosate and imazapyr, which per the literature has been found to be more effective. The active ingredients of both have different modes of action on the plant, making it more effective. Even imazapyr alone has been demonstrated in the literature as more effective than glyphosate. However, our Phragmites often exists in mixed stands with other desired plant species. Thus, we wanted to use a product that is effective in controlling Phragmites with the least amount of impact to other plant species. Saltgrass for one is known to survive applications of glyphosate, but imazapyr can be very effective in killing it. Our hope was to be able to fully kill Phragmites, but only injure other species such as saltgrass which would then recover and occupy the treated site.

See Appendix B for acres of Phragmites mapped and treated in 2010 in Curlew, Egret and Ibis units, as well as monitoring results for that single application one year outward. Single year monitoring of effectiveness was not completed for Pintail and Shoveler applications in 2011. Effectives of control will be remeasured in 2013 (after the second treatment in 2012) for Curlew, Egret and Ibis, then again in 2014 for Shoveler and Pintail.

Experimental cattail control, another management pest plant, was conducted in various locations on the Refuge, but monitoring was limited to visual observations. To date, cattail appears to be effectively reduced by drying the sites for prolonged periods (across multiple growing seasons). Also, following a prescribed single drawdown event, cattail at some sites was sprayed in early September (glyphosate at 3 quarts/acre with 1 quart LI-700 per 100 gallons of solution), mowed 2-3 weeks later, and then flooded over through the winter. However, effective spraying is problematic after drawdown at that time of year. During the onset of growing season, due to the lack of water, cattail growth is greatly reduced and provides few live, green plant parts to spray in September. Killing the rhizosphere by chemical means requires sufficient chemical absorption and translocation from the above ground plant parts. Since the rhizosphere for cattail is extensive, a large amount of above ground surface area in plant parts is needed for chemical contact and absorption into the plant for translocation to below ground tissues. Delaying the timing of drawdown would likely lessen the impact on cattail growth early in the growing season and would improve the effectiveness of the chemical application in September. That said, the method of spray-mow-flood on that timeline appears to be highly effective.

Chemical treatment was also used to control pepperweed, knapweed, and tamarisk, all of which are invasive plants of concern on the Refuge. In 2010, all three species were treated with Polaris: pepperweed from late May to early July, knapweed from late July to early August, and tamerisk from late September to late October. Milestone was supposed to be used for knapweed. There are also superior products to be used for pepperweed. In 2011 and 2012, the use of products was upgraded to Telar for pepperweed and Milestone for knapweed. For locations of treated plants see Appendix H.

For pepperweed management beginning in 2010 we: 1) set up a database for record keeping, 2) determined the amount of plants treated by area in acres, and 3) developed and utilized RLGIS. A database was set up for historic pepperweed information and data that was available was entered. Acres treated in 2010 were determined by documenting a radius from GPS points and estimating plants present and percent cover for the plot. Calculations were made to obtain an area for each plot in acres. Calculations were then made to get acres of percent cover pepperweed. We visited approximately 39 acres, and within that area, there was a minimum of approximately four acres and a maximum of approximately eleven acres of pepperweed treated. There were 97 plots visited (73 plots had plants) with approximately 21,955 plants treated. Historic and new GPS points were loaded into RLGIS. In 2011, RLGIS will be utilized to map treated pepperweed as polygons. See Appendix E for pepperweed control and monitoring methods, summary information, data, and comparative graphs with historic data.

For knapweed management beginning in 2010 we set up a database for record keeping, started determining the area of plants treated, and initiated use of RLGIS. Area treated in 2010 was determined by documenting the number of plants treated per stand, with an average plant stand radius. Calculations were then made to obtain square feet and acres of knapweed. There were 4.22 acres searched with 100 plants identified and treated. With plants having an average of a one foot diameter, there was 78.5 square feet or 0.001802 acres of knapweed identified on refuge lands. There is substantial knapweed growth in the bottoms of draws on BLM land west of the refuge. Historic and new GPS points were loaded into RLGIS. GPS points represent plots with a thirty foot radius. In 2011 and 2012, knapweed was not be mapped with polygons since knapweed growth on the refuge is still documented with ease by the number of plants treated. For knapweed control and monitoring methods and 2010-12 data see Appendix F.

For tamarisk management in 2010, we set up a database for record keeping and began using RLGIS. Treatment of 73 plants was conducted. In 2011, GPS points will be taken for each tree treated since tamarisk growth on the refuge is still easily documented by number of plants treated. For tamarisk control and monitoring methods and 2010-12 data see Appendix G.

See Appendix E for mapped treatment locations for pepperweed, knapweed, tamarisk for 2010-12.

CCP strategies for partnering:

Fish Springs NWR currently has no endangered species located on or that use Refuge lands. From 2011-12, our key intention in using strategies for partnering was to maximize our efforts in having positive effect at reducing the need for future federal or state listings of endangered species on the Refuge, within Utah, and with the region. We also pursued partnering opportunities that benefit our management planning and other activities on the Refuge.

In 2010, the refuge manager and assistant refuge manager became involved in Utah Division of Wildlife Resources (UDWR) meetings for the Wildlife Action Plan (WAP) and Watershed Restoration Initiative (WRI). The purpose as stated above was to participate as a partner in taking action to protect against the need for future listings of state or federal endangered species. We also began soliciting input or support by UDWR into management actions and planning on the Refuge.

Similar past efforts prior to 2010 involved repatriation attempts of least chub in Walter and Deadman Springs (a CCP objective above). Although sufficient historical information is lacking for confirmation, least chub are believed to be native to Fish Springs wetlands. Currently least chub are a candidate species for federal listing. The first actions of past repatriation efforts involved removal of mosquito fish (*Gambusia*) in Walter and Deadman springs with use of rotenone in a joint project with UDWR. Initially the project appeared successful, but at subsequent dates, mosquito fish re-established and the repatriated least chub were eventually outcompeted and completely lost from both spring systems. A second project was pursued that involved repatriation of least chub in selected management impoundments (Pintail and Ibis pools). Flat fish screens were installed on water control structures. However, the screens were problematic (clogged by SAV) and this project was also unsuccessful. A survey for least chub was conducted within these same impoundments in 2010 and 2011 to check on presence. None were founds as reported below in "Section III Habitat Response".

Also, in 2010 a meeting and site visit was conducted on the Refuge with an UDWR aquatics biologist and USFWS ES Utah field station aquatics specialist to assess new possibilities to successfully repatriate least chub. A project proposal was agreed upon and was later drafted by UDWR and ES (Utah Field Station) staff (see Appendix H). The project was fully expected to be funded with ES project dollars. However, after least chub were moved to candidate status for federal listing, this project proposal was put on hold until further assessment could be made. In 2011, no progress was made. In 2012, when approached by the Fish Sprigs refuge manager, UDWR expressed renewed interest in pursuing least chub repatriation at Fish Springs NWR. An expanded proposal was presented to the Least Chub Conservation Team at an annual meeting by the refuge manager. This project proposal was well received by the team and UDWR specifically. The project falls within the framework of the draft HMP and plans are to move forward with UDWR involvement. See Appendix H for a project description.

Substantial use by Snowy Plover (SNPL) on the Refuge was first documented in 1988 as part of a four-state survey. In subsequent years, counts were performed and the results are reported in Annual Narratives. As part of a list of recommendations left behind by outgoing management staff in 1991, there was a proposal to manage Gadwall and Harrison Units for *Salicornia* habitat to serve as goose forage (see MMP). At this time, there was also a perceived issue in the northern units regarding salinity toxicity to gosling Canada geese (see thesis report by Stolley 1998). In 1994, the water management of Gadwall Unit was changed to a partial drawdown scenario. This was intended to discourage goose nesting and provide *Salicornia* for goose forage, as well as providing shoreleine habitats for use by foraging SNPL. The type of water management changes are documented in a few available Water Use Reports, but only briefly. Otherwise there is almost no documentation of these efforts or the effects of water management beyond periodic refuge-wide bird counts.

It is our current determination that an adequate baseline has not been established to realistically pursue CCP Objective #10, listed above in Section II Habitat Objectives . During 2010-12 we continued the same water management strategy and began to pursue baseline information. In 2010, we initiated SNPL surveys and collected water monitoring data. In 2011, a multi-partner project was initiated to assess SNPL site occupancy on areas known or thought to be used by SNPL on the Refuge and neighboring lands on Dugway Proving Ground (DPG). Also, in 2011 and 2012, the vegetation of the unit was mapped as part of our refuge-wide NVCS mapping project. For SNPL survey and project reports see Appendices J, K and L. See Appendix M for the relationship of SNPL foraging use to water management. Refer to the Water Use Reports from 2010-12 to see details of the water management strategy used.

The least chub and SNPL work conducted in 2010 and beyond involved multiple partners to address higher priority and larger landscape needs. The 2010 least chub project proposal was developed through involvement by UDWR specialized aquatics staff, USFWS ES staff and Refuge staff. For SNPL project work in 2010, preliminary discussions were held by our neighboring Dugway Proving Grounds (DPG) biologist and the Fish Springs refuge manager. Following this, an initial partner meeting was held by the refuge manager and assistant manager with specialized staff from DPG lead by supervisory biologist Robbie Knight; Dr. Randy Larsen of Brigham Young University; BLM (our other land neighbor) district biologist Traci Allen; UDWR subject experts Jim Parrish, Kim Asmus and Jimi Gragg; Suzanne Fellows of the USFWS migratory bird office; Dr. John Cavitt of Weber State University; Refuge volunteer Raven Reistetter, PhD science advisor of the DPG chemical testing program; and expert birder Jack Skalicky, PhD of the U. of Utah Biochemistry Department, who had performed volunteer bird surveys on the Refuge for the past several years. Stemming from this meeting and subsequent actions taken, a graduate project was funded by DGP with BYU as supported by the Refuge with onsite housing and a vehicle for project use. Kristen Ellis of BYU began conducting the project for her MS thesis under principal investigator Dr. Randy Larsen of BYU, as well as the lead DPG biologist (Robbie Knight), with John Cavitt residing on her committee, as well as participation by the Refuge and other partners. See section IV Wildlife Response directly following, and Appendices K and L for snowy plover graduate project reports.

IV. Wildlife Response.

This section is intended for evaluation of the response of the Resources of Concern as well as nontarget resources to the habitat management strategies and prescriptions. We are to provide analysis of results identifying the positive and negative impacts of each prescribed strategy. We are to then use this information to help select the management strategy(ies) with the most positive effect on refuge resources as a whole.

During 2010-12, measures of wildlife response to habitat management strategies that were employed to be useful to HMP development included: water flow and quality monitoring; special targeted bird surveys for long-billed curlew, white-faced ibis, black-necked stilt, and American avocet; 2010 snowy plover surveys; snowy plover MS graduate project; 2012 waterfowl nesting production study; an analysis of past waterfowl nesting production data, 2011 coyote diet study; 2012 coyote population index (scat surveys); 2012 nest predator study; and analyses of data from refuge-wide bird surveys (initiated in 2012 and to be completed in 2013). A report of these measures of wildlife response are included directly below, with further data provided in identified appendices.

Water Monitoring

See the subsection below on the graduate MS project involving impact of *Gambusia* on aquatic macroinvertebrate resources. Data shared to date from this project demonstrates the effectiveness of prescribed water drawdowns for aquatic macroinvertebrates as an avian food resource.

Appendix M provides charts demonstrating the relationship between water management and snowy plover use. This is also discussed further below in the subsection for the SNPL graduate project. There is potential to expand this type of evaluation to other units and targeted species uses, but it has not been done yet at this time.

For additional information on water monitoring and use refer to the 2010-12 Water Use Reports.

Refuge-wide bird surveys

Refuge-wide bird surveys have been conducted since the establishment of the Refuge. There is also an Access database for these surveys that is populated with count information from the 1970's to present. Data for earlier years has been located and plans are for it to be entered into the database. Also ongoing is an effort to summarize the count information in the database for use in the HMP to assess changes in biodiversity and other effects of management activities. Information is intended to be fully summarized for use in the HMP during 2013.

Christmas Bird Count and Mid-winter Waterfowl Survey

From 2010-12, we continued the tradition of conducting a Christmas Bird Count (CBC) on the first Sunday of January within the count year. The CBC was initiated at Fish Springs in 1980 and has been conducted each year except 1995 and 1987. The CBC has doubled to provide data to the state coordinator for the Mid-winter Waterfowl Survey. The total number of species sighted each count from 2012 to 2010 were 39, 50, and 48, respectively. Comparatively, there were 51 in 2009. For the full history of the count, the running total number of confirmed species is 105. The lower total number of species sighted in 2012 may reflect the extremely cold conditions with snow. Most raptor species were up in number in 2012, including short-eared owls (5), which hadn't been recorded since 2008. This long-term dataset has value to assess trends relative to Refuge management activities. However, to date no such an assessment has been completed. See Appendix N for 2010-12 count information.

National Breeding Bird Survey

The Callao route of the BBS was initiated in 1992 and continued to 2006 followed by a 3- year lapse from 2007 to 2009. In 2010, the survey was reinstated. A portion of the Callao route is conducted on Refuge lands and thus provides value as a long-term data set to assess trends. Survey results are listed in Appendix O.

Special-targeted Bird Surveys

Beginning in 2011, we began special surveys to obtain additional baseline information for long-billed curlew, white-faced ibis, black-necked stilts, and American avocet. All species were considered to be potential ROC selections for the HMP prior to that development process. The purpose of the surveys was to better document species use by management unit and habitat types. The outcomes for survey efforts from 2011-12 are presented in Appendix P.

Observations by the Refuge Manager

The data from the above survey methods have not been analyzed for a fuller assessment on the effectiveness of wildlife response to management strategies. However, some otherwise notable observations of wildlife response are worthy of mention.

Waterfowl and other water bird uses of the impounded pools substantially increased in the first few years following drawdown. Likewise bird uses decreased from one year to the next in pools that had not been drawn down. This was clearly apparent during spring and breeding seasons over the years 2010-12. Thus, it appears that prescribed drawdowns are effective as designed to increase aquatic macroinvertebrate food resources through implementation of wet/dry cycles. Also see MS project by Steve Merkely and Dr. Russell Rader of BYU, below.

Temporary and seasonal alterations of water levels from established "optimum pool" water levels of the MMP/CCP can clearly attract and increase bird uses. For example, when pools are being draw down by prescription of the MMP/CCP, the shrinking pools notably attract a variety of bird uses. However, rather than fully and immediately drawing down a pool to initiate a dry cycle per the MMP, some drawdowns were experimentally prolonged to create site conditions with shallow water and mudflat shorelines for a protracted period before going dry. This alteration to drawdown has been demonstrated through special monitoring (see below and Appendices J, K, L) as beneficial to SNPL foraging during the spring season. Shoveler unit water management is not specifically designed for and normally does not support this use. Attraction and benefits to other birds also occurred. The largest concentration of waterfowl on the Refuge at this time was within these shallow waters. Curlew, willet and many other bird species were clearly drawn to the site conditions. See the photograph, below.

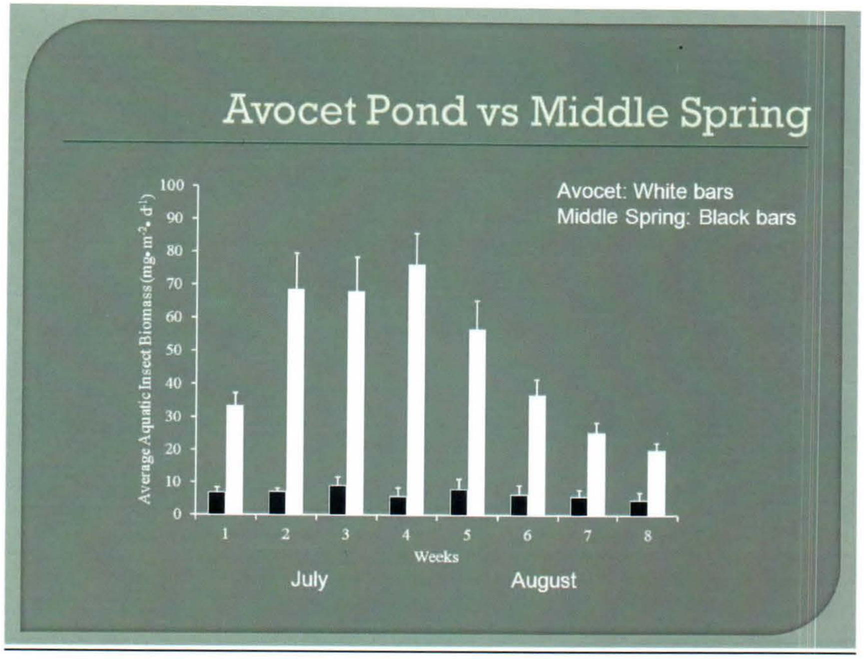
High spring-season bird use in shallow waters of prolonged drawdown, Shoveler Unit 2011

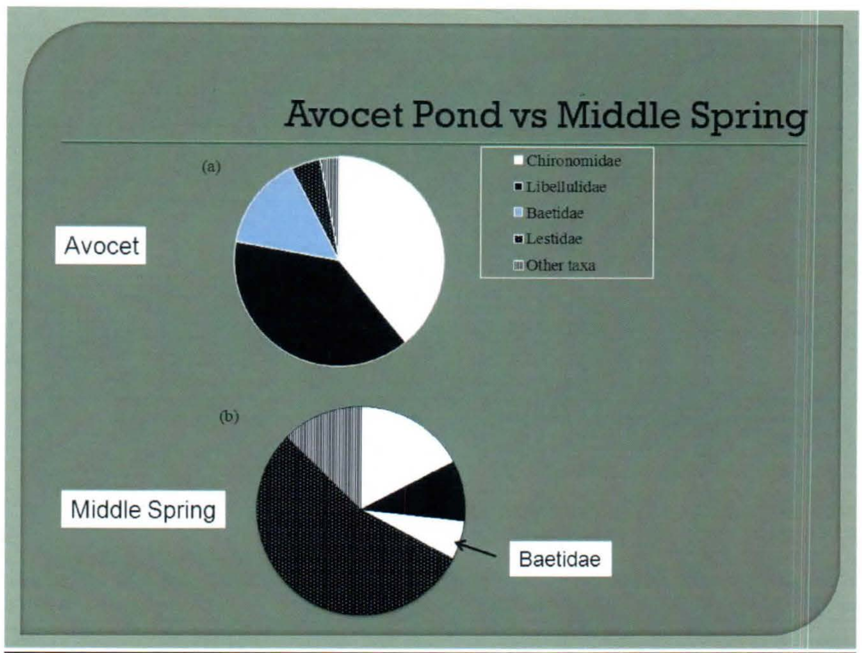
Additionally, in 2012, water levels in the fall season in Shoveler unit were experimentally raised above "optimum pool" water levels. The water level was increased sufficiently (about 1 foot) to flood extensive areas of saltgrass and more limited sites of Baltic rush. An increased use by waterfowl during fall migration was clearly apparent over other years when this action was not done.

Impact of *Gambusia* on aquatic macroinvertebrate resources - MS graduate project

During 2010 and 2011, field work was conducted by Steve Merkely, MS graduate student, under the lead investigator Dr. Russell Rader of BYU, to study the impact of Gambusia (mosquito fish) on the availability of aquatic macroinvertebrates to other consumers such as least chub and migratory birds. The project was done as a continuation of earlier research conducted to benefit least chub conservation efforts.

Data shared to date from this project demonstrates the effectiveness of artificial drawdowns as prescribed at Fish Springs NWR in benefitting migratory bird resources. The following charts display comparative production levels between middle spring wetlands and Avocet pool. Middle spring wetlands function naturally with permanent flooding by continuous water flows. Conversely, Avocet pool water resources are managed to be semipermanently flooded though prescribed drawdown once every 5 years. The results show the effectiveness of artificial wet/dry cycles in dramatically increasing the production of aquatic macroinvertebrates for use by migratory birds. See the following two charts, below.





2010 Special Snowy Plover (SNPL) Survey

The purpose of the 2010 SNPL monitoring was to better document where, when, and what the SNPL are doing on Refuge lands. The SNPL were monitored two days per week, three times per day, from late May to mid-July. The SNPL were observed at all hours of the day into July. From mid-July to late-July, SNPL were monitored with observations made two times per day in the mornings and evenings. From late July to mid-August, SNPL were monitored once per day in the evenings. The highest count at any one time was 80+ birds. The major activity observed was foraging. There were no nesting surveys conducted and no nesting activities observed (other than six young observed in Harrison unit in early August). During a general bird survey conducted by a volunteer in early May, SNPL were observed foraging in the Gadwall Unit main pool area. However, during the SNPL monitoring effort, SNPL were mainly observed in Ibis Unit utilizing the shoreline area as the main pool was slowly evaporating down. Later in the summer when the main pool of the Ibis Unit evaporated down to low levels, SNPL foraging activity transitioned to the Harrison Unit main pool, as it was just beginning to dry down sufficiently to provide large areas of shoreline with adjacent mudflats. The 2010 methods were modified throughout the season and later standardized to the national survey methods with assistance from the Region-6, Migratory Bird Division, non-game migratory bird biologist. For the 2010 data and methods, see Appendix J.

Snowy plover MS graduate project

Mentioned above, as a partner project in support of HMP development, snowy plover graduate project field work on DPG and Refuge lands was completed during 2011 and 2012 by MS graduate student Kristen Ellis under the principle investigator Dr. Randy Larsen of BYU. See Appendices K and L for a project reports.

Additionally, see the charts in Appendix M demonstrating the relationship of SNPL foraging use to water management during 2010-12 in the four northernmost impoundments on the Refuge. As noted above in section III Habitat Response, Gadwall unit water management is specifically designed to benefit snowy plover use. As also noted in that section, Ibis was drawn down in 2010 and again in 2012, but only a partial drawdown. This was also the case with Pintail pool in 2011. In 2010, Ibis pool was intended to be fully drawn down, but we could only do a partial drawdown due to the outlet channel being clogged.

After observing how a partial drawdown supported SNPL use in Ibis in 2010, we purposely performed a partial drawdown in Pintail in 2011 and then one for Ibis in 2012. The charts in Appendix M display snowy plover use in response to this water management. Prior to this time, significant SNPL use had only been documented in Gadwall or Harrison. Water management in Gadwall employs a partial drawdown that supports early SNPL use. Harrison unit as managed per the MMP (as designed for waterfowl production) begins to dry down in summer and typically provides mudflat shoreline habitat from about late July to mid-August, which corresponds to foraging activity by SNPL in that unit. Likewise in Ibis and Pintail units, SNPL use occurred when mudflat shoreline conditions were provided during the window of their seasonal presence on the Refuge (April through August). When units dry down and provide mudflat shoreline habitat after that window, there has been little to no SNPL use. Additionally, the surveys of Ellis as reported in Appendices K and L also show SNPL use in other units, such as Shoveler and Egret that happened to be partially drawn down and providing mudflat shoreline habitat during the spring season on the Refuge.

2011 Coyote diet study

See Appendix Q for a report.

2012 Nest Predator Report

See Appendix R for a report.

Analysis of 1993 waterfowl nesting production study data

See Appendix S for a report.

2012 waterfowl nesting production study

See Appendix T for a report.

Least Chub Survey

In 2011 and 2012, UDWR staff conducted surveys for least chub on the Refuge at sites of past repatriation efforts and found no least chub present.

V. Unmet Habitat Needs.

Some of the most urgent needs for information to better assess current habitat management and priorities, as useful for HMP development, include:

- *Identifying causes of poor waterfowl production, including impacts of nest predation, in order to better assess the role of waterfowl production as a priority.*

- *Assess the relationship of site-specific water management to water quality and production of aquatic macroinvertebrate foods used by priority ROC species of the HMP.*

- *Better identify site-specific habitat uses by priority ROC selected in the HMP development process.*

VI. Strategies to Achieve Unmet Habitat Needs.

Identifying causes of poor waterfowl production, including impacts of nest predation, in to better assess the role of waterfowl production as a priority:

- In 2013, we will conduct an additional waterfowl production study to assess whether or not the poor reproductive results of the 2012 study were an anomaly.

- In 2013, we will also continue the coyote population index (scat survey), and in future years, we need to more fully assess actual coyote population numbers.

- In 2013, we will also continue our nest predator inventory with a more comprehensive effort. If time warrants, we will follow the fates of nests as part of this effort, preferably those of priority ROC species.

Assess the relationship of site-specific water management to water quality and production of aquatic invertebrate foods used by priority ROC species of the HMP.

- Continue long-term to monitor site-specific water use and water quality. In 2013 initiate study of aquatic invertebrates (inventory and seasonal production) with priority given to the northernmost impoundments, where the most altered water management prescriptions are proposed for providing seasonal mudflat shoreline habitats, and where invertebrate information is most lacking. In future years, pursue information on aquatic invertebrates in expanses of seasonally-flooded saltgrass, where information is also lacking; plus contribute to the current knowledge base on aquatic invertebrate production in the southern pools managed as semi-permanent wetlands.

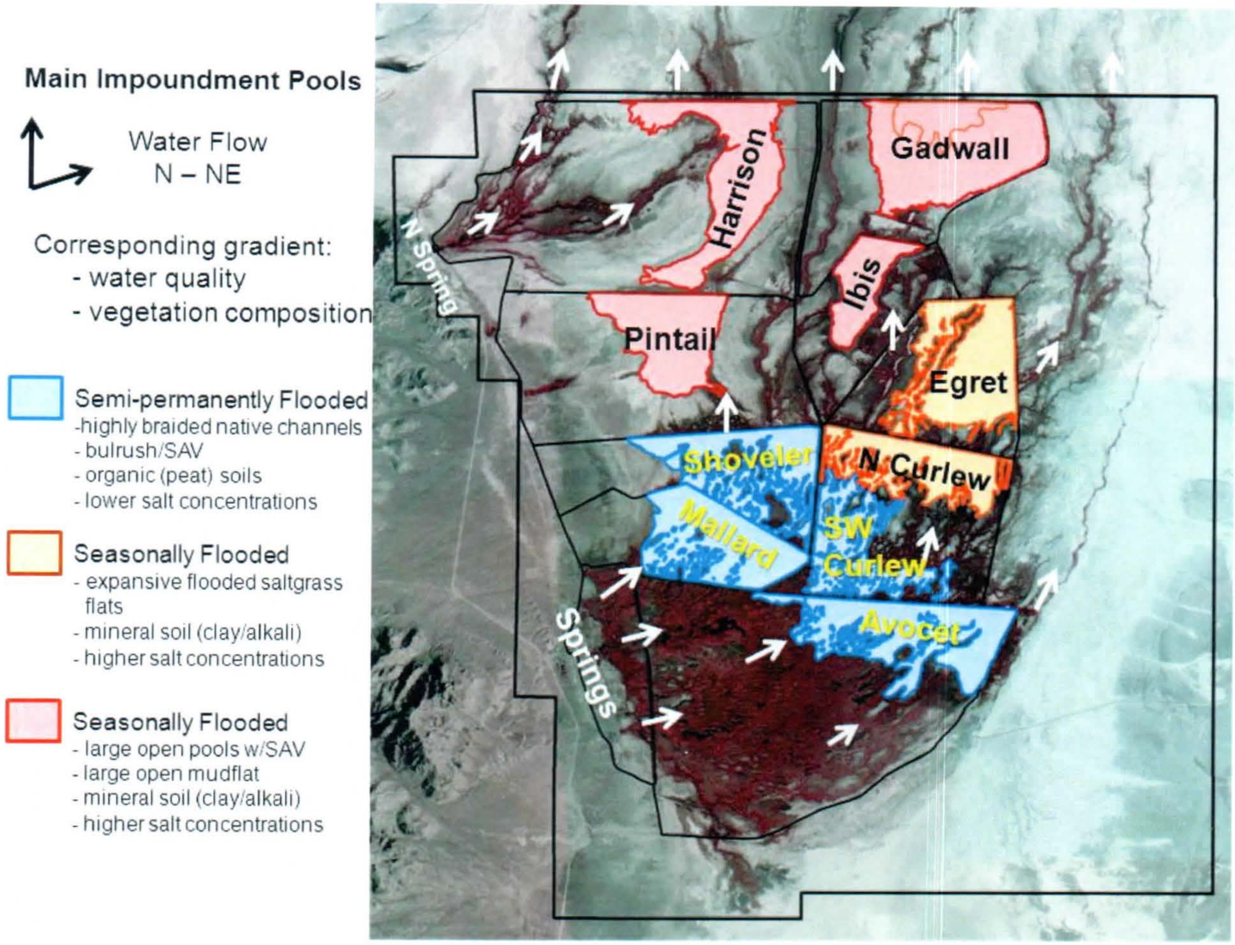
Better identify site-specific habitat uses by priority ROC selected in the HMP development process.

- In 2013, and long-term, continue special SNPL surveys, both for foraging use and nesting activity. In 2013, continue special-targeted bird surveys identifying location and habitat use for selected priority ROC species (long-billed curlew, American avocet, and white-faced ibis.

VII. Management Strategy Prescriptions.

In this section, we are to identify specific management strategy prescriptions from the HMP that will occur in the coming year. This report is transitioning to the HMP from the CCP's amended goals and revised objectives.

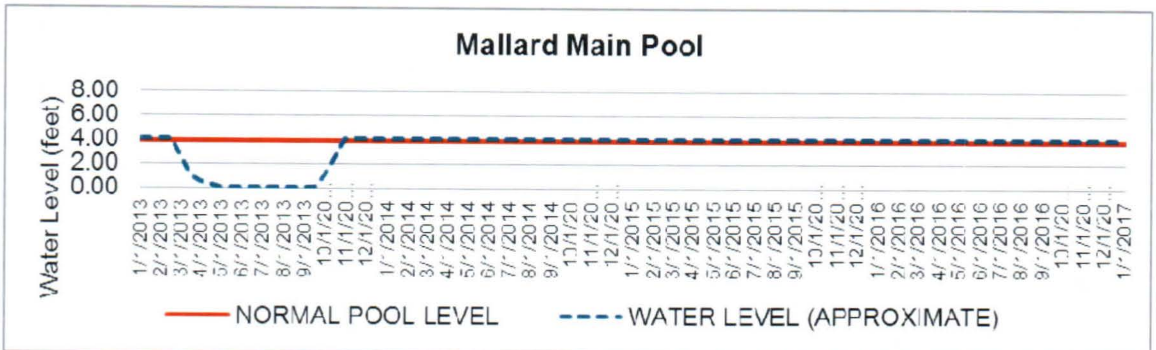
The HMP uses area-specific water management strategies to benefit targeted priority ROC (see following diagram).

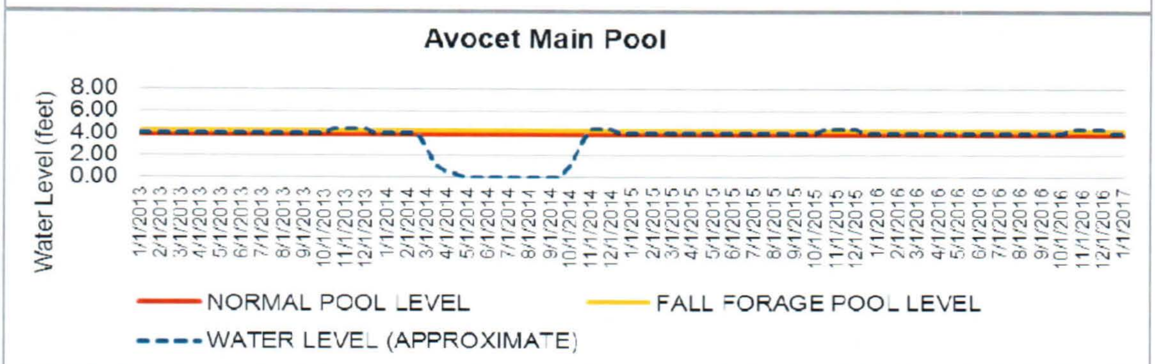


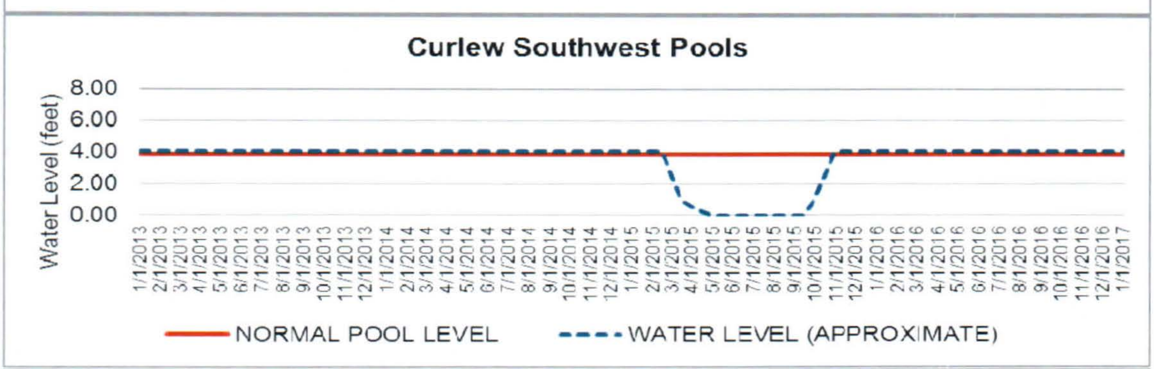
Areas not colored on the above diagram (still under construction) will be substantially managed as seasonally flooded wetlands. Exceptions incude: Spring basins; Disabled hunter hunt blind ponds (Avocet Unit); upstream portions of channel braids extending dowstream from North Spring.

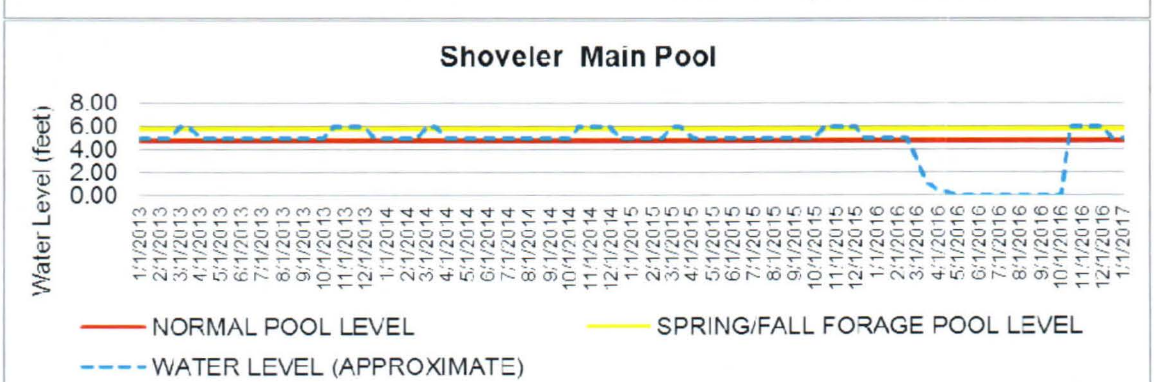
Semi-permanently flooded wetland objective-

This objective will involve the main impoundment pools of Mallard, Shoveler, SW Curlew, and Avocet. Additionally, there will be smaller semi-permanently flooded impoundments maintained, such as the disabled hunter hunt area ponds and the upper portions of braided channels flowing downstream from North Spring (not included on diagram). The four main impoundments of Mallard, Shoveler, SW Curlew, and Avocet will be fully impounded 3 out of 4 years, with a single unit fully drawn down rotationally each year. In 2013, Mallard will be scheduled for drawdown. The impounded pools will be maintained at long-existing "optimum pool" water levels to support emergent marshlands and the production of SAV for use by targeted priority ROC species. Only selected sites can be maintained ice free in winter. However, due to ongoing Phragmites control, and additional needs for repairs to the water delivery system, Shoveler will also be drawn down in 2013. The water levels of the dewatered pools will be reduced over a prolonged timeframe from as early as mid-February to as late as early June before going fully dry. Target "Trust" resources include breeding, migrating, and wintering migratory birds. For the impounded pools, the priority ROC include American bittern, American wigeon, gadwall, northern pintail, redhead, tundra swan (winter), Virginia rail, and white-faced ibis. The dewatered pools will support the additional priority ROC species, long-billed curlew, long-billed dowitcher, and snowy plover. Hydrographs of specific water management strategies follow for years 2013-16. Water levels are staff gauge readings of the individual pools.









Seasonally flooded wetland objective-

This objective involves all remaining areas of refuge wetlands. These seasonal wetlands are divided further into three defined types of areas (see diagram above) as detailed following:

The main impoundment pools of Pintail, Harrison, Ibis, and Gadwall are large expansive open pools that will have water managed on a 2-year drawdown rotation. This water prescription provides seasonal mudflat shoreline habitat using partial drawdowns, as well as maintaining seasonal expanses of open water. Each year, two pools are scheduled for partial drawdown, including Harrison and Pintail for 2013. The other two impoundments each year will have water levels maintained for as long as possible through summer (Pintail or Ibis), providing vegetated shorelines and SAV production until eventually drying down. In 2013 the pool with priority water maintenance will be Ibis. One of the other two pools (Gadwall or Harrison) will sufficiently evaporate down (without prescribed drawdown) to provide additional mudflat shoreline habitat for late-season (August) shorebird uses; in 2013 this pool will be Gadwall. As such, three of these four pools in 2013 (Harrison, Pintail, and Gadwall) will provide continuous mudflat shoreline habitat, in a step-wise fashion, from spring migration season through the breeding season into early fall migration season of shorebirds. Target priority ROC include snowy plover, American avocet, and long-billed curlew. Other notable non-priority species to receive beneficial uses will include black-necked stilt, willet, Wilson's phalarope, and waterfowl. Target priority ROC for the pools maintained full for as long as possible include American wigeon, gadwall, long-billed curlew, northern pintail, redhead, and white-faced ibis. Notable non-priority species include black-necked stilt, willet, Wilson's phalarope, eared grebe, other waterfowl species, and +/- 1,000 wing molting Canada geese. Hydrographs of specific water management strategies for all four pools follow. Other water management details are based on SNPL monitoring results from 2010-12.

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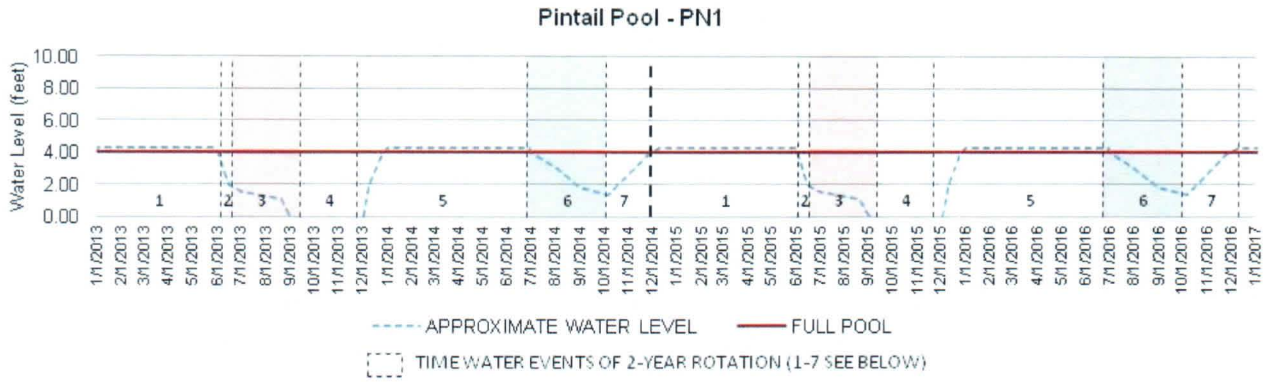
Pintail Pool – planned water management
2-year water rotation (2013-2016)



2013/14 - Timed Events (1-7):

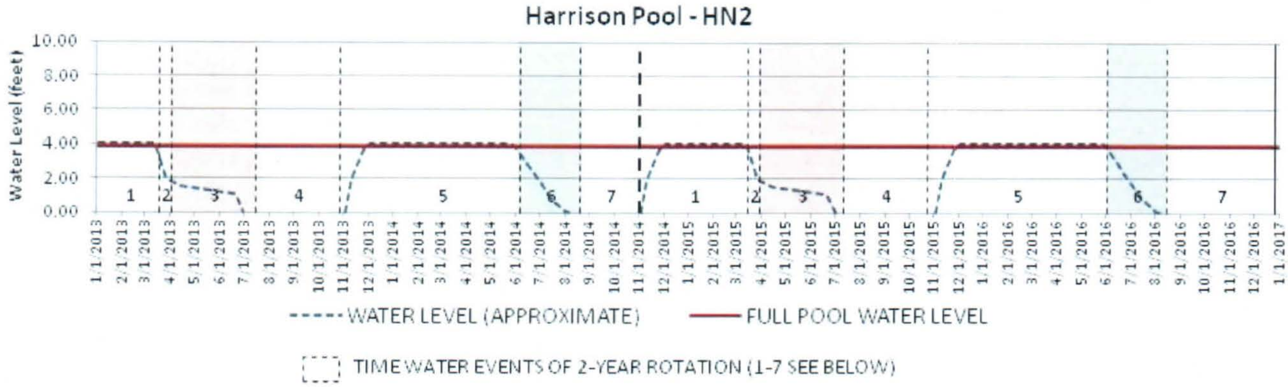
1. Water restored and held near full pool (4.66 feet on staff gauge of WCS GN2).
2. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
3. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
4. Pool area fully dry.
5. Water restored and held at maximum level (water surplus period).
6. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
7. Water restored to full pool (water surplus period).

2015/16 - Repeat Timed Events (1-7):

1. Water held near full pool (4.66 feet on staff gauge of WCS GN2).
2. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
3. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
4. Pool area fully dry.
5. Water restored and held at maximum level (water surplus period).
6. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
7. Water restored to full pool (water surplus period).

(Repeat timed events 1-7 for years 2017-18, 2019-20, 2021-22, etc.)

Harrison Pool – planned water management
2-year water rotation (2013-2016)



2013/14 - Timed Events (1-7):

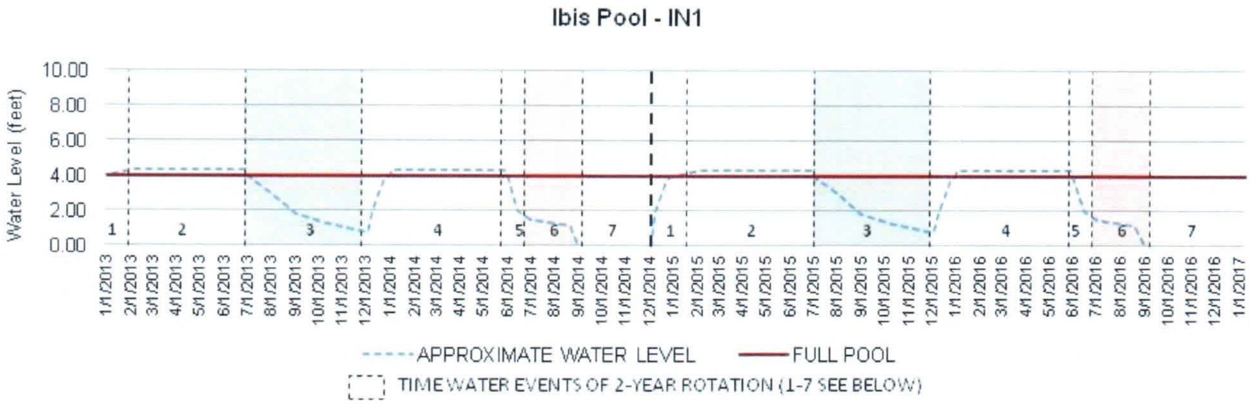
8. Water level restored and held near full pool (3.80 feet on staff gauge of WCS HN2).
9. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
10. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
11. Pool area fully dry.
12. Water level restored and held at full pool (water surplus period).
13. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
14. Pool area fully dry.

2015/16 - Repeat Timed Events (1-7):

1. Water level restored and held near full pool (3.80 feet on staff gauge of WCS HN2).
2. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
3. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
4. Pool area fully dry.
5. Water level restored and held at full pool (water surplus period).
6. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
7. Pool area fully dry.

(Repeat timed events 1-7 for years 2017-18, 2019-20, 2021-22, etc.)

Ibis Pool – planned water management
2-year water rotation (2013-2016)



2013/14 - Timed Events (1-7):

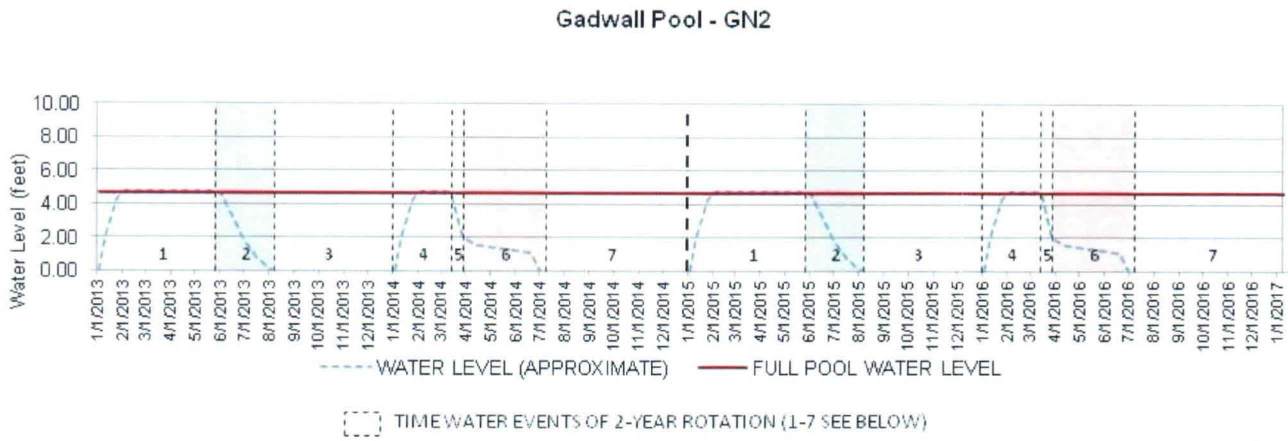
15. Water level restored to full pool (3.80 feet on staff gauge of WCS HN2).
16. Water level held at full pool (water surplus period).
17. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
18. Water level held at full pool (water surplus period).
19. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
20. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
21. Pool area fully dry.

2015/16 - Repeat Timed Events (1-7):

1. Water level restored to full pool (3.80 feet on staff gauge of WCS HN2).
2. Water level held at full pool (water surplus period).
3. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
4. Water level held at full pool (water surplus period).
5. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
6. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
7. Pool area fully dry.

(Repeat timed events 1-7 for years 2017-18, 2019-20, 2021-22, etc.)

Gadwall Pool – planned water management
2-year water rotation (2013-2016)



2013/14 - Timed Events (1-7):

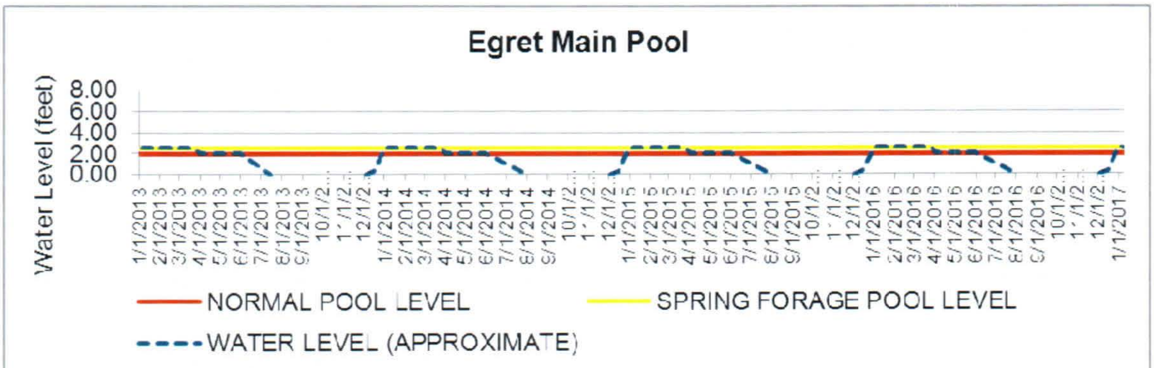
22. Water restored and held near maximum level (4.66 feet on staff gauge of WCS GN2).
23. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
24. Pool area fully dry.
25. Water restored and held at maximum level (water surplus period).
26. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
27. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
28. Pool area fully dry.

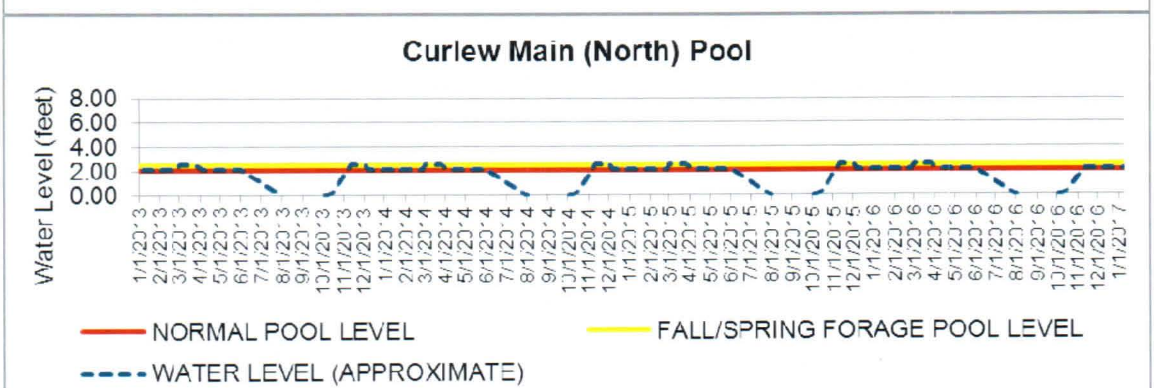
2015/16 - Repeat Timed Events (1-7):

1. Water restored and held near maximum level (4.66 feet on staff gauge of WCS GN2).
2. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). ***Late-season mudflat-shoreline habitat for use by foraging SNPL.***
3. Pool area fully dry.
4. Water restored and held at maximum level (water surplus period).
5. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
6. ***Early-season mudflat-shoreline habitat for use by foraging SNPL.***
7. Pool area fully dry.

(Repeat timed events 1-7 for years 2017-18, 2019-20, 2021-22, etc.)

The main impoundment pools of Egret and North Curlew will provide expansive areas of saltgrass to be flooded on a seasonal basis. Annually, both pools will be partially drawn down in spring from long-established "optimum pool" (full) pool levels and then allowed to evaporate dry in summer. This prescription will provide large expanses of flooded saltgrass from Fall to early Spring, with reduced flooding throughout the growing season in order to best support saltgrass production. In addition, avian foraging and nesting activities within the salt grass stands will be better supported by the seasonally changing pool levels. Aquatic macroinvertebrate production will be maintained though relatively shorter, but annual, dry cycles. Incidental to this water management, open water and production of SAV will also be provided. Target priority ROC species include long-billed curlew, white-faced ibis, and northern pintail. Other priority waterfowl species and non-priority species will also benefit, such as American wigeon, gadwall, redhead, willet and black-necked stilt. Hydrographs of specific water management strategies for both pools follow for years 2013-16.





Remaining seasonal wetlands (uncolored areas on the above diagram) are made up of native channel braids that fall outside of the main impoundment pools. These areas will be flooded and flushed from Fall through Spring. Water flows will cease by June allowing the areas to go dry during summer. All priority ROC waterbird species will be supported by this management. Charts detailing water management are not provided.

Invasive and pest species management:

In 2013, the second treatment of initial control efforts for Phragmites will be completed in Pintail and Shoveler units. Additionally the first treatment will be completed in Mallard unit. Experimental cattail control will be continued in Shoveler and Avocet units. Perennial pepperweed control efforts will be focused in Pintail, Shoveler, and Mallard. More widespread control will be considered based on need and time available. Traditional knapweed sites will be assessed and treated. Searching will be conducted to locate new infestations and treated as necessary. Tamarisk will be searched and treated Refuge-wide. Updating will be completed to the RLGIS database.

Other management strategies:

Artificial nesting enhancements will be assessed for possible implementation within Harrison unit for snowy plover and American avocet. The need for saltgrass control will be assessed in Harrison Pool in support of maintaining mudflat shoreline habitat. Maintenance and improvement to infrastructure for the water delivery system will be performed in Shoveler unit, Mallard unit, and possibly Walter Spring in Pintail Unit.

VIII. Create Management Strategy Documents File.

In this section we are to identify specific management strategy documents from the HMP, and to include as necessary, for each management action: necessary resources; documentation of special uses; documentation of compliance; and RONS or other budgetary requests.

NEPA, sec-7 ESA, and other environmental compliance are on file in the refuge manager's office. State permits for fieldwork are on file in the wildlife biologist's office. See Appendix U for the 2012 NVCS mapping project status report to the I&M team.

IX. Appendices A through V.

Appendix A.
Policy compliance issues identified with the CCP

The CCP lists two goals to meet "Ecological Integrity Management Direction"— an "overall goal" to provide habitat for maximum wildlife diversity and a "specific goal" for restoring Harrison Unit to a braided marsh to mimic historical conditions. Developing a HMP is the sole objective listed for achieving the "overall goal" of providing habitat for maximum wildlife diversity. The CCP says to focus refuge management on providing habitat for maximum wildlife diversity, and to give priority to species other than migratory birds that have not been fully integrated into management efforts.

There are some substantial issues involved with this management direction that need discussed (refer to 601 FW 3, 620 FW 1 and 702 FW 2).

One key issue is that managing for "maximum wildlife diversity" as outlined in the CCP goes strictly against policy for maintaining or restoring the biological integrity, diversity, and environmental health of the refuge. As stated in policy, "[m]aintaining or restoring biological integrity is not the same as maximizing biological diversity. Maintaining biological integrity may entail managing for a single species or community at some refuges and combinations of species or communities at other refuges. For example, a refuge may contain critical habitats for an endangered species. Maintaining that habitat (and, therefore, that species), even though it may reduce biological diversity at the refuge scale, helps maintain biological integrity and diversity at the ecosystem or national landscape scale" (601 FW 3.10.A.(3)).

Another key issue with this CCP direction is that Refuge purposes are clearly stated " . . . for use as an inviolate sanctuary, or for any other management purpose, for migratory birds" (16 U.S.C. 715d). "The Refuge Administration Act states that each refuge will be managed to fulfill refuge purpose(s) as well as to help fulfill the System mission, and we will accomplish these purpose(s) and our mission by ensuring that the biological integrity, diversity, and environmental health of each refuge are maintained, and where appropriate, restored" (601 FW 3.7.B). Establishing an "overall goal" to manage for a maximum of species and giving priority to a maximum number of species other than migratory birds is clearly in conflict with Refuge purposes and the System mission. By policy, "Resources of Concern are the primary focus of the HMP" (620 FW 1). We are to identify priority refuge plant and animal species, species groups, and communities specifically identified in refuge purpose(s), System mission, or international, national, regional, State, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect "migrating waterfowl and shorebirds." Federal or State threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts (620 FW 1). Inventory and monitoring emphasis should be on species or groups of species of critical management importance as they relate to management of Service units and Federal trust species (702 FW 2).

The two preceding issues were addressed by the refuge manager with the refuge supervisor during and after a regional review of the station. A determination was made by the refuge supervisor that successfully benefitting one species on the Refuge, such as re-establishing least chub (currently a Candidate species), would be a fully adequate current effort in contributing to diversity.

Additionally, there are some issues with the restoration of Harrison Marsh as outlined in the CCP. The proposed restoration was another topic of discussion during a regional station review conducted in March 2010. The consensus formed by refuge staff and the reviewing team was that the stated restoration effort is too focused on outcomes that do not provide ample consideration to refuge purpose(s). This restoration effort would have an overall detrimental outcome to migratory birds, as it would reduce avian diversity at the refuge-sale, and it provides no stated consideration to avian diversity at landscape scales. Further, the refuge staff and the reviewing team felt that there were too many existing alterations to natural conditions to overcome, such as the substantial loss of peat soils from burning, the excavation of "nesting potholes and other water delivery alterations, and the detrimental influences of exotic plant and animal species. Therefore, this proposal is viewed as too detrimental to refuge purposes and not fully compliant with policy for maintaining or restoring the biological integrity, diversity, and environmental health of the refuge. By policy, "[i]n deciding which management activities to conduct to accomplish refuge purpose(s) while maintaining biological integrity, we start by considering how the ecosystem functioned under historic conditions" (601 FW 3.10A(4)). "We strive to manage in a holistic manner the combination of biological integrity, diversity, and environmental health. We balance all three by considering refuge purpose(s), System mission, and landscape scales. Considered independently, management strategies to maintain and restore biological integrity, diversity, and environmental health may conflict" (601 FW 3.11.A.).

Furthermore, "[w]e may find it necessary to modify the frequency and timing of natural processes at the refuge scale to fulfill refuge purpose(s) or to contribute to biological integrity at larger landscape scales' (601 FW 3.10.A.5). ". . . [P]hysical structures and chemical applications are often necessary to maintain biological integrity and to fulfill refuge purpose(s). We may use dikes and water control structures to maintain and restore natural hydrological cycles [or in our case to create beneficial cycles], or use rotenone to eliminate invasive carp [in our case mosquito fish] from a pond. These unnatural physical alterations and chemical applications would compromise environmental health if considered in isolation, but they may be appropriate management actions for maintaining biological integrity and accomplishing refuge purpose(s)" (601 FW 3.11.B).

Similar discussion is provided in the HMP.

Appendix B.

2010 Phragmites mapped and treated areas and monitoring results

Refuge-wide *Phragmites* mapping will be made available in 2013 as part of the NVCS mapping effort initiated in 2011.

OVERALL TOTALS:

- Acres Dense: 46.30
- Acres Sparse: 51.93
- Total Acres phrag: 98.23
- Acres Dense Treated: 38.48
- Treated with: aquatic glyphosate @ 3 % solution or 3 qts/acre

(Due to rounding and possible missed pieces when selecting, may not add up to overall total which was taken in RLGIS)

Curlew Unit

- Acres Dense: 37.95
- Acres Sparse: 39.81
- Total Acres phrag: 77.76
- Acres Dense Treated: 31.10
- Treated with: aquatic glyphosate @ 3 % solution or 3 qts/acre

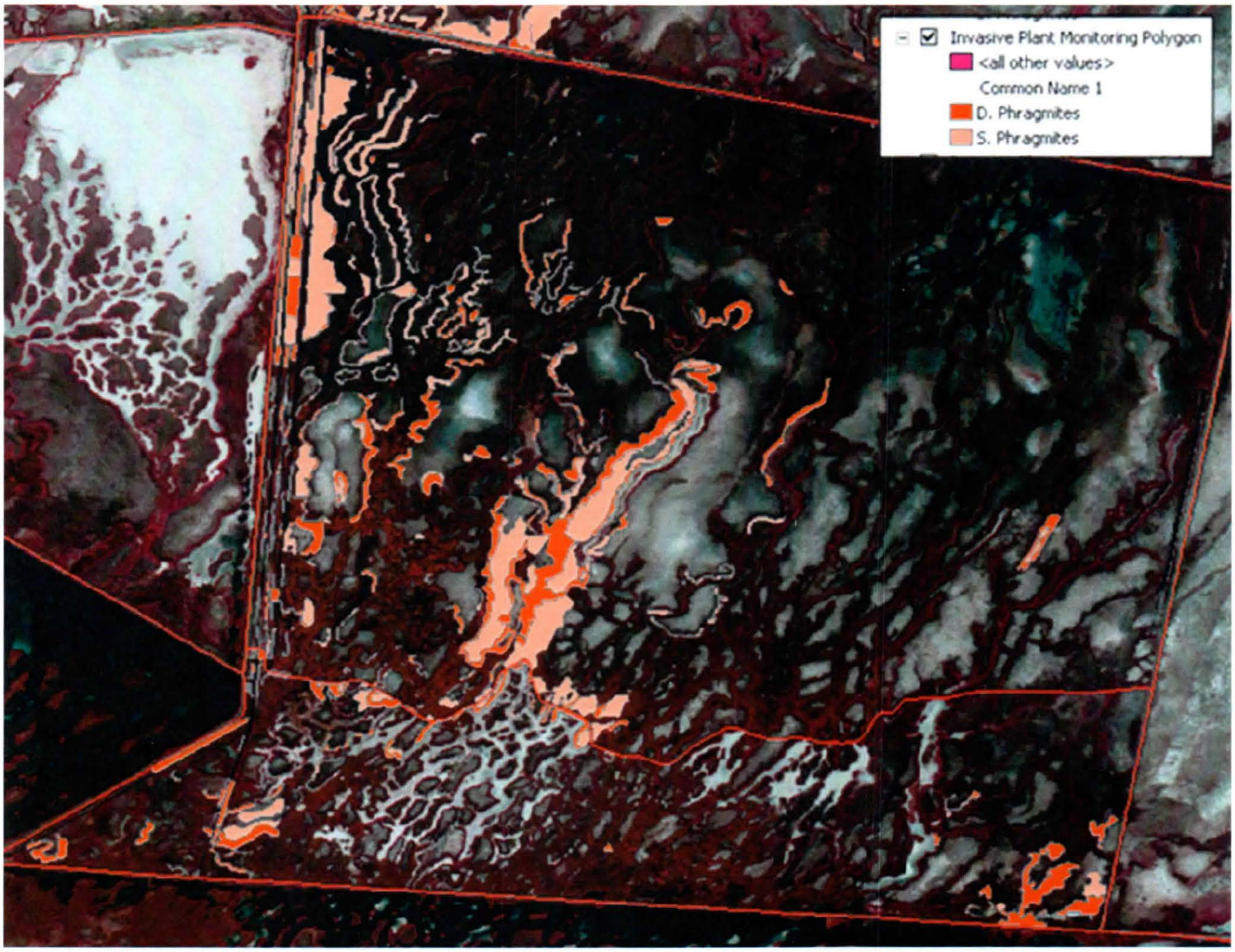
Egret Unit

- Acres Dense: 5.10
- Acres Sparse: 8.42
- Total Acres phrag: 13.52
- Acres Dense Treated: 4.74
- Treated with: aquatic glyphosate @ 3 % solution or 3 qts/acre

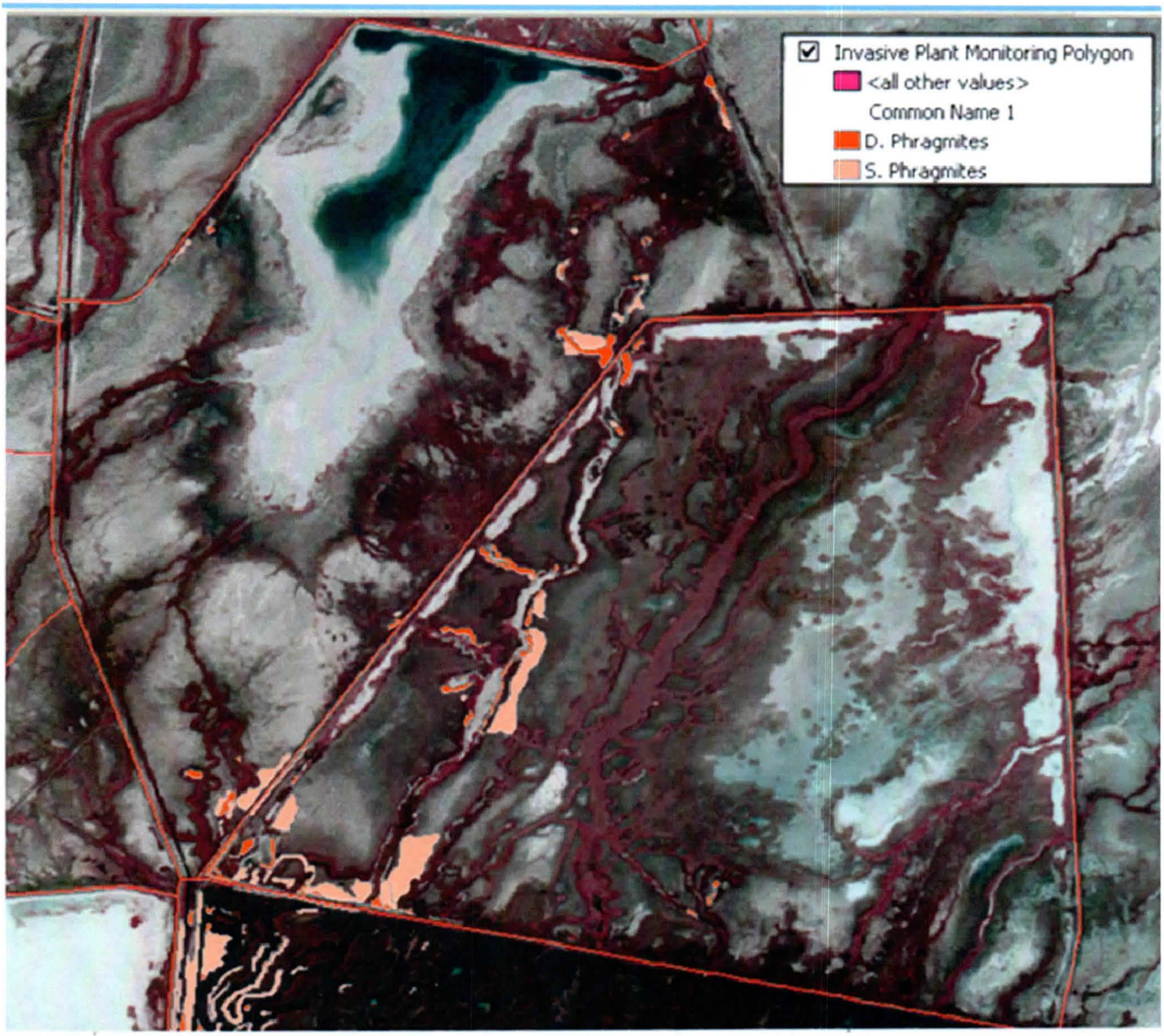
Ibis Unit

- Acres Dense: 2.23
- Acres Sparse: 3.70
- Total Acres phrag: 5.93
- Acres Dense Treated: 2.21
- Treated with: aquatic glyphosate @ 3 % solution or 3 qts/acre

Phragmites mapped in Curlew 2010



Phragmites mapped in Egret and Ibis 2010



2010 Phragmites Monitoring Results

Strata	ID	Date	Year	Frame	area in sq ft	Live Stems	stems per sq ft	Observers
Sparse Treated Meadow	1	10/3/2010	2010	1MX1M	10.8	20	1.851851852	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	2	10/3/2010	2010	1MX1M	10.8	23	2.12962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	3	10/3/2010	2010	1MX1M	10.8	21	1.944444444	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	4	10/3/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	5	10/3/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	6	10/3/2010	2010	1MX1M	10.8	7	0.648148148	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	7	10/3/2010	2010	1MX1M	10.8	11	1.018518519	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	8	10/3/2010	2010	1MX1M	10.8	6	0.555555556	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	9	10/3/2010	2010	1MX1M	10.8	17	1.574074074	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow	10	10/3/2010	2010	1MX1M	10.8	5	0.462962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Treated Meadow					108	126	1.166666667	
Sparse Control Shoreline	1	10/3/2010	2010	1MX1M	10.8	10	0.925925926	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	2	10/3/2010	2010	1MX1M	10.8	23	2.12962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	3	10/3/2010	2010	1MX1M	10.8	7	0.648148148	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	4	10/3/2010	2010	1MX1M	10.8	1	0.092592593	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	5	10/3/2010	2010	1MX1M	10.8	9	0.833333333	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	7	10/3/2010	2010	1MX1M	10.8	9	0.833333333	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	8	10/3/2010	2010	1MX1M	10.8	27	2.5	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	9	10/3/2010	2010	1MX1M	10.8	7	0.648148148	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	10	10/3/2010	2010	1MX1M	10.8	11	1.018518519	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	11	10/3/2010	2010	1MX1M	10.8	10	0.925925926	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	12	10/3/2010	2010	1MX1M	10.8	6	0.555555556	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	13	10/3/2010	2010	1MX1M	10.8	5	0.462962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	14	10/3/2010	2010	1MX1M	10.8	4	0.37037037	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	15	10/3/2010	2010	1MX1M	10.8	10	0.925925926	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	16	10/3/2010	2010	1MX1M	10.8	5	0.462962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	17	10/3/2010	2010	1MX1M	10.8	24	2.222222222	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	18	10/3/2010	2010	1MX1M	10.8	12	1.111111111	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	20	10/3/2010	2010	1MX1M	10.8	55	5.092592593	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	22	10/3/2010	2010	1MX1M	10.8	3	0.277777778	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	23	10/3/2010	2010	1MX1M	10.8	43	3.981481481	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	25	10/3/2010	2010	1MX1M	10.8	21	1.944444444	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	28	10/3/2010	2010	1MX1M	10.8	25	2.314814815	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	29	10/3/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME

Sparse Control Shoreline	30	10/3/2010	2010	1MX1M	10.8	24	2.222222222	T.DOLGOFF, R.ORME, T.ORME
Strata	**ID**	**Date**	**Year**	**Frame**	**area in sq ft**	**Live Stems**	**stems per sq ft**	**Observers**
Sparse Control Shoreline	31	10/3/2010	2010	1MX1M	10.8	13	1.203703704	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	32	10/3/2010	2010	1MX1M	10.8	4	0.37037037	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	34	10/3/2010	2010	1MX1M	10.8	30	2.777777778	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	35	10/3/2010	2010	1MX1M	10.8	9	0.833333333	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	37	10/3/2010	2010	1MX1M	10.8	25	2.314814815	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	38	10/3/2010	2010	1MX1M	10.8	3	0.277777778	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	39	10/3/2010	2010	1MX1M	10.8	3	0.277777778	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	40	10/3/2010	2010	1MX1M	10.8	3	0.277777778	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	41	10/3/2010	2010	1MX1M	10.8	3	0.277777778	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	43	10/3/2010	2010	1MX1M	10.8	4	0.37037037	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	44	10/3/2010	2010	1MX1M	10.8	5	0.462962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	45	10/3/2010	2010	1MX1M	10.8	12	1.111111111	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	46	10/3/2010	2010	1MX1M	10.8	33	3.055555556	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	48	10/3/2010	2010	1MX1M	10.8	15	1.388888889	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	49	10/3/2010	2010	1MX1M	10.8	4	0.37037037	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline	50	10/3/2010	2010	1MX1M	10.8	14	1.296296296	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Shoreline					432	539	1.247685185	
Sparse Control Meadow	1	10/3/2010	2010	1MX1M	10.8	20	1.851851852	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	2	10/3/2010	2010	1MX1M	10.8	5	0.462962963	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	3	10/3/2010	2010	1MX1M	10.8	15	1.388888889	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	4	10/3/2010	2010	1MX1M	10.8	10	0.925925926	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	5	10/3/2010	2010	1MX1M	10.8	9	0.833333333	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	6	10/3/2010	2010	1MX1M	10.8	4	0.37037037	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	7	10/3/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	8	10/3/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	9	10/3/2010	2010	1MX1M	10.8	10	0.925925926	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow	10	10/3/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME
Sparse Control Meadow					108	97	0.898148148	
Dense Control	1	10/2/2010	2010	1MX1M	10.8	18	1.666666667	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	3	10/2/2010	2010	1MX1M	10.8	87	8.055555556	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	5	10/2/2010	2010	1MX1M	10.8	61	5.648148148	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	6	10/2/2010	2010	1MX1M	10.8	61	5.648148148	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN

Dense Control	7	10/2/2010	2010	1MX1M	10.8	8	0.740740741	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	8	10/2/2010	2010	1MX1M	10.8	11	1.018518519	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Strata	**ID**	**Date**	**Year**	**Frame**	**area in sq ft**	**Live Stems**	**stems per sq ft**	**Observers**
Dense Control	9	10/2/2010	2010	1MX1M	10.8	16	1.481481481	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	11	10/2/2010	2010	1MX1M	10.8	142	13.14814815	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	12	10/2/2010	2010	1MX1M	10.8	53	4.907407407	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	13	10/2/2010	2010	1MX1M	10.8	101	9.351851852	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	15	10/2/2010	2010	1MX1M	10.8	75	6.944444444	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	17	10/2/2010	2010	1MX1M	10.8	90	8.333333333	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	18	10/2/2010	2010	1MX1M	10.8	22	2.037037037	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	19	10/2/2010	2010	1MX1M	10.8	22	2.037037037	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control	20	10/2/2010	2010	1MX1M	10.8	32	2.962962963	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Control					162	799	4.932098765	
Dense Treated	1	10/2/2010	2010	1MX1M	10.8	92	8.518518519	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	2	10/2/2010	2010	1MX1M	10.8	64	5.925925926	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	3	10/2/2010	2010	1MX1M	10.8	91	8.425925926	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	4	10/2/2010	2010	1MX1M	10.8	60	5.555555556	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	5	10/2/2010	2010	1MX1M	10.8	12	1.111111111	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	6	10/2/2010	2010	1MX1M	10.8	95	8.796296296	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	7	10/2/2010	2010	1MX1M	10.8	142	13.14814815	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	8	10/2/2010	2010	1MX1M	10.8	112	10.37037037	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	10	10/2/2010	2010	1MX1M	10.8	60	5.555555556	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	12	10/2/2010	2010	1MX1M	10.8	98	9.074074074	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	13	10/2/2010	2010	1MX1M	10.8	119	11.01851852	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	14	10/2/2010	2010	1MX1M	10.8	127	11.75925926	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	15	10/2/2010	2010	1MX1M	10.8	39	3.611111111	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	17	10/2/2010	2010	1MX1M	10.8	19	1.759259259	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	18	10/2/2010	2010	1MX1M	10.8	125	11.57407407	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	19	10/2/2010	2010	1MX1M	10.8	85	7.87037037	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	22	10/2/2010	2010	1MX1M	10.8	182	16.85185185	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	23	10/2/2010	2010	1MX1M	10.8	56	5.185185185	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	24	10/2/2010	2010	1MX1M	10.8	30	2.777777778	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	25	10/2/2010	2010	1MX1M	10.8	41	3.796296296	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	26	10/2/2010	2010	1MX1M	10.8	64	5.925925926	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	27	10/2/2010	2010	1MX1M	10.8	136	12.59259259	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN

Dense Treated	28	10/2/2010	2010	1MX1M	10.8	39	3.611111111	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	29	10/2/2010	2010	1MX1M	10.8	47	4.351851852	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	30	10/2/2010	2010	1MX1M	10.8	180	16.66666667	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Strata	**ID**	**Date**	**Year**	**Frame**	**area in sq ft**	**Live Stems**	**stems per sq ft**	**Observers**
Dense Treated	31	10/2/2010	2010	1MX1M	10.8	84	7.777777778	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	32	10/2/2010	2010	1MX1M	10.8	108	10	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	33	10/2/2010	2010	1MX1M	10.8	65	6.018518519	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	35	10/2/2010	2010	1MX1M	10.8	50	4.62962963	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	36	10/2/2010	2010	1MX1M	10.8	59	5.462962963	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	37	10/2/2010	2010	1MX1M	10.8	90	8.333333333	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	38	10/2/2010	2010	1MX1M	10.8	35	3.240740741	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	39	10/2/2010	2010	1MX1M	10.8	71	6.574074074	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	40	10/2/2010	2010	1MX1M	10.8	127	11.75925926	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	41	10/2/2010	2010	1MX1M	10.8	34	3.148148148	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	43	10/2/2010	2010	1MX1M	10.8	192	17.77777778	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	44	10/2/2010	2010	1MX1M	10.8	128	11.85185185	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	47	10/2/2010	2010	1MX1M	10.8	40	3.703703704	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	48	10/2/2010	2010	1MX1M	10.8	48	4.444444444	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated	50	10/2/2010	2010	1MX1M	10.8	108	10	T.DOLGOFF, R.ORME, T.ORME, B.ALLEN
Dense Treated					432	3354	7.763888889	

Appendix C.

2010 Avocet Unit Phragmites test plot

Phragmites / Vegetation Transect Protocol

Data / transects are in invasives_monitoring_points and invasives_monitoring_lines as dense Phragmites

Equipment:

- String or rope ten meters in length with two pieces of rebar tied to the ends for handles.
- Two PVC poles around twenty feet in length with red paint and flagging tape on one end.
- One three foot PVC pipe with a PVC pipe attached to the side that is a half meter in length.
- Mark the side PVC pipe at the 0.25 meter mark.
- Data sheets, Pencil, Pictures of plants found in past recordings, and a clipboard.

Methods:

1) Preferably work in a group of three people.
2) Slide one of the 20 ft poles on the first transect post on the south west end of the transect plot.
3) Slide the next 20ft pole on the second transect post on the north west end of the transect plot.
4) Start work at the first post, NW corner of the transect plot. Work north to south on the first one. This is transect number one.
5) Have the first person hold the line at the first post.
6) The second person walks and pulls out the length of the line.
7) The Third person stands behind the first person and lines the first and second person with the 20ft pole marking the other end of the transect.
8) When the third person confirms that the string is lined up with the far 20ft pole, have the second person mark the location. They can mark it by placing the rebar into the ground.

9) The first person walks up to the marked location and places the three foot PVC pipe in the exact spot. It can be slide onto the rebar.

10) The first person then spins the pole and states what living vegetation is found under the pipe and states whether it is within the 0.25 or the 0 .5 meter mark.
11) Note: If plant is unknown, take a picture or a sample to identify it later. Record it as unk #__.

12) The third person then records the data on the data sheets as present or absent. Using a 1 for present and a 0 for absent.
13) Record the present vegetation when in the field. Absent can be filled in later.

14) Repeat steps 6-12 for each 10 meter reading / sampling point. (There will be 31 points on some and fewer on others)

15) Once the first transect is finished, move the 20ft pole to the third post. This will be to complete the 3rd transect North to South.

16) Then go to the second post on the south west side of the transect plot and repeat steps 5-12 going South to North.

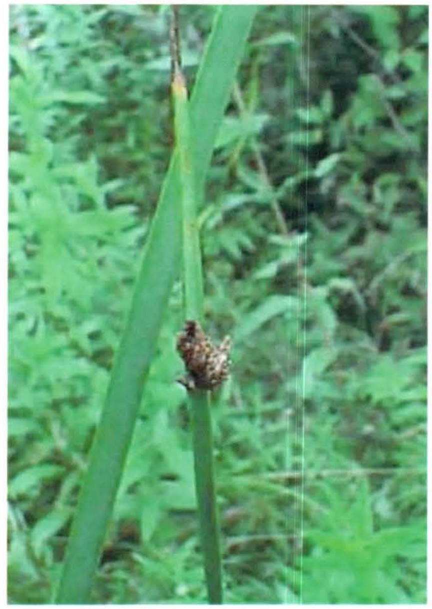
17) Note: you will always be headed towards an even numbered post with the 20ft pole on it when traveling north; and an odd numbered post when traveling south.

18) Note: Every time a transect is completed you will be moving the 20ft pole two posts down.

19) After completion of the all the transects, enter the recorded data into the database on the computer. Data sheets and a summary sheet will be put into the binder.

Avocet Test Plot Plants

Alkali Bulrush



Olneys Bulrush

Nevada Bulrush

Baltic Wire Rush

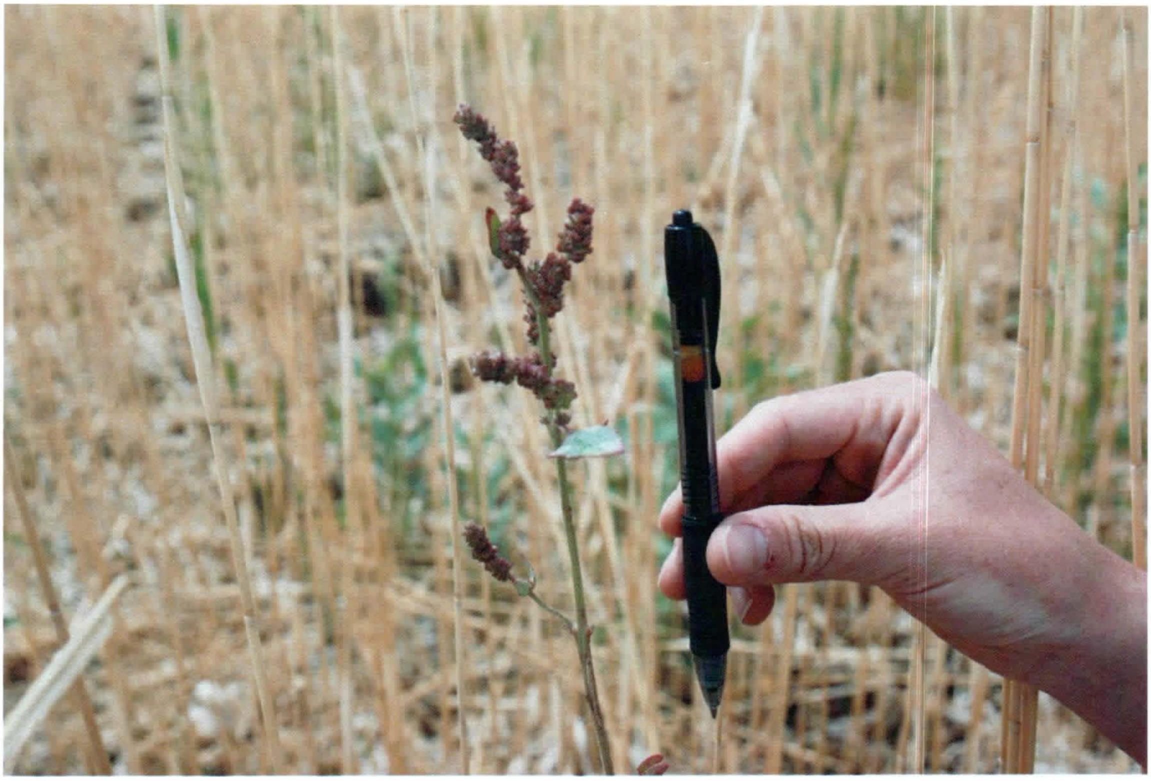
Spike Rush

Rabbits Foot

White Clover

Switch Grass

Maple leaf Goosefoot


Spearscale


Milkweed

Unknown #9

Unknown #11

Unknown #10

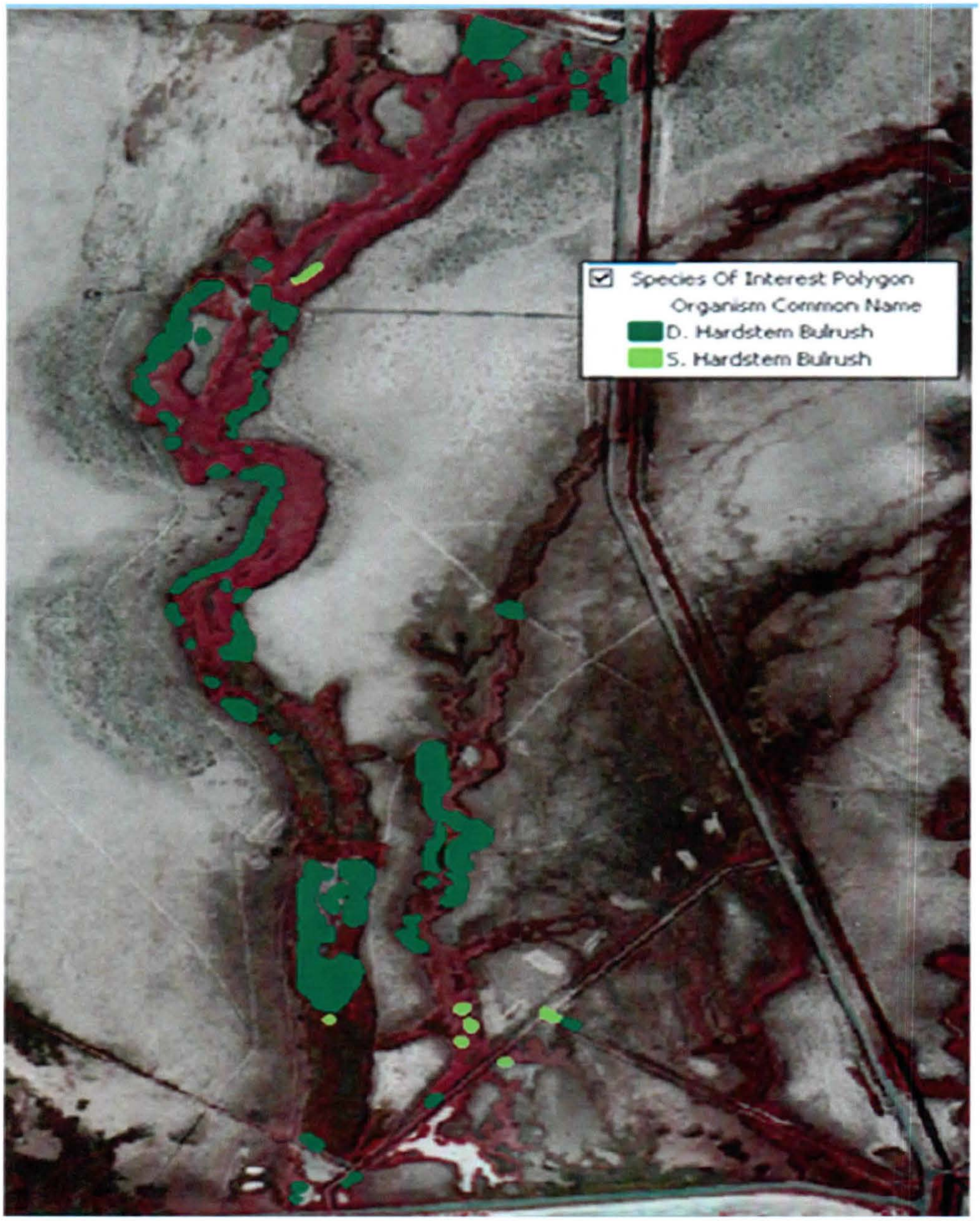
Avocet test plot data 2010

SPECIES	SIZE	TRAN 1 TOTAL	TRAN 2 TOTAL	TRAN 3 TOTAL	TRAN 4 TOTAL	TRAN 5 TOTAL	TRAN 6 TOTAL	TRAN 7 TOTAL	TRAN 8 TOTAL	TRAN 9 TOTAL	TRAN 10 TOTAL	TRAN 11 TOTAL	TRAN 12 TOTAL	TRAN 13 TOTAL	TRAN 14 TOTAL	SUMM TOTAL	% freq
Phragmites	0.5	1	1	5	3	5	1	4	2	3	5	3	4	0	1	38	0.09
(Phragmites australis)	0.25	0	0	1	0	4	2	3	1	2	3	0	1	0	0	17	
Salt Grass	0.5	26	28	26	23	27	27	28	25	25	29	30	31	31	29	385	0.89
(Distichlis stricta)	0.25	26	26	26	23	27	26	27	25	24	29	30	30	30	29	378	
Spike Rush	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
(Eleocharis rostellata)	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Olney's Bulrush	0.5	0	0	2	2	2	1	1	0	1	0	0	0	0	2	11	0.03
(Scirpus americanus)	0.25	0	0	0	0	2	1	0	0	1	0	0	0	0	2	6	
Alkali Bulrush	0.5	0	0	0	0	0	0	1	2	1	1	5	4	1	2	17	0.04
(Scirpus paludosus)	0.25	0	0	0	0	0	0	0	0	2	0	1	2	1	1	7	
Nevada Bulrush	0.5	0	1	0	1	0	1	0	0	0	0	0	0	0	0	3	0.01
(Scirpus nevadensis)	0.25	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
Unk #1 Switch Grass	0.5	1	0	0	1	0	1	0	1	0	2	1	5	1	0	13	0.03
(Panicum virgatum)	0.25	0	0	0	1	0	2	0	0	0	0	0	3	0	1	7	
Unk #2 Cattails	0.5	9	6	8	11	10	11	9	8	10	4	3	3	6	5	103	0.24
(Typha)	0.25	5	6	6	9	8	8	10	10	8	4	0	3	5	2	84	
Unk #3 Spearscale	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
(Atriplex triangularis)	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unk #4 Hard Stem	0.5	0	2	2	1	2	0	0	2	1	0	0	2	3	3	18	0.04
(Scirpus acutus)	0.25	0	2	2	1	2	0	0	1	1	0	0	1	2	2	14	
Unk #5	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unk #6 Sunflower	0.5	0	0	2	1	0	0	0	0	0	0	0	0	0	0	3	0.01
(Helianthus annuus)	0.25	0	0	2	1	1	0	0	0	0	0	0	0	0	0	4	
Unk #11	0.5	4	6	7	4	4	9	4	5	2	9	9	3	3	2	71	0.16
	0.25	3	4	3	3	2	7	5	4	3	10	6	5	3	2	60	

SPECIES	SIZE	TRAN 1 TOTAL	TRAN 2 TOTAL	TRAN 3 TOTAL	TRAN 4 TOTAL	TRAN 5 TOTAL	TRAN 6 TOTAL	TRAN 7 TOTAL	TRAN 8 TOTAL	TRAN 9 TOTAL	TRAN 10 TOTAL	TRAN 11 TOTAL	TRAN 12 TOTAL	TRAN 13 TOTAL	TRAN 14 TOTAL	SUMM TOTAL	% freq
Unk #8 Mapleleaf Goosefoot	0.5	0	0	1	1	2	0	2	1	2	2	2	0	0	0	13	0.03
(Chenopodium simplex)	0.25	0	0	1	0	0	0	1	2	1	0	1	0	0	0	6	
Baltic / Wire Rush	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
(Juncus balticus)	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Milkweed	0.5	2	2	1	0	1	0	2	2	2	1	1	1	0	0	15	0.03
(Asclepias syrica)	0.25	3	1	1	0	0	1	1	2	0	1	2	0	0	0	12	
Kochia	0.5	0	1	0	0	0	2	0	1	0	1	1	1	0	0	7	0.02
	0.25	0	0	0	0	0	1	0	1	0	0	1	1	0	0	4	
Rabbits Foot	0.5	2	1	2	0	0	1	0	0	0	1	2	0	2	0	11	0.03
(Polypogon monspeliensis))	0.25	0	1	0	0	0	1	0	0	1	1	0	0	0	0	4	
White Top	0.5	0	0	0	0	0	0	0	0	2	1	0	0	0	0	3	0.01
(Lepidium draba)	0.25	0	0	0	0	0	0	0	0	2	1	0	0	0	0	3	
unk #9	0.5	3	1	0	0	2	2	0	0	0	0	0	1	0	1	10	0.02
	0.25	3	1	0	0	3	3	0	0	0	0	0	0	0	2	12	
unk #10	0.5	2	1	1	1	2	1	1	2	1	0	1	2	3	4	22	0.05
	0.25	1	0	1	0	1	1	1	2	2	0	1	1	0	3	14	
Dog bain	0.5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.00
	0.25	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.00
Unk #7 Sweet White Clover	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
(Meliotus albus)	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00

Appendix D.
2010 Hardstem bulrush maps and data

Hardstem bulrush mapped in Pintail 2010



2010 HSB data

Name	Unit	Date	Month	Year	polyline or point	width / radius	Density	Colonies	Notes	Initial
HSB 1	Pintail	6/17/2010	June	2010	Polyline		High	present	Black Birds	To/Ro
HSB 2	Pintail	6/17/2010	June	2010	Point	5-10 ft	Low			To/Ro
HSB 3	Pintail	6/17/2010	June	2010	Polyline		High	present	Black Birds,Pelicans,Night Herons, Egrets	To/Ro
HSB 4	Pintail	6/23/2010	June	2010	point	5-10 ft	Low			To/Ro
HSB 5	Pintail	6/23/2010	June	2010	Point	5-10 ft	Low			To/Ro
HSB 6	Pintail	6/23/2010	June	2010	Point	5-10 ft	Low			To/Ro
HSB 7	Pintail	6/23/2010	June	2010	Polyline		High	present	Night Herons	To/Ro
HSB 8	Pintail	6/23/2010	June	2010	Polyline		High	present	Night Herons, Black birds	To/Ro
HSB 9	Pintail	6/23/2010	June	2010	Polyline		High	present	Night Herons, Black birds	To/Ro
HSB 10	Pintail	6/23/2010	June	2010	Point	10-20 ft	Low	present	Night Herons, Black birds	To/Ro
HSB 11	Pintail	6/23/2010	June	2010	Polyline		High			To/Ro
HSB 12	Pintail	6/23/2010	June	2010	Polyline		High	present	Yellow Headed Black Birds	To/Ro
HSB 13	Pintail	6/23/2010	June	2010	Polyline		Low	present	Black Birds	To/Ro
HSB 14	Pintail	6/23/2010	June	2010	Polyline		High		Marked from bank, Covers canal on west side of line, 20 ft wide	To/Ro
HSB 15	Pintail	6/23/2010	June	2010	Polyline		High		Marked from east bank. 25 ft wide, west side of the line.	To/Ro
HSB 16	Pintail	6/23/2010	June	2010	Point	20-30 ft	High	present	Black birds	To/Ro
HSB 17	Pintail	6/23/2010	June	2010	Polyline		High	present	15 Cinamon teal, 1 Canvas Back, Night Heron, Black Bird	To/Ro
HSB 18	Pintail	6/23/2010	June	2010	Point	10-20 ft	High	present	Little brown birds	To/Ro
HSB 19	Pintail	6/23/2010	June	2010	Point	10-20 ft	High			To/Ro

Appendix E.
2010 Pepperweed control program methods and monitoring

Data is in invasives_management_points.
** Will begin to map and become invasives_management_polygons*

- **Main Objective:**
  - Determine area in acres of WT aka PW treated
  - Set up database and data sheets
  - Implement RLGIS
- **Methods:**
  - USE THE FOUR-WHEELERS AND THEIR HAND GUNS.

- **2010:**
  - COLLECT POINT DATA WITH RADIUSES
  - Return to previous treated areas year after year. Document status and treat if needed.
  - #1 Priority plots are 1WT - 34WT (these points have been visited continuously from 2008).
  - #2 Priority plots are 35WT – 85WT (these points have been visited continuously from 2009).
  - #3 Priority plots are 86WT and higher (these points were found after 2009)
  - Work in pairs/groups. Navigate to a point- as close as you can. Look for treated area and new growth.
  - Determine radius/area containing WT. (Minimum of 30 ft to account for GPS accuracy. Max of 150 ft?) If areas of WT growth begin to exceed 150 ft from point or are hard to see from the point set a new point up.
  - Document how many major groups there are in the point or if the growth is 1 big one / 1 long one. Document average density of major groups.
    - 1B= I big plot   1L= I long plot (usually along waters edge)
  - Document the percent cover
  - Document the unit(s) the point plot falls within… and which side of what road… should do a quick check on both sides of road if the radius would encompass both sides.

2010 pepperweed summary data

ACRES VISITED	% COVER PEPPERWEED	MIN. ACRES PEPPERWEED TREATED	MAX. ACRES PEPPERWEED TREATED
1.627307163	0		
8.430280073	0-5	0.084302801	0.421514004
17.42822544	5 - 25	0.871411272	4.357056359
10.03415978	25-50	2.508539945	5.01707989
0.3532140	50-75	0.176607	0.2649105
0.7208448	75-100	0.5406336	0.7208448
TOTALS: 38.59403125		4.181494617	10.78140555

We visited 38.5 acres and out of that there was ~4 to 11 acres of pepperweed present and treated.

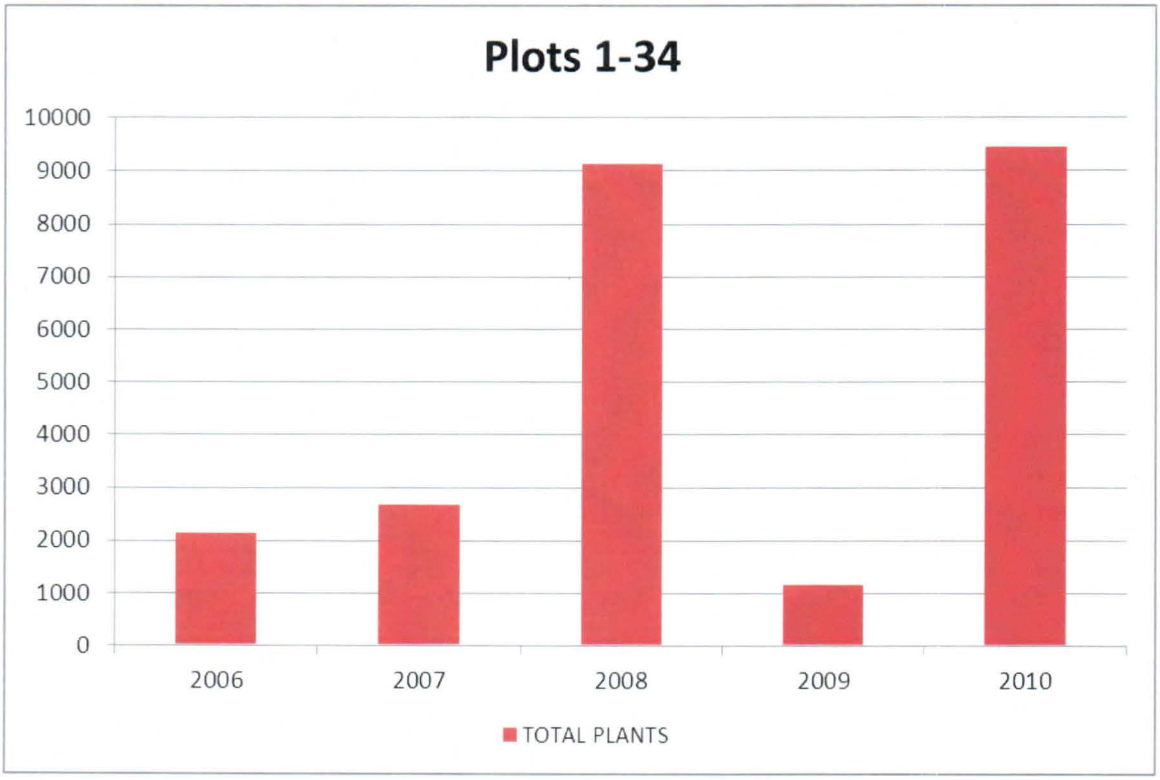
Pepperweed **2010 data**

Point Name	LATITUDE N.	LOGITUDE W.	Radius FT.	AREA SQ FT (3.14xRSQUARED)	ACRES (1 ACRE IS 43560 SQ FT)	DATE	MONTH	YEAR	UNIT	PLANTS	% Cover whole plot	Major Groups	Density (average of groups)	CHEMICAL	%
42WT	39.87866666670	-113.36047222200	25	1962.5	0.0450528	6/28/2010	june	2010	ib	0	0	0	L	Habitat	2
44WT	39.88047222220	-113.35816666700	25	1962.5	0.0450528	6/28/2010	June	2010	ib	0	0	0	L	Habitat	2
46WT	39.87063888890	-113.36527777800	25	1962.5	0.0450528	6/28/2010	june	2010	av	0	0	2	L	Habitat	2
07WT	39.86672500000	-113.36894444400	30	2826	0.064876	6/9/2010	June	2010		0	0			Habitat	2
09WT	39.88172222220	-113.35161111100	30	2826	0.064876	6/9/2010	June	2010		0	0			Habitat	2
18WT	39.88933333330	-113.40097222200	30	2826	0.064876	6/14/2010	June	2010	ha	0	0	0	L	Habitat	2
23WT	39.86391666670	-113.36883333300	30	2826	0.064876	6/14/2010	June	2010	cu	0	0	0	L	Habitat	2
27WT	39.86708333330	-113.37133333300	30	2826	0.064876	6/14/2010	June	2010	sh	0	0	0	L	Habitat	2
33WT	39.88183333330	-113.35494444400	30	2826	0.064876	6/16/2010	June	2010	ib	0	0	0	L	Habitat	2
41WT	39.85027777780	-113.40183333300	30	2826	0.064876	6/28/2010	June	2010	dump	0	0	0	L	Habitat	2
54WT	39.83905555560	-113.38933333300	30	2826	0.064876	6/28/2010	June	2010	av	0	0	0	L	Habitat	2
56WT	39.88919444440	-113.40400000000	30	2826	0.064876	6/28/2010	June	2010	ha	0	0	0	L	Habitat	2
62WT	39.88905555560	-113.41019444400	30	2826	0.064876	6/28/2010	June	2010	ha	0	0	0	L	Habitat	2
63WT	39.88830555560	-113.40736111100	30	2826	0.064876	6/28/2010	June	2010	ha	0	0	0	L	Habitat	2
68WT	39.87797222220	-113.35711111100	30	2826	0.064876	6/28/2010	June	2010	eg	0	0	0	L	Habitat	2
69WT	39.87852777780	-113.35680555600	30	2826	0.064876	6/28/2010	June	2010	eg	0	0	0	L	Habitat	2
70WT	39.88011111110	-113.35738888900	30	2826	0.064876	6/28/2010	June	2010	eg	0	0	0	L	Habitat	2
75WT	39.88138888890	-113.35594444400	30	2826	0.064876	6/28/2010	June	2010	eg	0	0	0	L	Habitat	2
76WT	39.87822222220	-113.36011111100	30	2826	0.064876	6/29/2010	June	2010	ib	0	0	0	L	Habitat	2
78WT	39.84938888890	-113.37447222200	30	2826	0.064876	6/29/2010	June	2010	ma	0	0	0	L	Habitat	2
79WT	39.88350000000	-113.35705555600	30	2826	0.064876	6/29/2010	June	2010	eg	0	0	0	L	Habitat	2
80WT	39.87927777780	-113.40588888900	30	2826	0.064876	6/29/2010	June	2010	ha	0	0	0	L	Habitat	2
57WT	39.84577777780	-113.38177777800	60	11304	0.2595041	6/16/2010	June	2010	av	0	0	0		Habitat	2
01WT	39.88119166670	-113.37258333300	20	1256	0.0288338	6/7/2010	June	2010		150	5 - 25			Habitat	2
48WT	39.87355555560	-113.36152777800	25	1962.5	0.0450528	6/30/2010	June	2010	ib	30	5 - 25	3	L	Habitat	2
12WT	39.88119444440	-113.35788888900	30	2826	0.064876	6/2/2010	June	2010		100	5 - 25			Habitat	2
37WT	39.88283333330	-113.35941666700	30	2826	0.064876	30-Jun	June	2010	eg	100	5 - 25	2	L	Habitat	2
40WT	39.88102777780	-113.35938888900	30	2826	0.064876	6/30/2010	june	2010	ib	75	5 - 25	2	M	Habitat	2
83WT	39.87741666670	-113.37238888900	30	2826	0.064876	6/30/2010	June	2010	pi	50	5 - 25	2	M	Habitat	2
86WT	39.88117000000	-113.35808000000	30	2826	0.064876	6/16/2010	June	2010	ib	250	5 - 25	3	L	Habitat	2
87Wt	39.88086000000	-113.35815000000	30	2826	0.064876	6/2/2010	June	2010	ib	100	5 - 25	2	M	Habitat	2
89WT	39.86680000000	-113.36688000000	30	2826	0.064876	6/7/2010	June	2010	cu	65	5 - 25	2	L	Habitat	2
94WT	39.88122000000	-113.36869000000	30	2826	0.064876	6/16/2010	June	2010	ga	70	5 - 25	2	M	Habitat	2
95WT	39.87793000000	-113.35993000000	30	2826	0.064876	6/16/2010	June	2010	eg	50	5 - 25	3	L	Habitat	2
66WT	39.87922222220	-113.35786111100	35	3846.5	0.0883035	7/1/2010	July	2010	eg	60	5 - 25	7	L	Habitat	2
39WT	39.88138888890	-113.35941666700	35	3846.5	0.0883035	6/30/2010	June	2010	ib	500	5 - 25			Habitat	2

19WT	39.88936111110	-113.40127777800	40	5024	0.1153352	6/14/2010	June	2010	ha	50	5 - 25	1	L	Habitat	2
15WT	39.87530555560	-113.36016666700	50	7850	0.1802112	6/10/2010	June	2010	eg	100	5 - 25	1L	M	Habitat	2
35WT	39.88411111110	-113.35908333300	50	7850	0.1802112	6/30/2010	june	2010	ib	300	5 - 25	3	M	Habitat	2
47WT	39.87361111110	-113.36186111100	50	7850	0.1802112	6/30/2010	June	2010	ib	200	5 - 25	1	M	Habitat	2
88WT	39.84798000000	-113.37595000000	50	7850	0.1802112	6/16/2010	June	2010	cu	200	5 - 25	4	L	Habitat	2
06WT	39.87094444440	-113.40080555600	60	11304	0.2595041	6/9/2010	June	2010		300	5 - 25			Habitat	2
25WT	39.86122222220	-113.34680555600	60	11304	0.2595041	6/16/2010	June	2010	cu	100	5 - 25	2	L	Habitat	2
30WT	39.87511111110	-113.35986111100	60	11304	0.2595041	7/12/2010	July	2010	eg	200	5 - 25	2	H	Habitat	2
04WT	39.87858333330	-113.37591666700	70	15386	0.353214	6/9/2010	June	2010	pi	500	5 - 25	3	H	Habitat	2
08WT	39.86861111110	-113.36780555600	70	15386	0.353214	6/9/2010	June	2010	ib, eg	45	5 - 25			Habitat	2
32WT	39.88086111110	-113.35794444400	70	15386	0.353214	6/2/2010	June	2010		300	5 - 25			Habitat	2
14WT	39.87788888890	-113.35875000000	100	31400	0.7208448	6/14/2010	June	2010	eg	200	5 - 25	3	M	Habitat	2
17WT	39.87025000000	-113.36727777800	100	31400	0.7208448	7/12/2010	June	2010	ib	5000	5 - 25	1L	M	Habitat	2
11WT	39.87611111110	-113.36177777800	150	70650	1.6219008	6/10/2010	June	2010	ib, eg	150	5 - 25	5	M	Habitat	2
28WT	39.89080555560	-113.40294444400	150	70650	1.6219008	6/16/2010	June	2010	ha	140	5 - 25	5	M	Habitat	2
29WT	39.87572222220	-113.36088888900	150	70650	1.6219008	6/10/2010	June	2010	eg	150	5 - 25	1L	M	Habitat	2
16WT	39.87936111110	-113.36169444400	160	80384	1.8453627	6/14/2010	June	2010	ib	200	5 - 25	3S	L	Habitat	2
45WT	39.84552777780	-113.38075000000	200	125600	2.8833792	16-Jun	june	2010	av	75	5 - 25	7	L	Habitat	2
51WT	39.84497222220	-113.38186111100	200	125600	2.8833792	6/16/2010	june	2010	av	100	5 - 25	7	L	Habitat	2
84WT	39.85038888890	-113.37194444400	5	78.5	0.0018021	7/12/2010	July	2010	ma	1	0-5	1	L	Habitat	2
50WT	39.85883333330	-113.34791666700	10	314	0.0072084	6/30/2010	June	2010	cu	4	0-5	1	L	Habitat	2
71WT	39.83822222220	-113.37202777800	20	1256	0.0288338	7/12/2010	July	2010	av	0	0-5	0	L	Habitat	2
72WT	39.83883333330	-113.37191666700	20	1256	0.0288338	7/12/2010	july	2010	av	4	0-5	1	L	Habitat	2
73WT	39.83805555560	-113.36969444400	20	1256	0.0288338	7/12/2010	July	2010	av	1	0-5	1	L	Habitat	2
03WT	39.87322222220	-113.37383333300	30	2826	0.064876	6/7/2010	June	2010		1	0-5			Habitat	2
05WT	39.86697222220	-113.36925000000	30	2826	0.064876	6/9/2010	June	2010		1	0-5			Habitat	2
10WT	39.87102777780	-113.36130555600	30	2826	0.064876	6/10/2010	June	2010	eg	20	0-5	1	H	Habitat	2
20WT	39.88955555560	-113.40211111100	30	2826	0.064876	6/14/2010	June	2010	ha	10	0-5	1	L	Habitat	2
22WT	39.89258333330	-113.40311111100	30	2826	0.064876	6/15/2010	June	2010	ha	12	0-5	1	L	Habitat	2
43WT	39.87905555560	-113.36127777800	30	2826	0.064876	6/28/2010	June	2010	ib	20	0-5	1	M	Habitat	2
53WT	39.83791666670	-113.38980555600	30	2826	0.064876	6/30/2010	June	2010	av	30	0-5	1	M	Habitat	2
55WT	39.88963888890	-113.40291666700	30	2826	0.064876	7/1/2010	July	2010	ha	6	0-5	1	L	Habitat	2
60WT	39.84780555560	-113.37488888900	30	2826	0.064876	6/28/2010	June	2010	cu	1	0-5	1	L	Habitat	2
61WT	39.88750000000	-113.41327777800	30	2826	0.064876	7/1/2010	July	2010	ha	4	0-5	1	L	Habitat	2
64WT	39.88563888890	-113.35552777800	30	2826	0.064876	7/1/2010	July	2010	eg	5	0-5	1	L	Habitat	2
67WT	39.87822222220	-113.35800000000	30	2826	0.064876	7/1/2010	July	2010	eg	3	0-5	1	L	Habitat	2
77WT	39.83900000000	-113.38797222200	30	2826	0.064876	7/1/2010	July	2010	av	1	0-5	1	L	Habitat	2
49WT	39.87119444440	-113.36191666700	35	3846.5	0.0883035	6/30/2010	June	2010	ib	20	0-5	2	L	Habitat	2
02WT	39.87680555560	-113.37225000000	40	5024	0.1153352	6/7/2010	June	2010		20	0-5			Habitat	2
31WT	39.87852777780	-113.35830555600	50	7850	0.1802112	6/16/2010	June	2010		40	0-5	3	M	Habitat	2
36WT	39.88425000000	-113.35858333300	50	7850	0.1802112	6/30/2010	june	2010	eg	60	0-5	1	L	Habitat	2
85WT	39.86416666670	-113.36872222200	50	7850	0.1802112	7/1/2010	July	2010	cu	12	0-5	2	L	Habitat	2
38WT	39.88197222220	-113.35919444400	50	7850	0.1802112	6/30/2010	June	2010	eg	185	0-5			Habitat	2

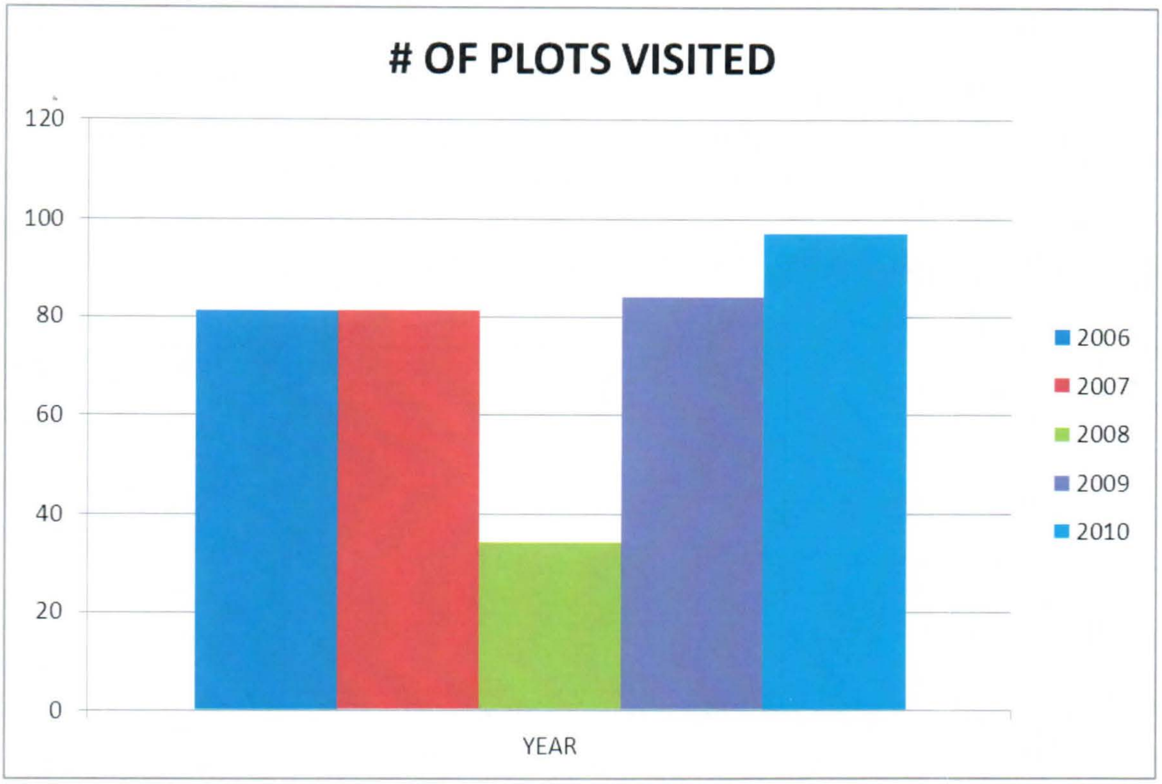
58WT	39.84747222220	-113.37613888900	60	11304	0.2595041	6/16/2010	June	2010	av	20	0-5	2	L	Habitat	2
26WT	39.88880555560	-113.40455555600	100	31400	0.7208448	6/16/2010	June	2010	ha	27	0-5	3	L	Habitat	2
59WT	39.84711111110	-113.37669444400	100	31400	0.7208448	7/12/2010	july	2010	av	8	0-5	4	L	Habitat	2
21WT	39.88900000000	-113.40383333300	150	70650	1.6219008	6/15/2010	June	2010	ha	10	0-5	2	L	Habitat	2
24WT	39.89644444440	-113.38575000000	150	70650	1.6219008	6/16/2010	June	2010		4	0-5	1	L	Habitat	2
52WT	39.84472222220	-113.37805555600	150	70650	1.6219008	16-Jun	june	2010	av	10	0-5	1	L	Habitat	2
65WT	39.87836111110	-113.35830555600	30	2826	0.064876	7/1/2010	July	2010	eg	55	25-50	2	M	Habitat	2
81WT	39.86013888890	-113.36969444400	30	2826	0.064876	7/1/2010	July	2010	sh	50	25-50	1	L	Habitat	2
96WT	39.84531000000	-113.37956000000	70	15386	0.353214	6/16/2010	June	2010		400	25-50	2	H	Habitat	2
13WT	39.87980555560	-113.35777777800	100	31400	0.7208448	6/14/2010	June	2010	eg	800	25-50	5	M	Habitat	2
97WT	39.85018000000	-113.39225000000	100	31400	0.7208448	6/17/2010	June	2010		400	25-50	3	M	Habitat	2
93WT	39.87534000000	-113.35939000000	100	31400	0.7208448	7/12/2010	July	2010	eg	1000	25-50	1	H	Habitat	2
92WT	39.86917000000	-113.36777000000	150	70650	1.6219008	7/12/2010	July	2010	ib	1000	25-50	1	M	Habitat	2
34WT	39.88319444440	-113.35733333300	200	125600	2.8833792	6/16/2010	June	2010	ib	800	25-50	3	M	Habitat	2
82WT	39.88244444440	-113.35008333300	200	125600	2.8833792	7/1/2010	July	2010	eg	1000	25-50	6	H	Habitat	2
90WT	39.87141000000	-113.40060000000	70	15386	0.353214	7/12/2010	July	2010	sh	3000	50-75	10	H	Habitat	2
91WT	39.86969000000	-113.36729000000	100	31400	0.7208448	7/12/2010	July	2010	ib	3000	75-100	1	H	Habitat	2
TOTAL PLOTS 97										**TOTAL PLANTS 21,955**					
74WT	39.84636111110	-113.36969444400				not accessable		2010	av						

Amount of pepperweed treated in plots 1-34 from 2006 to 2010



PLOTS 1-34					
YEAR	2006	2007	2008	2009	2010
TOTAL PLANTS	2120	2667	9130	1152	9430

Number of plots visited from 2006 to 2010



# OF PLOTS VISITED					
YEAR	2006	2007	2008	2009	2010
# OF PLOTS	81	81	34	84	97

Appendix F.
Knapweed control program methods and monitoring

Data is in invasives_management_points

- **Main Objective**:
  - Set up radiuses for points to get acres or square feet
  - Set up database and data sheets
- **Methods:**
  - USE A FOUR-WHEELER AND THE HAND GUN.
  - Return to previous treated areas year after year. Document status and treat if needed.
  - **2010:**
  - COLLECTE AS POINT DATA WITH RADIUSES
  - Beginning of August (around the last couple weeks of seasonal season) (kept it the same this year but will probably need to change for next year)
  - Begin with list of points previously identified... In...?
  - Create a priority list like the one for WT/PW?
    - Go down to S end of refuge on main road and work your way N hitting any points along the way.
      - At each point check a 30 foot radius to find old plant(s) if you can't find any right away – (accounting for gps accuracy)
      - *MULTIPLE PLANTS HAVE BEEN TREATED AT A POINT SO WE NEED TO SET UP PLOTS THIS YEAR.*
      - SET UP PLOTS: Some existing points might have overlapping 30 ft radiuses- that is okay. Still document 30 ft for each point. – not like white top where the radiuses vary- keep them all at 30 ft- based on the way KW grows compared to WT.
      - Document status on data sheet... and treat them.
      - NEW GROWTH: If found outside an existing plot create a new one.
        - If new growth is real close to another plot edge walk 25 feet away from the new growth to GPS your point and set up new 30ft plot that won't overlap.
    - Use trimbles to navigate to point

2010 Knapweed data

pt old name	pt new name	LATITUDE N.	LOGITUDE W.	Radius or L.&W.	Area sq ft	Acres	DATE	MONTH	YEAR	PLANTS	% Cover	CHEMICAL	%
KW01	KW 01	39.84895547	-113.4179825	30	2826	0.06487603	7/26/2010	July	2010	1	0-25	polaris	2
KW02	KW 02	39.84729485	-113.4100879	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
KW03	KW 03	39.84851366	-113.4086452	30	2826	0.06487603	7/26/2010	July	2010	2	0-25	polaris	2
NAP01	KW 04	39.82444813	-113.3973534	30	2826	0.06487603	7/27/2010	July	2010	1	0-25	polaris	2
NAP02	KW 05	39.83534326	-113.3979623	30	2826	0.06487603	7/27/2010	July	2010	1	0-25	polaris	2
NAP03	KW 06	39.84077591	-113.4008026	30	2826	0.06487603	7/26/2010	July	2010	1	0-25	polaris	2
NAP04	KW 07	39.83952558	-113.3999409	30	2826	0.06487603	7/27/2010	July	2010	0	0-25	polaris	2
NAP05	KW 08	39.83835949	-113.3993471	30	2826	0.06487603	7/26/2010	July	2010	1	0-25	polaris	2
NAP06	KW 09	39.82687896	-113.3982138	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP07	KW 10	39.82852391	-113.3985345	30	2826	0.06487603	7/27/2010	July	2010	2	0-25	polaris	2
NAP08	KW 11	39.82833398	-113.3981833	30	2826	0.06487603	7/26/2010	July	2010	1	0-25	polaris	2
NAP09	KW 12	39.82943662	-113.3984779	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP10	KW 13	39.82953502	-113.3986319	30	2826	0.06487603	7/27/2010	July	2010	2	0-25	polaris	2
NAP11	KW 14	39.828295	-113.3978408	30	2826	0.06487603	7/27/2010	July	2010	3	0-25	polaris	2
NAP12	KW 15	39.82973929	-113.3983284	30	2826	0.06487603	7/28/2010	July	2010	2	0-25	polaris	2
NAP13	KW 16	39.82978924	-113.3979004	30	2826	0.06487603	7/28/2010	July	2010	2	0-25	polaris	2
NAP14	KW 17	39.82958741	-113.3979473	30	2826	0.06487603	7/26/2010	July	2010	1	0-25	polaris	2
NAP15	KW 18	39.82992109	-113.3975728	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP16	KW 19	39.83010063	-113.3986958	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP17	KW 20	39.8300806	-113.3986743	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP18	KW 21	39.83011228	-113.3976487	30	2826	0.06487603	7/26/2010	July	2010	2	0-25	polaris	2
NAP19	KW 22	39.8304152	-113.3989602	30	2826	0.06487603	7/28/2010	July	2010	4	0-25	polaris	2
NAP20	KW 23	39.83103521	-113.3990622	30	2826	0.06487603	7/26/2010	July	2010	2	0-25	polaris	2
NAP21	KW 24	39.83085944	-113.3981773	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP22	KW 25	39.83125909	-113.3990633	30	2826	0.06487603	7/27/2010	July	2010	1	0-25	polaris	2
NAP23	KW 26	39.83144081	-113.398859	30	2826	0.06487603	7/26/2010	July	2010	1	0-25	polaris	2
NAP24	KW 27	39.83148708	-113.3987297	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2

pt old name	pt new name	LATITUDE N.	LOGITUDE W.	Radius or L.&W.	Area sq ft	Acres	DATE	MONTH	YEAR	PLANTS	% Cover	CHEMICAL	%
NAP25	KW 28	39.83154039	-113.3982601	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP26	KW 29	39.8315849	-113.3989991	30	2826	0.06487603	7/27/2010	July	2010	4	0-25	polaris	2
NAP27	KW 30	39.83185991	-113.3990032	30	2826	0.06487603	7/27/2010	July	2010	0	0-25	polaris	2
NAP28	KW 31	39.83221966	-113.3971041	30	2826	0.06487603	7/27/2010	July	2010	8	0-25	polaris	2
NAP29	KW 32	39.83202168	-113.3983087	30	2826	0.06487603	7/27/2010	July	2010	2	0-25	polaris	2
NAP30	KW 33	39.83256047	-113.3980128	30	2826	0.06487603	7/27/2010	July	2010	5	0-25	polaris	2
NAP31	KW 34	39.83257195	-113.3981898	30	2826	0.06487603	7/27/2010	July	2010	0	0-25	polaris	2
NAP32	KW 35	39.83280974	-113.3987047	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NAP33	KW 36	39.83309154	-113.3987843	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NAP34	KW 37	39.83345959	-113.3988832	30	2826	0.06487603	7/28/2010	July	2010	0	0-25	polaris	2
NAP35	KW 38	39.83285643	-113.3972086	30	2826	0.06487603	7/28/2010	July	2010	2	0-25	polaris	2
NAP36	KW 39	39.83288753	-113.3970534	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NAP37	KW 40	39.83748215	-113.3995946	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NAP38	KW 41	39.83681411	-113.4000817	30	2826	0.06487603	7/28/2010	July	2010	2	0-25	polaris	2
NAP39	KW 42	39.83761534	-113.3994552	30	2826	0.06487603	7/28/2010	July	2010	3	0-25	polaris	2
NAP40	KW 43	39.83796881	-113.3995515	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NAP41	KW 44	39.83824046	-113.400978	30	2826	0.06487603	7/28/2010	July	2010	0	0-25	polaris	2
NAP42	KW 45	39.83860013	-113.3989919	30	2826	0.06487603	7/28/2010	July	2010	0	0-25	polaris	2
NAP43	KW 46	39.83986488	-113.4022204	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NAP44	KW 47	39.84046259	-113.4011455	30	2826	0.06487603	7/28/2010	July	2010	3	0-25	polaris	2
NW01	KW 48	39.82662918	-113.3989414	30	2826	0.06487603	7/26/2010	July	2010	0	0-25	polaris	2
NW02	KW 49	39.82654209	-113.3978982	30	2826	0.06487603	7/28/2010	July	2010	5	0-25	polaris	2
NW03	KW 50	39.82837278	-113.3986046	30	2826	0.06487603	7/29/2010	July	2010	6	0-25	polaris	2
NW04	KW 51	39.8305152	-113.3985273	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NW05	KW 52	39.83210851	-113.3990391	30	2826	0.06487603	7/27/2010	July	2010	0	0-25	polaris	2
NW06	KW 53	39.83322758	-113.3980349	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NW07	KW 54	39.83737126	-113.3988186	30	2826	0.06487603	7/29/2010	July	2010	1	0-25	polaris	2
NW08	KW 55	39.83883424	-113.3965186	30	2826	0.06487603	7/29/2010	July	2010	3	0-25	polaris	2
NW09	KW 56	39.84875347	-113.4165807	30	2826	0.06487603	7/29/2010	July	2010	0	0-25	polaris	2

pt old name	pt new name	LATITUDE N.	LOGITUDE W.	Radius or L.&W.	Area sq ft	Acres	DATE	MONTH	YEAR	PLANTS	% Cover	CHEMICAL	%
NW10	KW 57	39.84884919	-113.4241219	30	2826	0.06487603	7/29/2010	July	2010	1	0-25	polaris	2
NW11	KW 58	39.84840059	-113.4269063	30	2826	0.06487603	7/29/2010	July	2010	6	0-25	polaris	2
NW12	KW 59	39.88552714	-113.4141263	30	2826	0.06487603	7/29/2010	July	2010	4	0-25	polaris	2
NW13	KW 60	39.85326553	-113.4111112	30	2826	0.06487603	7/29/2010	July	2010	2	0-25	polaris	2
NWB1	KW 61	39.82634277	-113.4009906	30	2826	0.06487603	7/29/2010	July	2010	2	0-25	polaris	2
NWB2	KW 62	39.82858493	-113.403495	30	2826	0.06487603	7/29/2010	July	2010	2	0-25	polaris	2
NWB3	KW 63	39.85298733	-113.413124	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NWB4	KW 64	39.83345071	-113.3988568	30	2826	0.06487603	7/28/2010	July	2010	1	0-25	polaris	2
NWB5	KW 65	39.85736629	-113.4190385	30	2826	0.06487603	7/29/2010	July	2010	0	0-25	polaris	2
TOTAL					183690	4.2169421				**100**			

Appendix G.
Tamarisk control methods and monitoring

Data is in invasives_management_points

- **Main Objective:**
  - Keep Tamarisks on refuge lands suppressed.
  - Set up a data base and data sheets.
  - Implement RLGIS

- **Methods:**
  - USE TRIMBLE TO NAVIGATE TO POINTS
  - DOCUMENT ON DATA SHEETS
  - USE THE 6-WHEELER AND BACKPACK SPRAYER FOR MOST APPLICATIONS (FOLIAR) AND SPRAY BOTTLE FOR A FEW STUMP TREATMENTS.

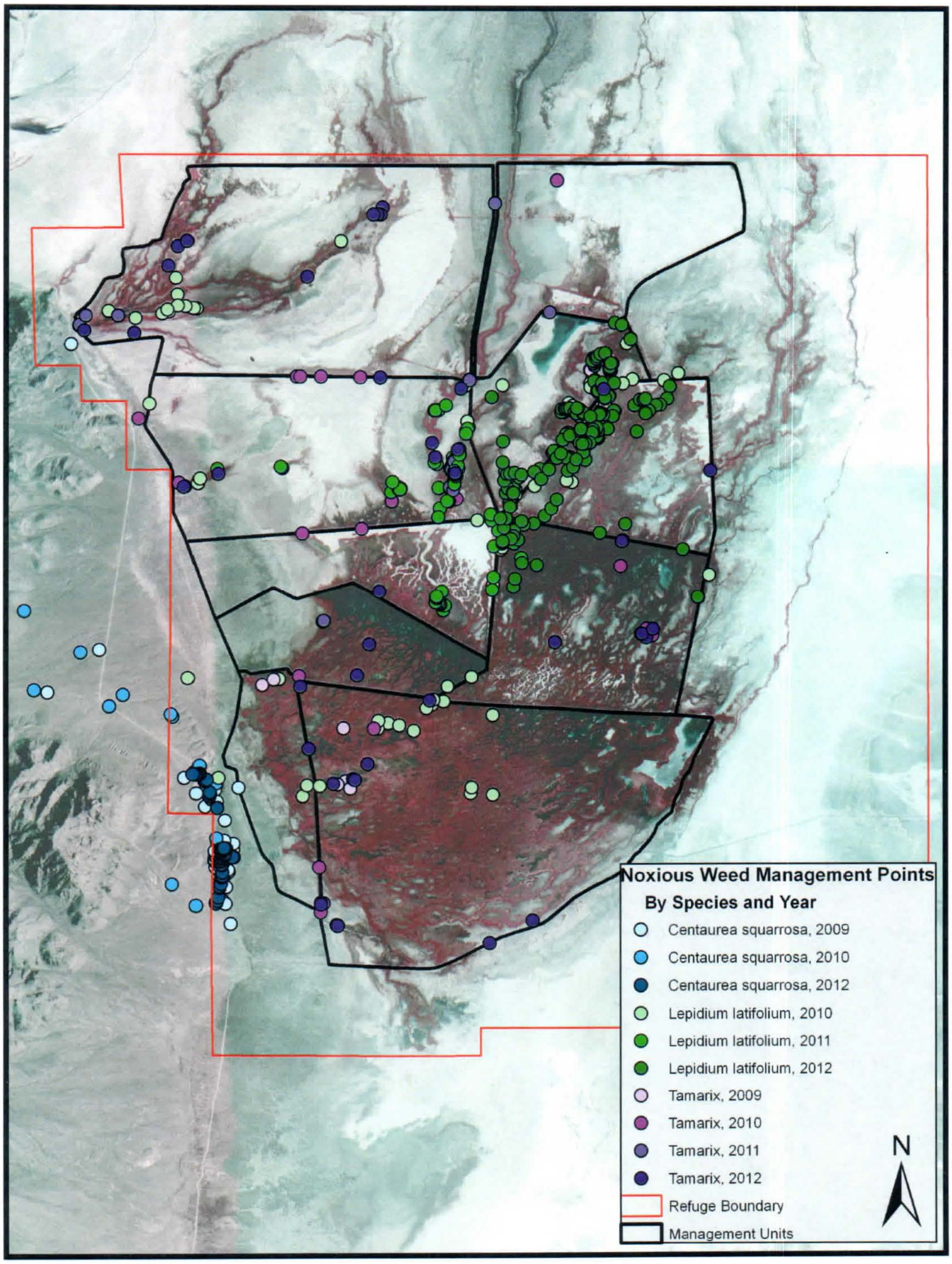
  - Have one pt if trees in the area are easily seen from that point
  - Have more then one point with the same ID if:
    - The trees are spread out and hard to see from one point (the multiple pts would indicate TAM in-between them)
    - The pt is an existing pt and the trees have spread beyond it (the new pt would indicate spread and the new edge of growth for that area)
      - Keep GIS pts dated as when created in RLGIS (shows spread)
      - Note in data sheet comments if extra pt is due to spread
  - If a once multiple point area has shrunk:
    - Do not delete pts /"re-map" just document live/dead tree amounts to show the decrease.
  - There are few enough TAM that it is possible to count how many trees are treated. Hence, why TAM is still point data and not mapped as polygons.

2010 Tamarisk data

ID	Yr. Est.	Lat.	Lon.	Unit	Treated?	Re-visit?	Date	Year	Live trees
SC01	2010	39.90278	-113.363	GA	Y	N	9/28/2010	2010	1
SC02-SC02	2009	39.89388	-113.404	HA	Y	Y	9/28/2010	2010	2
		39.89592	-113.403						
SC03	2010	39.8777	-113.407	HA	N/A	N/A	9/28/2010	2010	0
SC04	2010	39.88212	-113.388	PI	Y	N	9/28/2010	2010	1
SC05	2010	39.8745	-113.373	PI	Y	N	9/28/2010	2010	2
SC06	2010	39.87292	-113.374	PI	Y	N	9/28/2010	2010	1
SC07-SC07	2010	39.87274	-113.373	PI	Y	N	9/28/2010	2010	12
		39.87215	-113.374						
SC08	2010	39.86908	-113.38	PI	N/A	N/A	9/29/2010	2010	0
SC09	2010	39.8693	-113.374	PI	Y	N	9/29/2010	2010	4
SC10	2010	39.86567	-113.39	SH	Y	N	9/29/2010	2010	6
SC11	2010	39.86615	-113.384	SH	Y	N	9/29/2010	2010	17
SC12	2009	39.88279	-113.359	IB	Y	Y	9/29/2010	2010	1
SC13	2010	39.86217	-113.356	CU	Y	N	9/29/2010	2010	1
SC14	2010	39.85479	-113.353	CU	Y	N	9/29/2010	2010	4
SC15	2010	39.85549	-113.353	CU	Y	N	9/29/2010	2010	3
SC16	2010	39.85047	-113.39	MA	Y	N	9/29/2010	2010	2
SC17-SC17	2009	39.84954	-113.394	AV	Y	Y	9/29/2010	2010	2
		39.85012	-113.393						
SC18-SC18	2009	39.83948	-113.385	AV	Y	Y	9/29/2010	2010	1
		39.83915	-113.386						
		39.83873	-113.385						
SC19	2009	39.84501	-113.385	AV	N/A	N/A	9/29/2010	2010	0
SC20-SC20	2010	39.84497	-113.382	AV	Y	N	9/29/2010	2010	2
SC22	2010			HA	Y	N	10/29/2010	2010	5
SC23	2010			HA	Y	N	10/29/2010	2010	2
SC24	2010			HA	Y	N	10/29/2010	2010	1
SC25	2010			HA	Y	N	10/29/2010	2010	1
SC26	2010			PI	Y	N	10/29/2010	2010	1
SC27	2010			PI	Y	N	10/29/2010	2010	1
SC28	2010			PI	Y	N	10/29/2010	2010	1
SC29	2010			SH	Y	N	10/29/2010	2010	1
SC30	2010			AV	Y	N	10/29/2010	2010	2
SC31	2010			AV	Y	N	10/29/2010	2010	1
SC32	2010			AV	Y	N	10/29/2010	2010	1
TOTAL								**2010**	**73**

Appendix H
Noxious weed management points, 2010-12

Compiled by Tiffany Cummins



Appendix I.
SNPL summary notes on historic use

Created by Brian Allen, 2010

1988 Important crossroads in management at Fish Springs NWR (Jim Savory and Joe Engler):

- A newly revised Marsh Management Plan first initiated use of a 5-year rotational drawdown of management units within the impoundment system.
- Prior to that, water was being stacked during low evaporative periods and held as long as possible during high ET loss.
- Believed issues with salt loading and decreased productivity were identified.
- Pintail and Shoveler Units were the first units drawn down in the summer of 1988.
- They remained dry until December 1989 and were sampled for invertebrates in June 1990, as well as two units that were not drawn down.
- Shoveler and Pintail units exhibited a 40-fold increase in aquatic macro-invertebrate numbers as well as an increase in species diversity.
- The two units also had disproportionately higher use by nesting ducks and molting use by geese and ducks.
- Aquatic macro-invertebrates were monitored each year until 1995.
- The revised Marsh Management Plan was finalized at the end of 1990 and it had incorporated regular prescribed burns in the drawn down units.
- In 1990, conductivity monitoring started being reported for each management unit (the major pools). The monitoring was continued to 1995.
- The same Marsh Management Plan has been used to the current date, but its being revised under the policy guidance of our current Habitat Management Planning process.
- Current and past efforts of SNPL management are one specific management area that are being addressed.

1988 (cite 1988 Annual Narative Report):

- SNPL are only known to occur in small numbers on the refuge -- around a dozen.

1989 Snowy Plover use was further identified (cite 1989 Annual Narative Report):

- At this time Pintail and Shoveler Units were drawn down.
- SNPL were surveyed on Fish Springs NWR from June 3-8 in conjunction with Utah DWR, as part of a four state survey.
- A peak of 174 plovers were tallied on the refuge including 1 nest and 4 broods.
- 11 broods were counted throughout the nesting season.
- Greater than 90% of birds surveyed were males indicating a substantial breeding population in the area.

- It was believed that snowy plovers nesting off-refuge on the surrounding alkai flats utilize the Refuge shoreline for feeding, particularly when ephemeral pools have dried up.
- Highest use on the refuge is found in Gadwall Unit.

1990 (cite 1990 Annual Narative Report):
- a peak of 164 SNPL counted on May 24
- another peak of 151 counted June 28
- 12 broods were counted throughout the season.

1991 **(cite 1991 Annual Narative Report):**
- a peak of 70 SNPL were counted on June 8

1992 **(cite 1992 Annual Narative Report):**
- Reported research effort being conducted through the Utah Cooperative Fish and Wildlife Research Unit to identify nesting and foraging habitats. No counts were reported.

1993 **(cite 1993 Annual Narative Report):**
- a peak count of 65 SNPL were counted on July 21.

1994 **(cite 1994 Annual Narative Report):**
- a peak count of 65 SNPL were counted on July 9.

1995 **(cite 1995 Annual Narative Report):**
- a peak count of 57 SNPL were counted on August 9.

2004 **(cite 2004 Annual Narative Report):**
- SNPL reported in "good numbers" primarily in the Harrison Unit.

Appendix J.
2010 SNPL survey methods and data

OBJECTIVE:

-Determine what the plovers are doing on refuge lands.

Foraging?

Nesting?

What?

-Determine where plovers are using refuge lands.

What units/ multiple units?

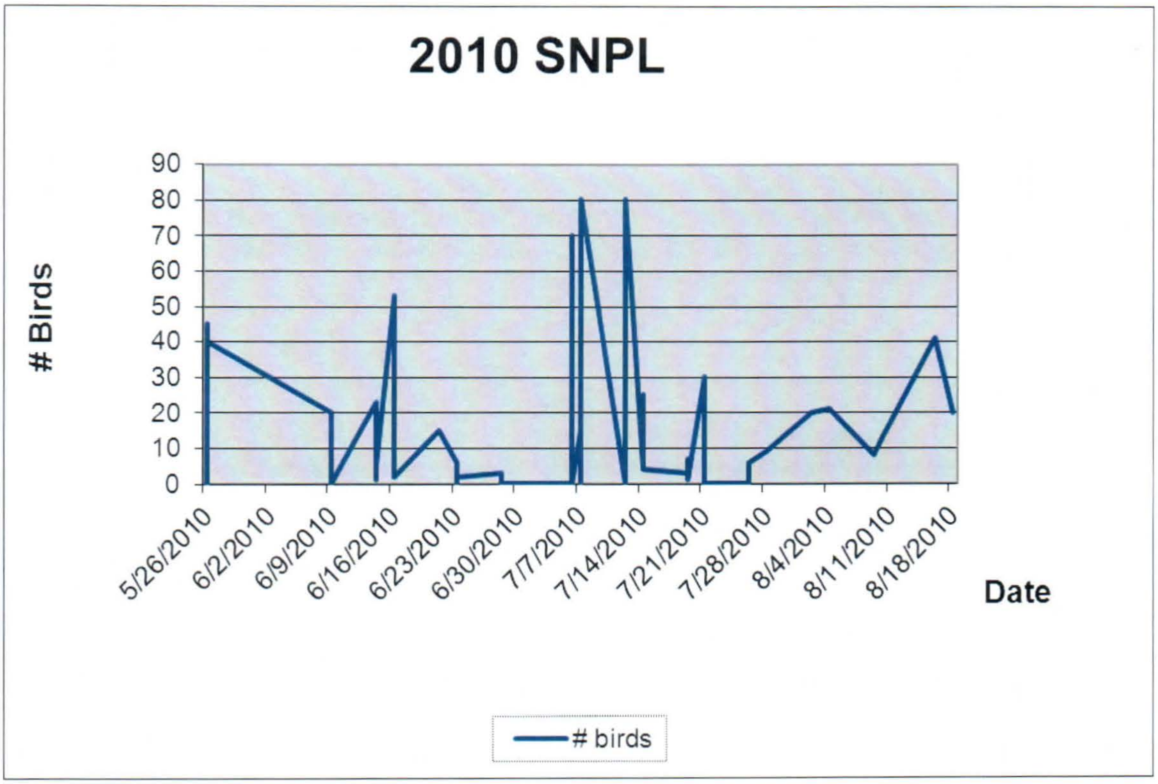
METHODS:

- Twice a week three one hour shifts are conducted.
  - One morning shift, one afternoon shift, and one evening shift.
  - If limited – can just do 2 shifts a day.
- During each hour shift a person is locating a group of plovers and documenting activities observed. The first person usually does the locating and some observing. The others can usually return to the site and just document activities observed.
- LOOK FOR PLOVERS ALONG RECIEDING SHORLINES IN THE UNITS DRAWING DOWN / DRYING OUT. (THE NORTHERN UNITS)
- One shift needs to document the water level/status of Gadwall and the unit where the birds are observed at.
- As temperatures increase only morning and evening shifts are conducted due to very low numbers observed in 2010 afternoon shifts.
- As water levels dropped conduct at least evening or morning shifts only. Watch to see if plovers follow the dropping water levels from unit to unit.
- Input data on days collected
- IF BIRDS ARE COLOR BANDED- INCLUDE IN THE COMMENTS SECTION - COLORS OBSERVED :HOW MANY OF EACH COLOR : UNIT OBSERVED AT
- Input data on days when it's collected if possible

DATE	Time Start	Time End	Total time	Minutes	# of birds	Unit	Gadwall H20 status	Observer	Comments
5/26/2010									all day observations
5/26/2010	6:00	7:00	1:00	60.00	0	Gadwall	moderatly full	T. Dolgoff	other species: canada geese, snowy egret, barn swallows, w. meadowlarks
5/26/2010	7:00	8:00	1:00	60.00	0	Gadwall	moderatly full	T. Dolgoff	
5/26/2010	8:00	9:00	1:00	60.00	0	Gadwall	moderatly full	T. Dolgoff	
5/26/2010	9:00	10:00	1:00	60.00	6	Ibis		T. Orme	Foraging
5/26/2010	10:00	11:00	1:00	60.00	4	Ibis		T. Orme	Foraging
5/26/2010	11:00	12:00	1:00	60.00	4	Ibis		T. Orme	Foraging
5/26/2010	12:00	13:00	1:00	60.00	0	Gadwall	moderatly full	R. Orme	
5/26/2010	13:00	14:00	1:00	60.00	4	Ibis		R. Orme	Foraging
5/26/2010	14:00	15:00	1:00	60.00	0	Gadwall	moderatly full	R. Orme	
5/26/2010	15:00	16:00	1:00	60.00	30+	Ibis		T. Dolgoff	Foraging, and grooming
5/26/2010	16:00	17:00	1:00	60.00	30+	Ibis		T. Dolgoff	Foraging, and grooming- nest search done- no nest found.
5/26/2010	17:00	18:00	1:00	60.00	35+	Ibis		T. Dolgoff	Foraging, and grooming
5/26/2010	18:00	19:00	1:00	60.00	40+	Ibis		T. Orme, R. Orme	Foraging
5/26/2010	19:00	20:00	1:00	60.00	45+	Ibis		T. Orme, R. Orme	Foraging, and they grouped together and flew around the lake
5/26/2010	20:00	21:00	1:00	60.00	40+	Ibis		T. Orme, R. Orme	Foraging and standing still in high winds
6/9/2010									3 observations a day
6/9/2010	6:20	6:40	0:20	20.00	20+	Ibis		T. Dolgoff	Foraging along S Ibis waters edge
6/9/2010	12:15	13:30	1:15	75.00	0	GA, PI, IB		T. Orme, R. Orme	
6/9/2010	16:30	17:30	1:00	60.00	0	GA, PI, IB		T. Orme, R. Orme	
6/14/2010	6:10	6:20	0:10	10.00	23	Ibis		T. Dolgoff	Foraging along S Ibis waters edge
6/14/2010	6:20	6:30	0:10	10.00	1	Egret		T. Dolgoff	Foraging along N shores/pools of Egret with 9 common plovers
6/14/2010	13:28	13:45	0:17	17.00	7	Ibis		R. Orme	5 Foraging, 2 standing around- nest search done- no nest found.
6/14/2010	15:30	16:00	0:30	30.00	5	Ibis		T. Orme	Foraging

DATE	Time Start	Time End	Total time	Minutes	# of birds	Unit	Gadwall H20 status	Observer	Comments
6/16/2010	7:20	7:40	0:20	20.00	53	Ibis		T. Dolgoff	Foraging along S Ibis waters edge 15 were sitting on most S end of group- almost looked like nesting- before I got ready to walk out closer they all got up and began foraging in that area.
6/16/2010	13:10	13:50	0:40	40.00	45	Ibis		T. Orme	Foraging at South end. A few were on the north end. Some were sitting down because of high winds.
6/16/2010	16:17	16:30	0:13	13.00	2	Ibis		R. Orme	Foraging. High winds. 70+ common plovers present.
6/21/2010	7:30	7:40	0:10	10.00	15	Ibis		T. Dolgoff	windy: Foraging S of Waters edge- whole group flew off and began foraging on waters edge.
6/23/2010	7:45	7:50	0:05	5.00	6	Ibis		T. Dolgoff	S Ibis foraging
6/23/2010	8:00	8:20	0:20	20.00	0	Gadwall	empty and dry!	T. Dolgoff	
6/23/2010	8:00	8:20	0:20	20.00	2	Ibis		T. Dolgoff	N Ibis foraging
6/23/2010	17:15	18:15	1:00	60.00	2	Gadwall		T. Orme	2 plovers were standing and running on shore and road.
6/28/2010	7:40	8:00	0:20	20.00	3	Ibis		T. Dolgoff	Foraging
6/28/2010	8:00	8:15	0:15	15.00	0	Harrison		T. Dolgoff	good foraging ground opening up
6/28/2010	12:20	12:35	0:15	15.00	0	Ibis		T. Dolgoff	
6/28/2010	12:40	13:00	0:20	20.00	0	Harrison		T. Dolgoff	
6/28/2010	16:30	17:30	1:00	60.00	0	IB, HA		T. Orme	
7/6/2010	6:10	6:15	0:05	5.00	0	Ibis		T. Dolgoff	
7/6/2010	6:20	6:30	0:10	10.00	0	Harrison		T. Dolgoff	
7/6/2010	6:40	6:50	0:10	10.00	25	Ibis		T. Dolgoff	Foraging and some sitting around. 4 little curlew looking birds present.
7/6/2010	11:20	11:30	0:10	10.00	4	Ibis		T. Dolgoff	Foraging and sitting around. Spotted from N. end of Ibis. Pool is ~ 1/2 the size it was in May
7/6/2010	20:00	20:10	0:10	10.00	70	Ibis		R. Orme	Most on N side foraging
7/6/2010	20:30	20:40	0:10	10.00	0	Harrison		R. Orme	
7/7/2010	6:20	6:30	0:10	10.00	15	Ibis		R. Orme	sitting on beach around pool

DATE	Time Start	Time End	Total time	Minutes	# of birds	Unit	Gadwall H20 status	Observer	Comments
7/7/2010	6:30	6:40	0:10	10.00	50	Ibis		R. Orme	large group came and flew around 3 times then landed at N. end of pool
7/7/2010	16:00	16:10	0:10	10.00	0	Harrison		R. Orme	could have been some on S end but too far to tell
7/7/2010	16:00	16:10	0:10	10.00	3	Ibis		R. Orme	Foraging
7/7/2010	21:00	21:10	0:10	10.00	80+	Ibis		R. Orme	foraging
7/12/2010	6:15	6:20	0:05	5.00	0	Harrison		R. Orme	
7/12/2010	6:15	6:20	0:05	5.00	6	Ibis		R. Orme	foraging
7/12/2010	13:40	13:50	0:10	10.00	2	Ibis		T. Dolgoff	one sitting one foraging
7/12/2010	13:55	14:00	0:05	5.00	0	Harrison		T. Dolgoff	
7/12/2010	20:20	21:20	1:00	60.00	15	Ibis		T. Orme	Foraging
7/12/2010	20:20	21:20	1:00	60.00	80+	Harrison		T. Orme	Foraging
7/14/2010	6:00	7:00	1:00	60.00	4	Ibis		T. Orme	Foraging and standing around
7/14/2010	6:00	7:00	1:00	60.00	25	Harrison		T. Orme	Foraging and flying around
7/14/2010	12:00	13:00	1:00	60.00	4	Ibis		T. Dolgoff	Foraging
7/14/2010	20:50	21:00	0:10	10.00	4	Ibis		R. Orme	Foraging
7/19/2010									Began mornings and evenings only
7/19/2010	6:15	6:25	0:10	10.00	3	Ibis		R. Orme	Foraging
7/19/2010	6:15	6:25	0:10	10.00	7	Harrison		R. Orme	Foraging
7/19/2010	20:20	21:20	1:00	60.00	1	Harrison		T. Orme	Foraging with a flock of different shore birds
7/21/2010	6:00	7:00	1:00	60.00	30	Harrison		T. Orme	Foraging and flying around
7/21/2010	18:00	19:00	1:00	60.00	0	Ibis		T. Orme	
7/21/2010	20:00	20:45	0:45	45.00	1	Pintail		R. Orme	Foraging on W. island
7/21/2010	20:00	20:45	0:45	45.00	1	Harrison		R. Orme	Foraging on East shore
7/21/2010	20:00	20:45	0:45	45.00	0	Ibis		R. Orme	
7/26/2010	6:00	7:00	1:00	60.00	0	PI, HA, IB		R. Orme	
7/26/2010	20:00	21:00	1:00	60.00	6	Harrison		T. Orme	Foraging on far shore
7/28/2010									Began evenings only
7/28/2010	20:00	21:00	1:00	60.00	9	Harrison		R. Orme	Foraging on W. side
8/2/2010	20:30	21:30	1:00	60.00	20+	Harrison		R. Orme	Foraging southwest shore some flying
8/4/2010	20:00	21:00	1:00	60.00	21	Harrison		T. Orme	Foraging where water had receeded
8/9/2010	20:00	21:00	1:00	60.00	8	Harrison		T. Orme	Foraging
8/10/2010	19:00	20:00	1:00	60.00	13	Harrison		R. Orme	Foraging, 6 baby plovers running by mothers
8/16/2010	20:00	21:00	1:00	60.00	40+,1	PI, HA		R. Orme	Foraging
8/18/2010	19:30	20:30	1:00	60.00	20+	Pintail		T.Orme	Foraging


2010 SNPL
Birds
90
80
70
60
50
40
30
20
10
0
5/26/2010
6/2/2010
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6/30/2010
7/7/2010
7/14/2010
7/21/2010
7/28/2010
8/4/2010
8/11/2010
8/18/2010
Date
birds

Appendix K.

ATTACHMENT #1—INTERIM PROGRESS REPORT:

Snowy Plover Inventory and Habitat Use at the U.S. Army's Dugway Proving Ground and U.S. Fish and Wildlife Service's Fish Springs National Wildlife Refuge

PREPARED BY:

Kristen Ellis—M.S. Student

Randy Larsen—Principal Investigator

PREPARED FOR:

Robert Knight, Environmental Directorate, U.S. Army Dugway Proving Ground

Keeli Marvel, U.S. Army Dugway Proving Ground

Brian Allen, Refuge Manager, Fish Springs National Wildlife Manager

COLLABORATORS:

Suzanne Fellows (USFWS)

Jim Parrish (UDWR)

Kim Hersey (UDWR)

Steve Madsen (BLM)

Traci Allen (BLM)

REPORTING PERIOD:

2011

PROJECT CONTACT:

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PROJECT PARTNERS & PROPONENTS:

Brian Allen (USFWS Fish Springs NWR), Suzanne Fellows (USFWS), Jim Parrish (UDWR), Kim Hersey (UDWR), Steve Madsen (BLM), Traci Allen (BLM)

BYU R ACCOUNT:

R0202312

PROJECT LOCATION:

Fish Springs National Wildlife Refuge and Dugway Proving Ground in western Utah.

EXECUTIVE SUMMARY:

This report is a summary of activities conducted during 2011 to inventory and assess habitat use by snowy plover (SNPL) at the U.S. Army's Dugway Proving Ground and U.S. Fish and Wildlife Service's Fish Springs National Wildlife Refuge. Between May and August of 2011, we sampled 104 random points and detected SNPL on 20 of these. These detections resulted in an occupancy rate of 20% with detection probabilities around 75%. Distance to water was strongly associated with detection of SNPL and received more support than any other model we evaluated. Many of the SNPL we detected were found near small streams flowing north from Fish Springs. The maximum number of SNPL seen during pond surveys at at USFWS Fish Springs refuge was 164 on 3 August 2011. Harrison and Pintail ponds had the most SNPL activity throughout the survey time frame with dramatically increased use of Harrison during the late summer. During the course of our work in 2011, we found seven SNPL nests located on the USFWS Fish Springs refuge. No nests were located on DPG, however, two sets of young chicks were seen. The first year of this project has been a resounding success. In 2012, we will continue and expand sampling further onto DPG. We will focus survey efforts in 2012 during peak breeding season (May through June 15). Over the next two years, we will continue assessment and provide a map of predicted habitat, an estimate of the breeding population size using the boundary between DPG and Fish Springs, and identify habitat use patterns for SNPL.

ADDITIONAL DETAIL ON PROGRESS:

Introduction

Snowy Plovers (*Charadrius alexandrinus*) are shorebirds of conservation concern and are believed to be declining throughout much of their range (Brown et al. 2001). These plovers depend on coastal shoreline and inland alkaline lake habitats for breeding, wintering, and migration stopover areas (Page et al. 2009). The quality and amount of these habitats available to Snowy Plover (SNPL) and other shorebirds continues to decline as human presence in these areas increases. There is little doubt that human influence is having a negative impact on shorebird populations (Page et al. 2009). Recent evidence, for example, suggests that human disturbance reduces SNPL chick survival as chick loss was greater on weekends and holidays when human activity was highest (Ruhlen et al. 2003).

North American populations of SNPL are listed as highly imperiled in the United States Shorebird Conservation Plan (Brown et al. 2001). The Pacific Coast population is currently federally listed as threatened by the U.S. Fish and Wildlife Service. Little is known, however, about SNPL population trends or dynamics in western Utah. Limited information suggests a small population (<200) breeds on the U.S. Army Dugway Proving Ground (DPG) and the U.S. Fish and Wildlife Service Fish Springs refuge (USFWS; Fish Springs annual breeding bird surveys). Additional work in this area is needed, however, given the status of SNPL and lack of information from which to make management decisions. Inventory of occurrence and seasonal use of habitats is of interest to both DPG and USFWS.

In 2011, DPG and USFWS initiated a project to assess and monitor the population of SNPL in western Utah. This study will help determine if and where this species is using DPG mission areas and where mission area expansion can occur. Our specific objectives were: 1) survey potentially suitable habitat on both DPG and USFWS Fish Springs refuge for SNPL and identify occupied habitats; 2) provide an estimate of the breeding population using DPG and the USFWS Fish Springs refuge; and 3) identify habitat features associated with probability of seasonal occurrence of SNPL at DPG and USFWS Fish Springs refuge.

Methods

Our study site encompasses a large area on the western side lands managed by DPG adjacent (southern border) to the USFWS Fish Springs refuge. In 2011, we conducted a pilot study to evaluate feasibility of SNPL sampling protocol for this remote area. Using ArcGIS, we generated random sample locations spaced 1 km apart over suspected suitable habitat (salt flats with low slope, limited vegetation, near water sources for foraging). We spaced sample points 1km apart to avoid double counting of non-incubating SNPL. Both parents alternate incubation and the non-incubating adult will forage up to several hundred meters away from the nest. We surveyed 800 m x 800 m cells centered at the survey point. Each plot was surveyed in a standardized pattern by foot and we attempted to maintain equal survey time across all visits. Surveys were conducted under similar weather conditions (no precipitation and wind <50km/h) and by a single observer to minimize variation in detection.

Between 5 May 2011 and 2 August 2011, we surveyed plots on two separate occasions to provide data for estimation of detection probabilities. In Utah, SNPL arrive in late March and begin laying eggs mid-April (Paton 1995). The breeding season continues through the end of July (Paton 1995). Timing of the surveys included the peak breeding season to satisfy the assumption of limited movement and independence. Although some movement in or out of the population may occur during this period, relaxation of the closure assumption is acceptable if movements occur at random (MacKenzie et al. 2006).

In addition to surveys for occupancy, we collected habitat measurements at each survey point. We recorded the distance to water, distance to road, percent shrub and grass in the area, average shrub and grass height, shrub decadence and a measure of obscurity (robel pole). We included these variables as potential individual covariates that influenced detection probability and/or occupancy. To evaluate hypotheses concerning detection probability and occupancy, we used Program Mark (White and Burnham 1999).

To further understand habitat use by SNPL in western Utah, we surveyed pond impoundments at USFWS Fish Springs refuge weekly during both the morning and evening periods. During these surveys, we recorded the number of SNPL observed, location of observed birds, and bird activity.

Results

We sampled 104 random points and detected SNPL on 20 of these (Figure 1). The occupancy rate generated from Program Mark was 20% with detection probabilities around 75%. Distance to water was strongly associated with detection of SNPL and received more support than any other model we evaluated. Many of the SNPL we detected were found near small streams flowing north from Fish Springs (Figure 1).

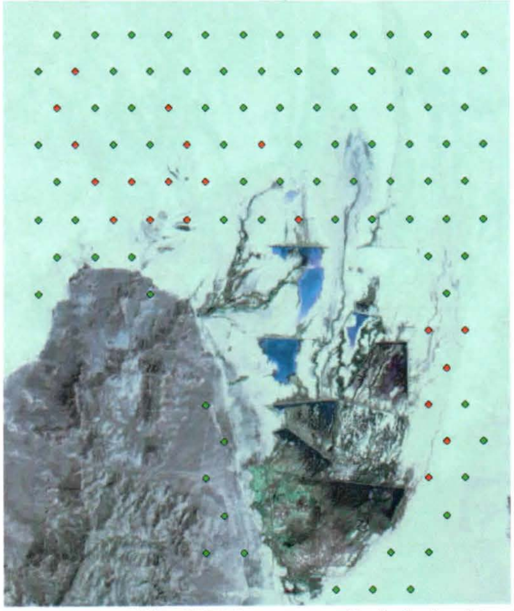

Figure 1. Map of locations where we surveyed for SNPL in western Utah during May 5, 2011 through August 2, 2011. Red points represent cells in which SNPL were detected whereas green points were surveyed, but without any detections.

The maximum number of SNPL seen during pond surveys at one time on USFWS Fish Springs refuge was 164 on 3 August 2011. Counts varied by month and time of day.

Harrison and Pintail ponds had the most SNPL activity throughout the survey time frame with dramatically increased use of Harrison during the late summer(Figure 2).

During the course of our work in 2011, we found seven SNPL nests located on the USFWS Fish Springs refuge. Four of these nests were located in the Harrison pond and the other three in Gadwall. Five of the seven nests hatched successfully. One nest was abandoned one day after the first egg was laid. The other unsuccessful nest contained eggs that were not viable; both parents incubated the nest for at least 67 days before abandoning. No nests were located on DPG, however, two sets of young chicks were seen.

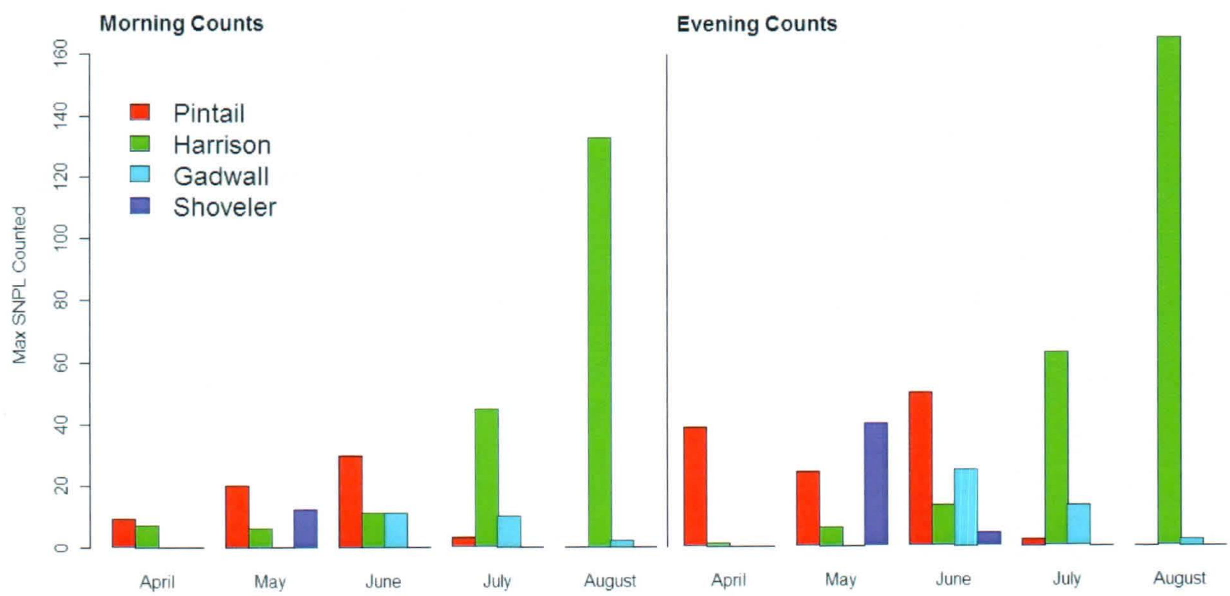

Figure 2. Maximum SNPL counted at specific ponds.

Future Plans

In 2012, we will expand sampling further onto DPG. We will adjust the 2008 USFWS predictive habitat map (shows high, medium, and low-likelihood of occurrence) and expand it so that Fish Springs refuge is included in the area of coverage. This map will be based off of topography (low slopes) and distance to water and will help prioritize further survey work. We will then survey at least 100 random points in 2012 using the methods outlined above. We will focus survey efforts during peak breeding season (May through June 15) to increase the likelihood that the assumption of limited movement between survey points is met.

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Appendix K.

2012 SNPL MS graduate study report

Snowy plover inventory and habitat use at the U.S. Army's Dugway Proving Ground and U.S. Fish and Wildlife Service's Fish Springs National Wildlife Refuge

Kristen Ellis – M.S. Student, BYU

Randy Larsen – Principal Investigator

Executive Summary

This report is a summary of activities conducted during the last two years to inventory and assess habitat use by snowy plover at the U.S. Army's Dugway Proving Ground and U.S. Fish and Wildlife Service's Fish Springs National Wildlife Refuge. In 2011 and 2012, we indirectly estimated abundance of snowy plovers in western Utah using occupancy estimation. We made repeated visits to randomly selected survey plots from May to July, recording the number of adults and habitat characteristics within each plot. We sampled 104 64ha cells in 2011 and 100 64ha cells in 2012. We estimated

occupancy of these cells by SNPL at 22% (95% CI = 15-33%) in 2011 and 18% (95% CI = 12-28%) in 2012 with detection probabilities estimated at 74% (95% CI = 50-89%) in 2011 compared to 80% (95% CI = 53-93%) in 2012. Occupancy of snowy plovers was strongly associated with distance to water in both years and models with this variable received more support than any other variable we evaluated (distance tot water $\beta = 2.70$, 95% CI = 1.83 – 3.58). Many of the snowy plover we detected were found foraging near small streams flowing out from Fish Springs NWR. We used this information to generate a predictive habitat model. Understanding habitat selection is important for maintaining the western Utah population of snowy plovers. SNPL counts from pond surveys at Fish Springs NWR varied by month and time of day. The maximum number of SNPL seen during pond surveys at one time on Fish Springs NWR was 164 on 3 August 2011 and 171 on 23 July 2012. We located 21 total SNPL nests, 7 in 2011 and 14 in 2012.

Introduction

Snowy plovers (*Charadrius nivosus*) are shorebirds of conservation concern believed to be declining throughout much of their geographic range (Brown et al. 2001). These plovers are broadly, but discontinuously distributed across North America and depend on coastal shoreline and inland alkaline lake habitats for breeding, wintering, and migration stopover areas (Page et al. 2009). The quality and amount of these habitats available to snowy plover (SNPL) and other shorebirds continues to decline as human disturbances in these areas increases. Recent evidence, for example, suggests that human disturbance reduces SNPL chick survival as chick loss was greater where human activity was highest (Ruhlen et al. 2003). Because human influence is having a negative impact on shorebird populations (including SNPL), there is a need to further our understanding of habitat-use patterns and ecology of these birds (Page et al. 2009). Increased understanding of SNPL ecology will inform managers as they seek to conserve this imperiled shorebird.

North American populations of SNPL are listed as Highly Imperiled in the United States Shorebird Conservation Plan (Brown et al. 2001) and the Pacific Coast population is classified as threatened by the U.S. Fish and Wildlife Service (Page et al. 2009). These designations highlight a need to understand how SNPL use habitats so that managers can proactively conserve this shorebird. In western Utah, little is known about SNPL population trends or dynamics. A small population (estimated at <200 individuals) is thought to breed on the border of the U.S. Army Dugway Proving Ground (hereafter DPG) and the U.S. Fish and Wildlife Service Fish Springs National Wildlife Refuge (hereafter Fish Springs NWR). Additional work in this area, however, is needed to establish distribution and clarify habitat preferences of SNPL in this area. Inventory of occurrence and seasonal use of habitats is of interest to both DPG and USFWS.

In 2011, DPG and USFWS initiated a project to assess and monitor the population of SNPL in western Utah. This study will help determine if and where this species is using DPG mission areas and where mission-area expansion could occur without impacting SNPL. Our specific objectives were to: 1) survey potentially suitable habitat on both DPG and Fish Springs NWR refuge for SNPL and identify occupied habitats; 2) provide an estimate of the breeding population using DPG and Fish Springs NWR; and 3) identify habitat features associated with probability of seasonal occurrence of SNPL at DPG and Fish Springs NWR.

Methods

Study Design

Our study area was located on alkaline flats in Tooele and Juab county, Utah in the southwestern region of the U.S. Army's Dugway Proving Ground and on the adjacent Fish Springs NWR. Although it would be desirable to count every SNPL in western Utah during the breeding season, a true census of the SNPL population is unrealistic. Consequently, we used occupancy models because they provide a reasonable method to evaluate and monitor populations that are small in size and widely dispersed (MacKenzie et al. 2006). Occupancy modeling has been successfully used for a variety of avian species including SNPL and allows for assessment of the influence of covariates such as habitat characteristics on occupancy rates and detection probabilities (Hood and Dinsmore 2007).

We stratified the study area into high, medium, and low likelihood of occupancy based on suspected suitable habitat using geographic information systems (GIS; ArcMap®, version 10, Environmental Systems Research Institute, Redlands, California) and imagery of the study area (obtained in 2011 from the National Agricultural Imagery Program). We generated random sample locations in each area of likelihood with 70% of sample points in high, 20% in medium and 10% in low-likelihood areas. We spaced sample points 1km apart to avoid double counting of non-incubating SNPL (Paton 1995). At each sample point, we surveyed 800m x 800m cells (64 ha) centered at the random location using accepted SNPL survey protocol (Thomas et al. 2012). We surveyed each plot in a standardized pattern by foot and attempted to maintain equal survey time (about 1 hour) across all visits. We conducted surveys under standardized weather conditions (no precipitation and wind <50 km/h). From 5 May - 2 August 2011 and 7 May - 15 June 2012 we surveyed each plot on two separate occasions with a different observer who was naïve to the survey location. Repeated sampling provided data for estimation of detection probabilities. In Utah, SNPL arrive in late March and begin laying eggs during mid-April (Paton 1995). The breeding season continues through the end of July (Paton 1995). Our survey dates ensured occupancy surveys were conducted during the core breeding period. Although some movement in or out of the population may occur during this period, relaxation of the closure assumption for occupancy models is acceptable if movements occur at random (MacKenzie et al. 2006).

To further understand distribution of SNPL in western Utah, we measured habitat characteristics at a random location within each sample plot. Along 25m transects in each cardinal direction from the random location, we measured vegetative cover (line-intercept method), vegetation height, and vegetation decadence. We also recorded distance to water and distance to roads as potential covariates that may influence habitat selection. We then incorporated these covariates into occupancy models.

In addition, we surveyed all ponds at Fish Spring Refuge for SNPL twice per week to generate a maximum count. We recorded the number and location of SNPL on these surveys. While conducting surveys, we opportunistically located new nests by observing SNPL flushing from or returning to nests. The location of each nest was recorded with a handheld GPS unit. Nests were defined as successful if at least one young hatched and survived long enough to exit the nest (Mabee and Estelle 2000). Nests were presumed successful if nests were found without eggs near the expected date of hatching and there was evidence of a successful hatching. This evidence included the presence of young, the presence of eggshell tops and bottoms near the nest, egg shell fragments 1-5 mm in size and detached egg membranes within the nest lining (Mabee 1997). For each nest, we recorded the following information: date of clutch initiation, maximum number of eggs, date of hatching, number of eggs hatched, nest fate, and location of nest.

Data Analysis

We used model selection (Burnham and Anderson 2002) within Program MARK (White and Burnham 1999) to evaluate hypotheses concerning site occupancy based on habitat characteristics. We evaluated relative model support using Akaike's Information Criterion adjusted for small sample sizes (AICc; Akaike 1973, Burnham and Anderson 2002). In the event of model-selection uncertainty, we generated model-averaged estimates of both detection probability and occupancy rates (Burnham and Anderson 2002). To evaluate effect sizes, we looked for overlap in confidence intervals associated with estimates and assessed the influence of individual covariates by determining whether confidence intervals around β estimates overlapped zero. We also used model selection and the nest survival model within Program MARK to evaluate daily survival rate for all nests found in 2011 and 2012.

Results

We sampled 104 64ha cells in 2011 and 100 64ha cells in 2012 (Figure 1). We estimated occupancy of these cells by SNPL at 22% (95% CI = 15-33%) in 2011 and 18% (95% CI = 12-28%) in 2012 with detection probabilities estimated at 74% (95% CI = 50-89%) in 2011 compared to 80% (95% CI = 53-93%) in 2012. Distance to water was strongly associated with detection of SNPL and received more support than any other variables we evaluated (distance to water $\beta = 2.70$, 95% CI = 1.83 – 3.58). Many of the SNPL we detected were found near small streams flowing north from Fish Springs NWR (Figure 1).

The maximum number of SNPL seen during pond surveys at one time on Fish Springs NWR was 164 on 3 August 2011 and 171 on 23 July 2012. On 9 July 2012, 226 SNPL were counted on both DPG and Fish Springs NWR representing the maximum count in either year. Counts varied by month and time of day. In 2011, Harrison and

Pintail ponds had the highest counts of SNPL throughout the survey time frame with dramatically increased use of Harrison pond during the late summer (Figure 2, top panel). In 2012 Ibis and Harrison ponds had the highest SNPL counts with a similar pattern of increased use at Harrison pond during late summer (Figure 2, bottom panel).

In 2011, we found 7 SNPL nests located on Fish Springs NWR. Four of these nests were located in Harrison pond and the other three in Gadwall. Five of the seven nests hatched successfully (daily survival rate = 0.98, 95% CI = 0.93 – 0.99). One nest was abandoned one day after the first egg was laid. The other unsuccessful nest contained eggs that were not viable; both parents incubated the nest for at least 67 days before abandoning. No nests were located on DPG in 2011, however, two sets of young chicks were seen. In 2012, we found 14 SNPL nests located on Fish Springs NWR and DPG. Six of these nests were located on DPG and 8 were located on Fish Springs NWR. Ten of the 14 nests hatched successfully (daily survival rate = 0.98, 95% CI = 0.95 – 0.99).

Using the coefficient estimates from Program MARK concerning occupancy rates and distance to water, we generated a predictive habitat model for the basin north of Fish Springs NWR, south of Interstate 80, east of the Deep Creek Mountain Range, and west of Granite Mountain in western Utah (Figure 3). This modeling effort highlighted predicted habitat associated with naturally occurring sources of water in this region and will help prioritize future SNPL surveys and guide conservation efforts for this imperiled species.

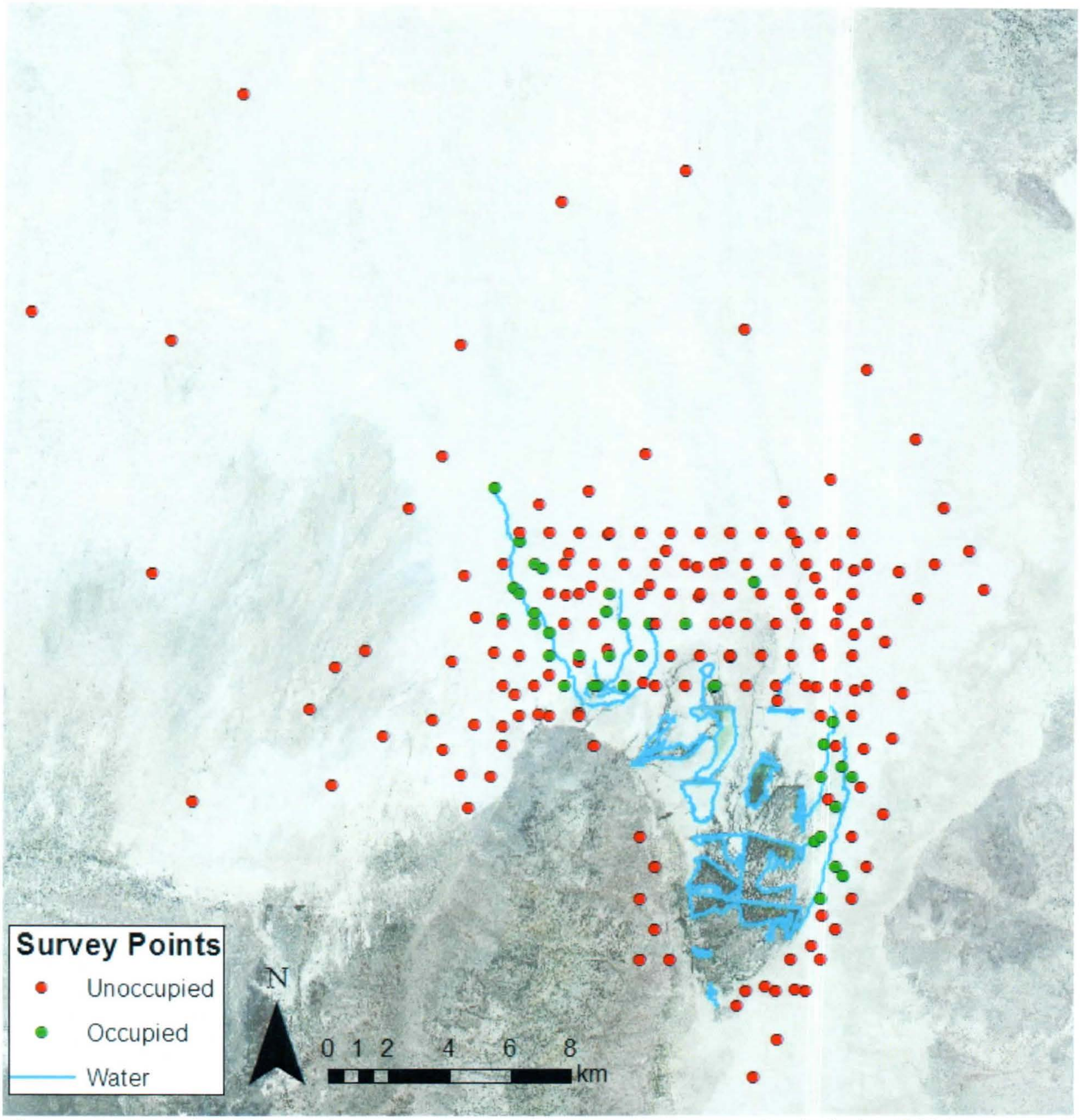

Figure 3. Map of locations where we surveyed for SNPL in western Utah during 2011 and 2012.

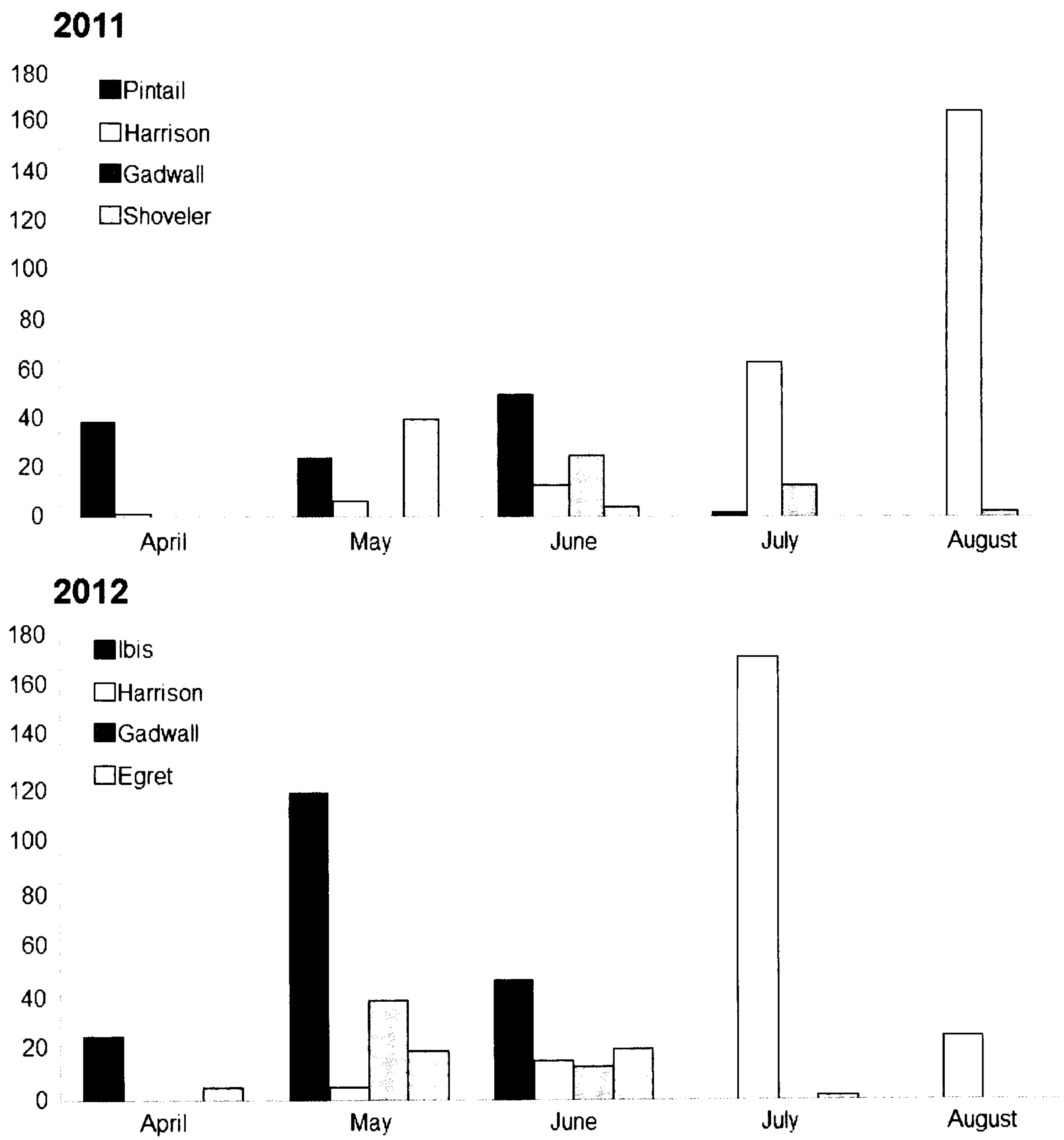

Figure 4. Maximum number of SNPL (y-axis) counted by month (x-axis) at ponds located on Fish Springs NWR during summer of 2011 (top panel) and 2012 (bottom panel).

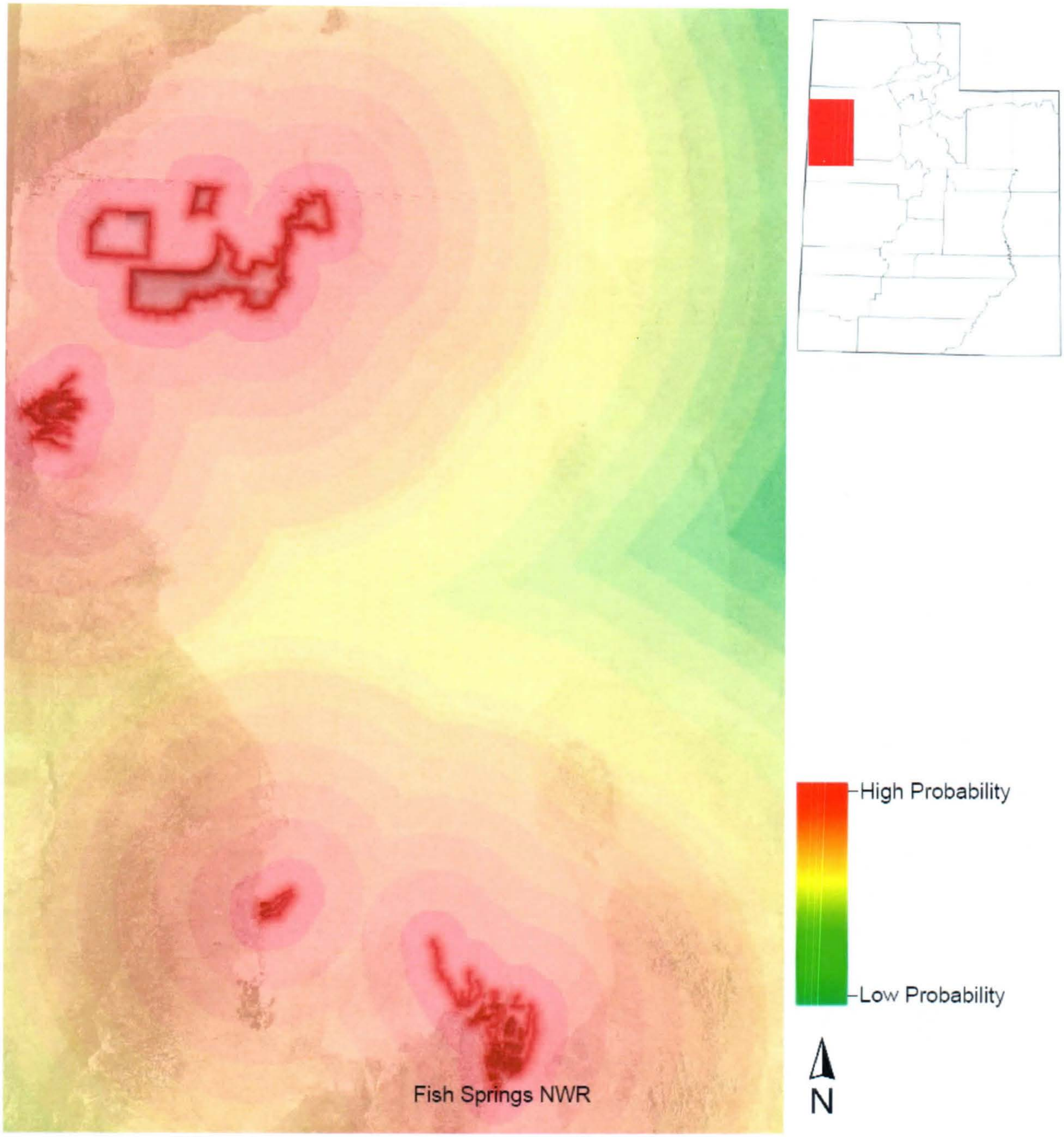

Figure 5. Predicted habitat for snowy plover in western Utah based on occupancy surveys conducted in 2011 and 2012. Highlighted red areas are those associated with naturally occurring sources of water. Distance to water was the best predictor of occupancy for snowy plover.

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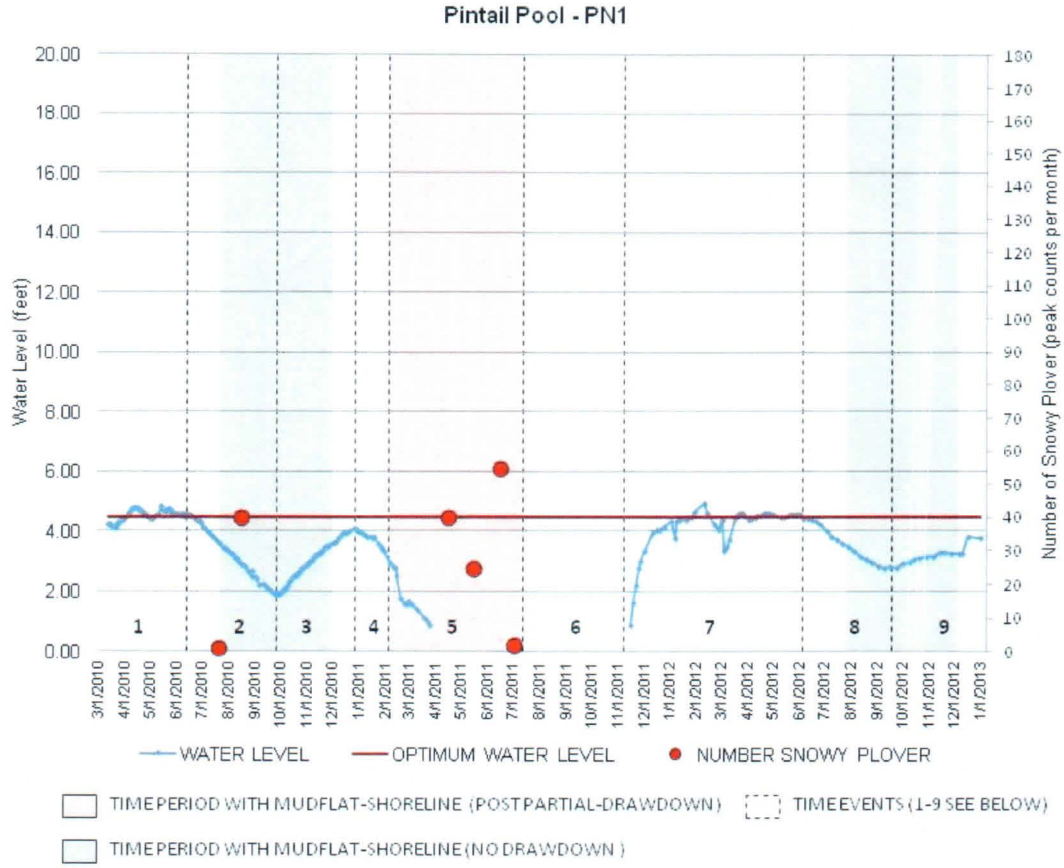
2010-2012 Pintail Pool water management – relationship to SNPL use



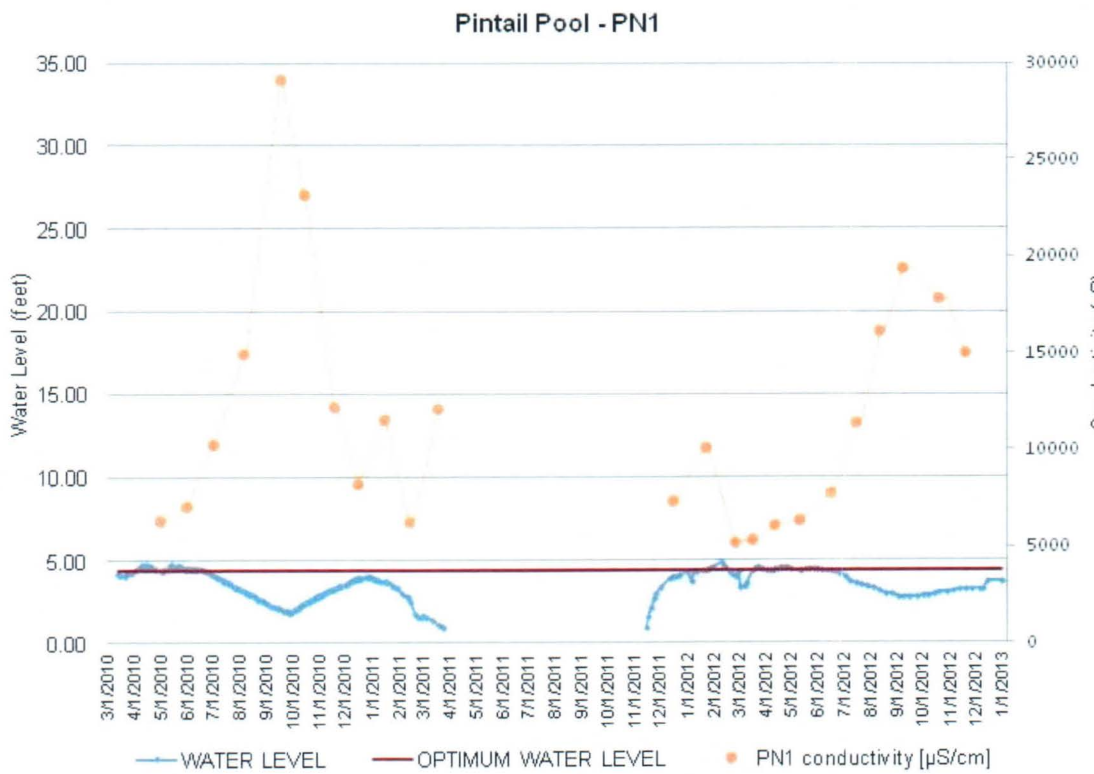
<u>Time Events - by corresponding number (1-9):</u>

29. Water maintained near "optimum pool" level (4.44 feet on staff gauge of WCS PN1).
30. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). Mudflat-shoreline was habitat available during the later potion of the period; ***SNPL use recorded by Fish Springs staff***.
31. Water level restored to "optimum pool" then pool maintained/flushed with continued flows (water surplus period). Mudflat-shoreline was habitat available during early portion of period, but no SNPL recorded by Ellis or Fish Springs staff.
32. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around reduced area of inundation.***
33. ***Available mudflat-shoreline habitat and corresponding use by foraging SNPL (peak counts per month by Ellis).*** The water level was not recordable on

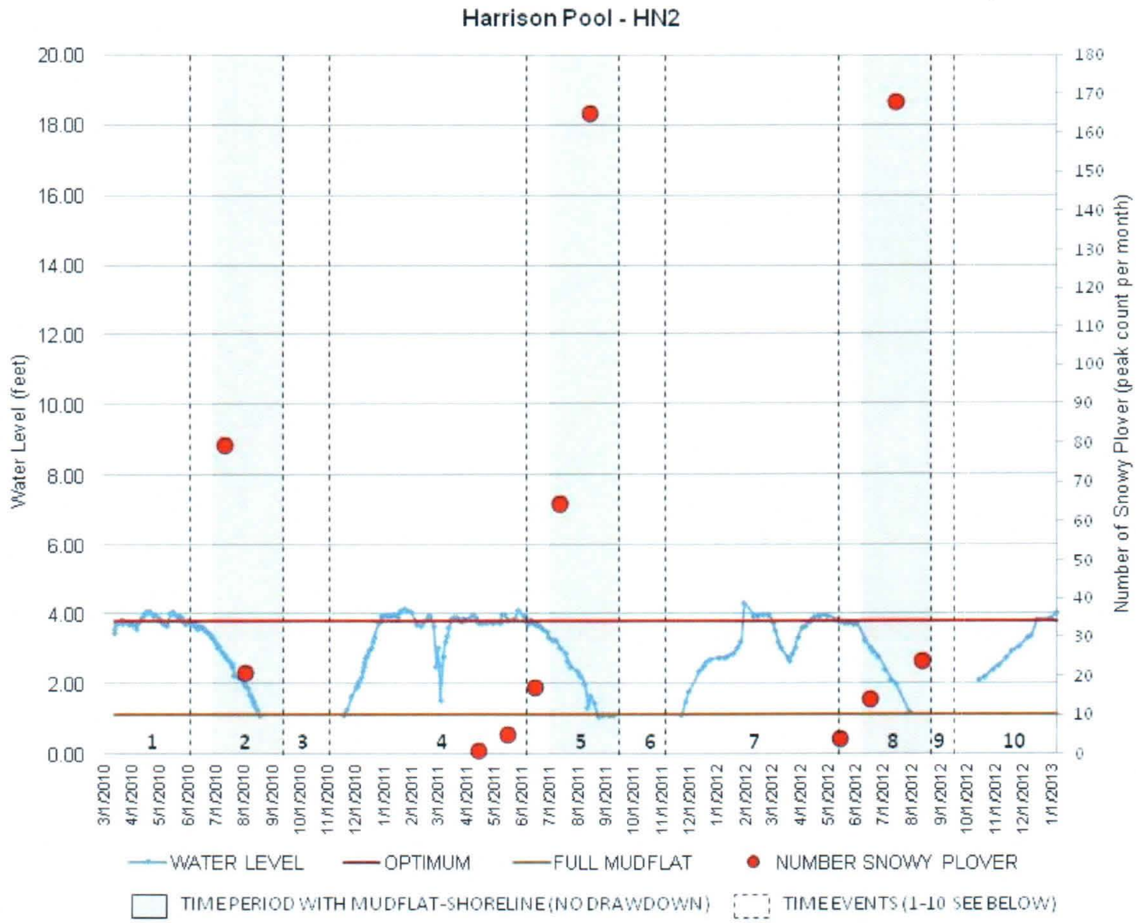
the staff gauge due to a silted-in channel between the pool and water control structure for outflow.

34. Pool area fully dry (silted channel was dredged out with excavator).
35. Water level restored to "optimum pool" then pool maintained/flushed with continued flows (water surplus period).
36. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). Mudflat-shoreline habitat was available, but no SNPL recorded by Ellis or Fish Springs staff.
37. Water level restored to "optimum pool" then pool maintained/flushed with continued flows (water surplus period). Mudflat-shoreline habitat was available during early portion of period, but no SNPL recorded by Ellis or Fish Springs staff.

Pintail Pool Water Quality - Conductivity



2010-2012 Harrison Pool water management – relationship to SNPL use

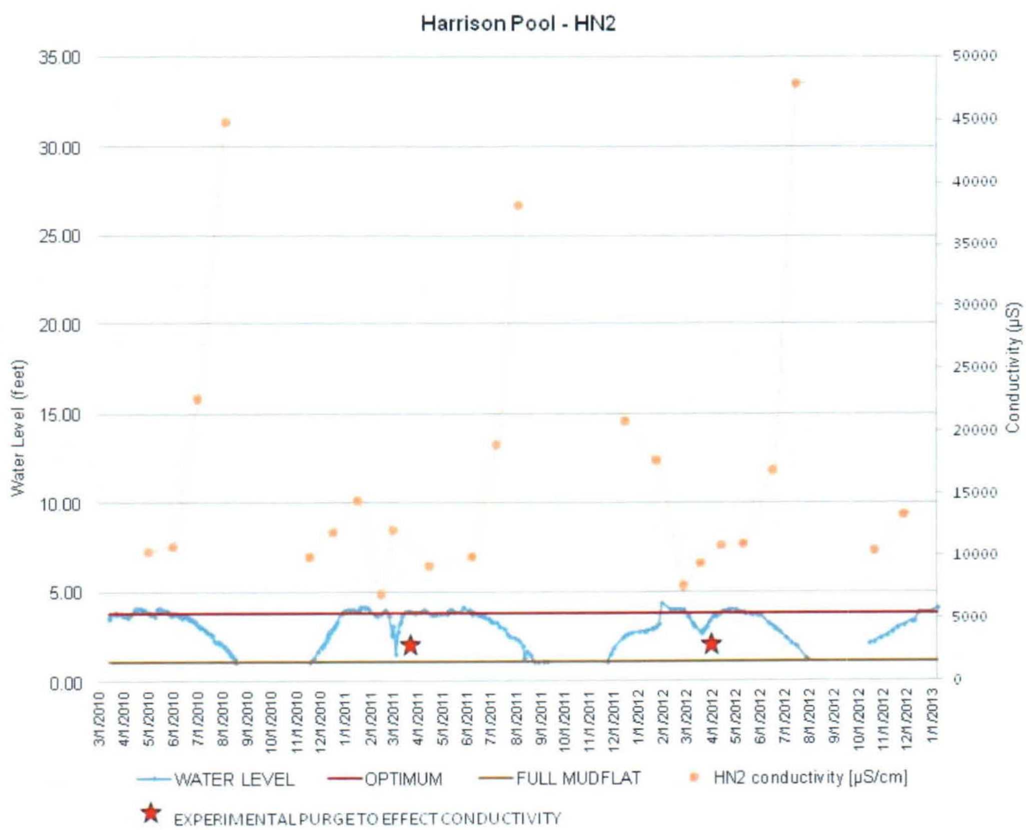


<u>Time Events - by corresponding number (1-10):</u>

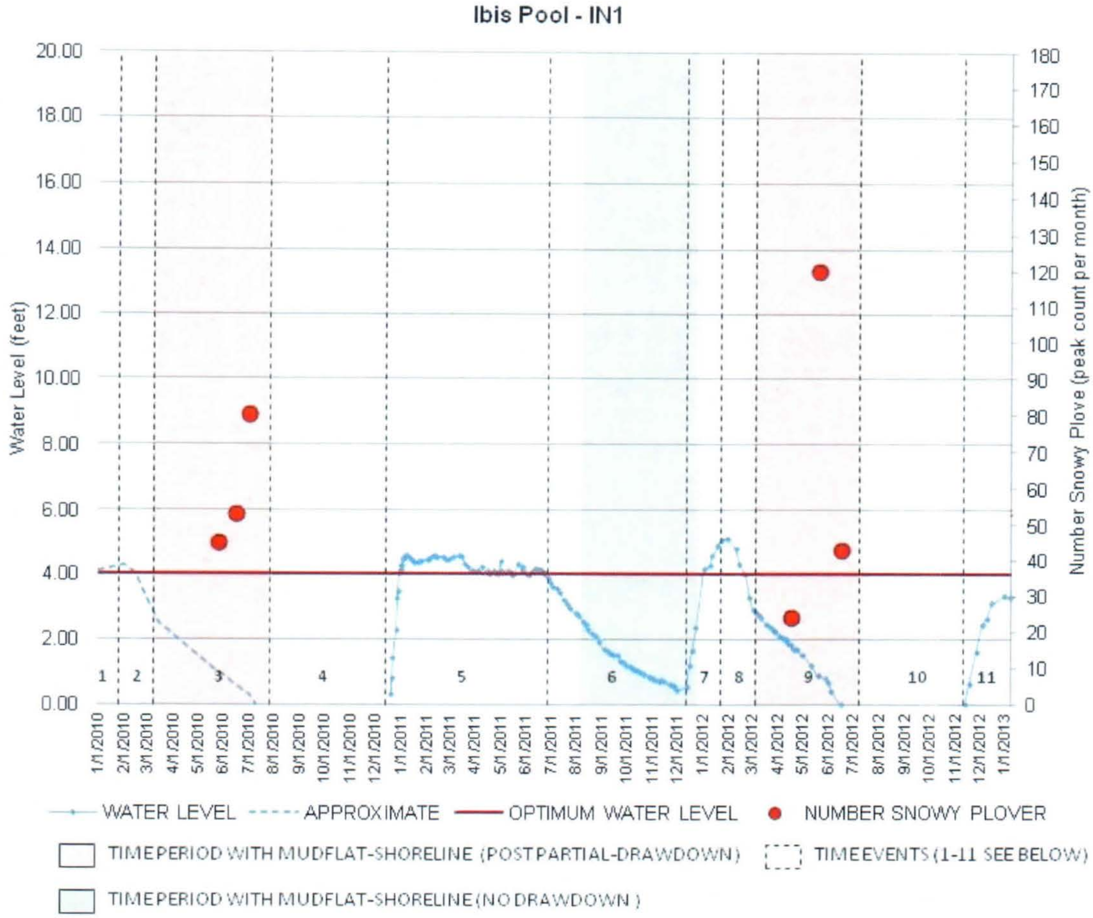
1. Water held near "optimum pool" level (3.80 feet on staff gauge of WCS HN2).
2. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). Mudflat-shoreline habitat was available during the mid to later portion of the period (once mostly mudflat, isolated pools of sheet-water persisted until eventually evaporating dry); ***SNPL use (peak counts per month by Fish Springs staff).***
3. Pool area fully dry.
4. Water restored to "optimum pool" level, then pool maintained/flushed with continued flows (water surplus period).
5. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). Mudflat-shoreline habitat was available during the mid to later portion of the period (once mostly mudflat, isolated pools of sheet-water persisted until eventually evaporating dry); ***SNPL use (peak counts per month by Ellis).***
6. Pool area fully dry.

7. Water restored to "optimum pool" level, then pool maintained/flushed with continued flows (water surplus period).
8. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). Mudflat-shoreline habitat was available during the mid to later portion of the period (once mostly mudflat, isolated pools of sheet-water persisted until eventually evaporating dry); ***SNPL use (peak counts per month by Ellis).***
9. Pool area fully dry.
10. Water restored to "optimum pool" level, then pool maintained/flushed with continued flows (water surplus period).

Harrison Pool Water Quality - Conductivity



2010-2012 Ibis Pool water management – relationship to SNPL use

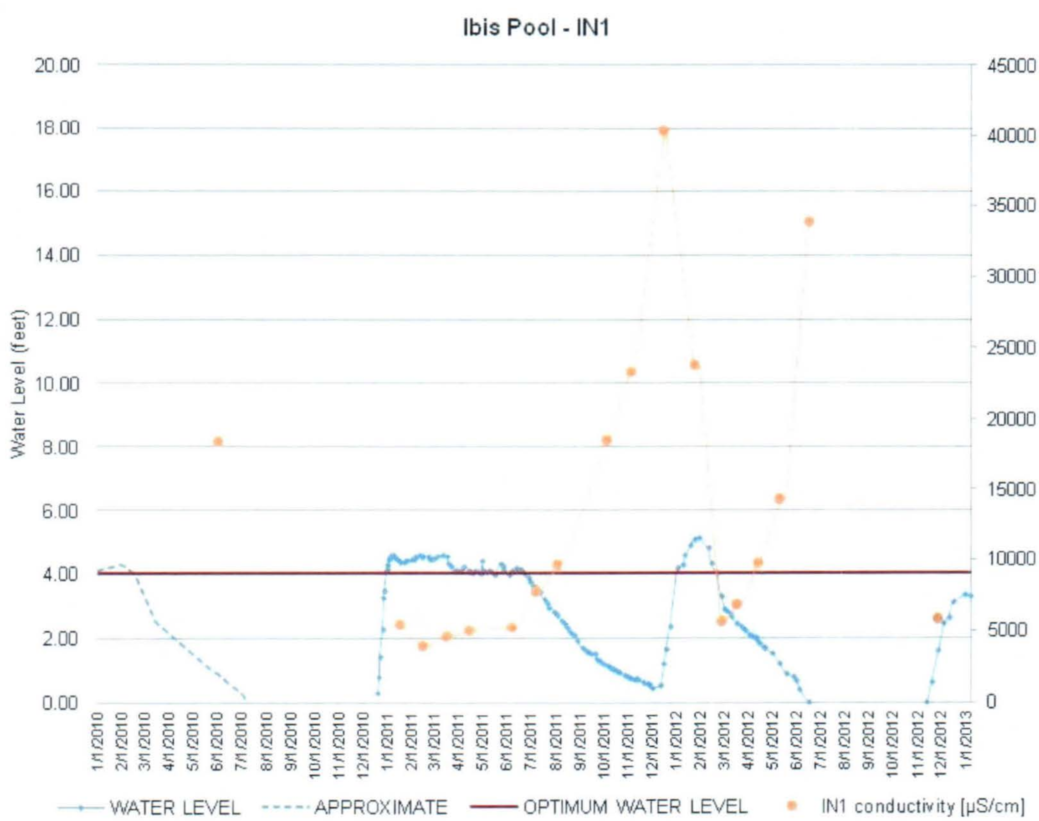


<u>Time Events - by corresponding number (1-11):</u>

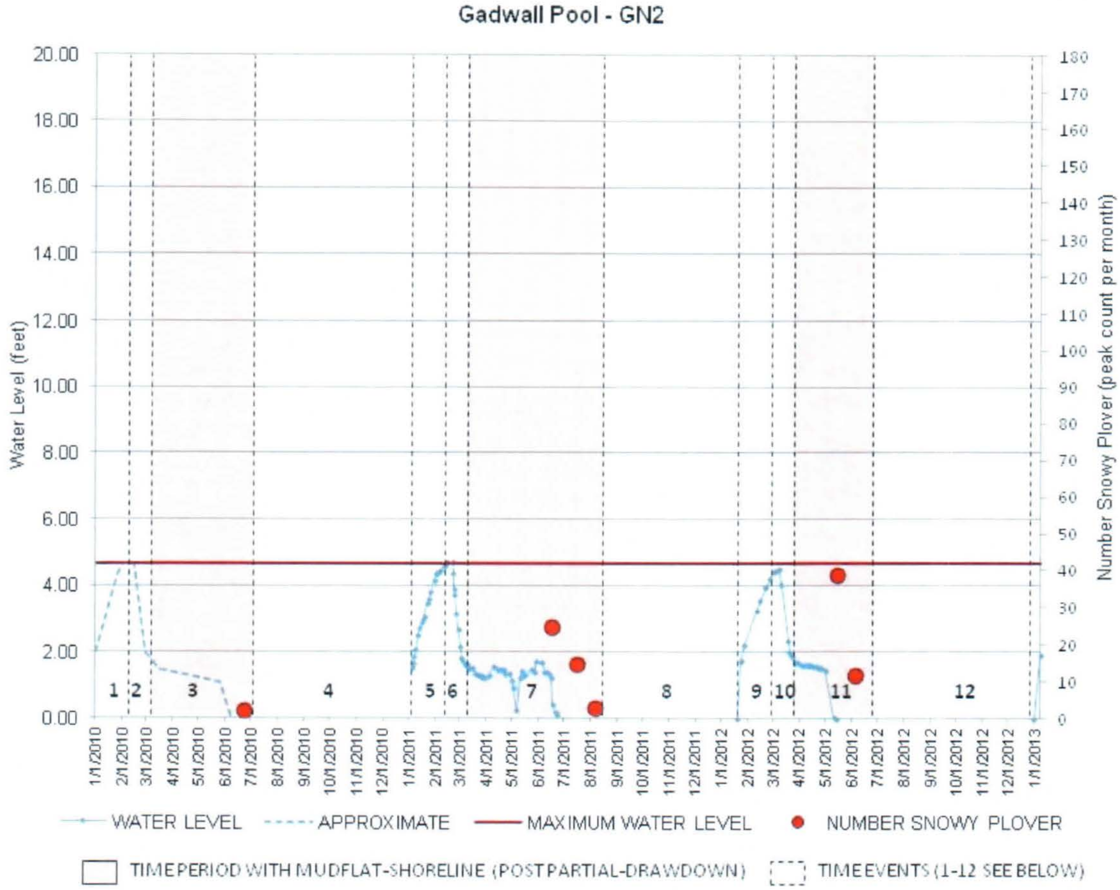
1. Water held near "optimum pool" level (4.00 feet on staff gauge of WCS IN1).
2. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
3. ***Available mudflat-shoreline habitat and corresponding use by foraging SNPL (peak counts by month by Fish Springs staff – no SNPL counts in April).*** The pool water level was not recordable on the staff gauge during the later portion of time period, due to a land-bridge between the pool and the water control structure for outflow. This partial pool persisted in a large, shallow depression in the pond bottom until eventually evaporating dry.
4. Pool area fully dry.
5. Water restored to "optimum pool" level, then pool maintained/flushed with continued flows (water surplus period).
6. No prescribed water level drawdown. Water level decrease driven by no flow input and high ET loss (water deficit period - summer). Mudflat-shoreline habitat was available (late Aug-Dec), but no SNPL use recorded by Ellis or Fish Springs staff.

7. Water level restored to "optimum pool" then pool maintained/flushed with continued flows (water surplus period).
8. ***Prescribed partial drawdown of water level to create mudflat shoreline habitat around the reduced pool area.***
9. ***Available mudflat-shoreline habitat and corresponding use by foraging SNPL (peak counts by month by Ellis).*** The pool water level was not recordable on the staff gauge during the later portion of this time period, due to a land-bridge between the pool area and the water control structure for outflow. The pool persisted in a large, shallow depression until eventually evaporating dry.
10. Pool area fully dry.
11. Water level restored to "optimum pool" then pool maintained/flushed with continued flows (water surplus period).

Ibis Pool Water Quality - Conductivity



2010-2012 Gadwall Pool water management – relationship to SNPL use



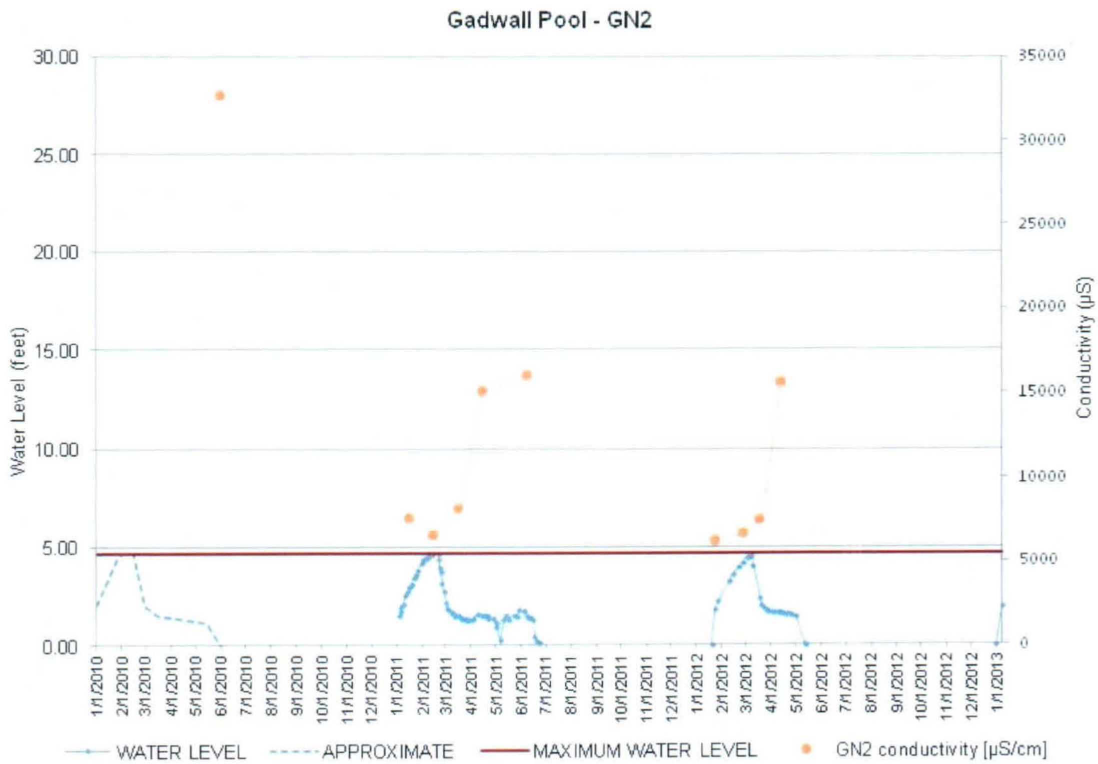
<u>Time Events - by corresponding number (1-12):</u>

1. Water held near maximum level (4.66 feet on staff gauge of WCS GN2).
2. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
3. ***Available mudflat-shoreline habitat and corresponding use by foraging SNPL (peak counts by month by Fish Springs staff – no SNPL counts completed in April).*** The pool water level was not recordable on the staff gauge during the later portion of time period, due to a land-bridge between the pool and the water control structure for outflow. A partial pool persisted in a large, shallow depression in the pond bottom until eventually evaporating dry.
4. Pool area fully dry.
5. Water restored to maximum level (water surplus period).
6. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
7. ***Available mudflat-shoreline habitat and corresponding use by foraging SNPL (peak counts by month by Ellis) .*** The pool water level was not recordable on the staff gauge during the later portion of time period, due to a land-bridge between the pool and the water control structure for outflow. A partial pool

persisted in a large, shallow depression in the pond bottom until eventually evaporating dry.

8. Pool area fully dry.
9. Water restored to maximum level (water surplus period).
10. ***Prescribed partial drawdown of the pool water level to provide mudflat-shoreline habitat around the reduced area of inundation.***
11. ***Available mudflat-shoreline habitat and corresponding use by foraging SNPL (peak counts by month by Ellis) .*** The pool water level was not recordable on the staff gauge during the later portion of time period, due to a land-bridge between the pool and the water control structure for outflow. A partial pool persisted in a large, shallow depression in the pond bottom until eventually evaporating dry.
12. Pool area fully dry.

Ibis Pool Water Quality - Conductivity



Appendix N.
Christmas Bird Count and Mid-Winter Waterfowl Survey

2010-12 count data compared to 2009. Species listed are the total historic list of species recorded during the CBC since 1980.

Species	2012 113	2011 112	2010 111	2009 110
American Avocet				
American Bittern	1	2	3	8
American Coot	425	1,603	1,080	1,122
American Crow				
American Goldfinch	1	5	17	7
American Kestrel				
American Pipit	3		1	22
American Robin		1	1	1
American Tree Sparrow	2	13	18	5
American White Pelican				
American Wigeon	120	450	250	152
Bald Eagle		4	2	1
Barn Owl				
Barn Swallow				
Bewick's Wren				
Black-billed Magpie				
Black-crowned Night-Heron	3	32	20	20
Black-throated Sparrow				
Blue-winged Teal				
Brewer's Blackbird			1	
Bufflehead			1	2
Bushtit				
Buteo sp.				
Canada goose		45	90	20
Canvasback	29	5	4	1
Cedar Waxwing				29
Chukar		2		
Cinnamon Teal	2	3	6	3
Common Goldeneye	1	1	1	7
Common Merganser				
Common Raven	28	11	665	15
Common Redpoll				
Dark-eyed Junco		12	8	14

Eared Grebe				
Eurasian Wigeon				
European Starling	cw	3	2500	1
Gadwall	201	200	150	360
Golden Eagle	3	1	1	2
Great Blue Heron	28	6	8	9
Great Egret	2	2	1	1
Great Horned Owl		1	2	2
Greater Yellowlegs	8	21	21	22
Green-winged Teal	350	600	600	400
Hairy Woodpecker				
Harris's Sparrow				
Hermit Thrush				
Hooded Merganser				
Horned Grebe				
Horned Lark	81	168	800	47
House Finch				
House Sparrow				
House Wren	1			
Juniper Titmouse				
Killdeer				
Lapland Longspur				
Lesser Goldfinch				
Lesser Scaup	7	1	1	1
Lesser Yellowlegs				
Loggerhead Shrike	2	6	6	4
Long-billed Dowitcher				
Long-eared Owl				
Mallard	370	180	250	400
Marsh Wren	3	5	13	63
Merlin				
Mountain Bluebird				
Mountain Chickadee				
Northern Flicker		2	1	
Northern Harrier	23	5	14	15
Northern Pintail	1004	700	500	900
Northern Shoveler	14	35	50	30
Northern Shrike				1
peep sp.				
Peregrine Falcon				

Pied-billed Grebe	37	17	40	40
Pine Siskin				
Pinyon Jay				
Prairie Falcon		1	1	2
Redhead	6	6	5	4
Red-tailed Hawk				
Red-winged Blackbird		7	40	14
Ring-billed Gull	1			
Ring-necked Duck	450	100	75	50
Ring-necked Pheasant				
Rough-legged Hawk	7	3	1	2
Ruby-crowned Kinglet				
Ruddy Duck	6	4	5	5
Rusty Blackbird				
Sage Sparrow		4	3	5
Sage Thrasher				
sandpiper sp.				
Savannah Sparrow	5			
scrub-jay sp.				
Sharp-shinned Hawk				
Short-eared Owl	5			
Snowy Egret				
Song Sparrow		29	110	73
Sora		2	1	
sparrow sp.	1			
Spotted Towhee				
Townsend's Solitaire		2		
Trumpeter Swan				
Tundra Swan	65	81	67	65
Virginia Rail	6	2	20	23
Water Pipit				
Western Meadowlark		1	1	
Western Scrub-Jay				
White-crowned Sparrow	1	3	2	2
White-faced Ibis	1			1
Wilson's Snipe		1	4	1
Yellow-rumped Warbler				

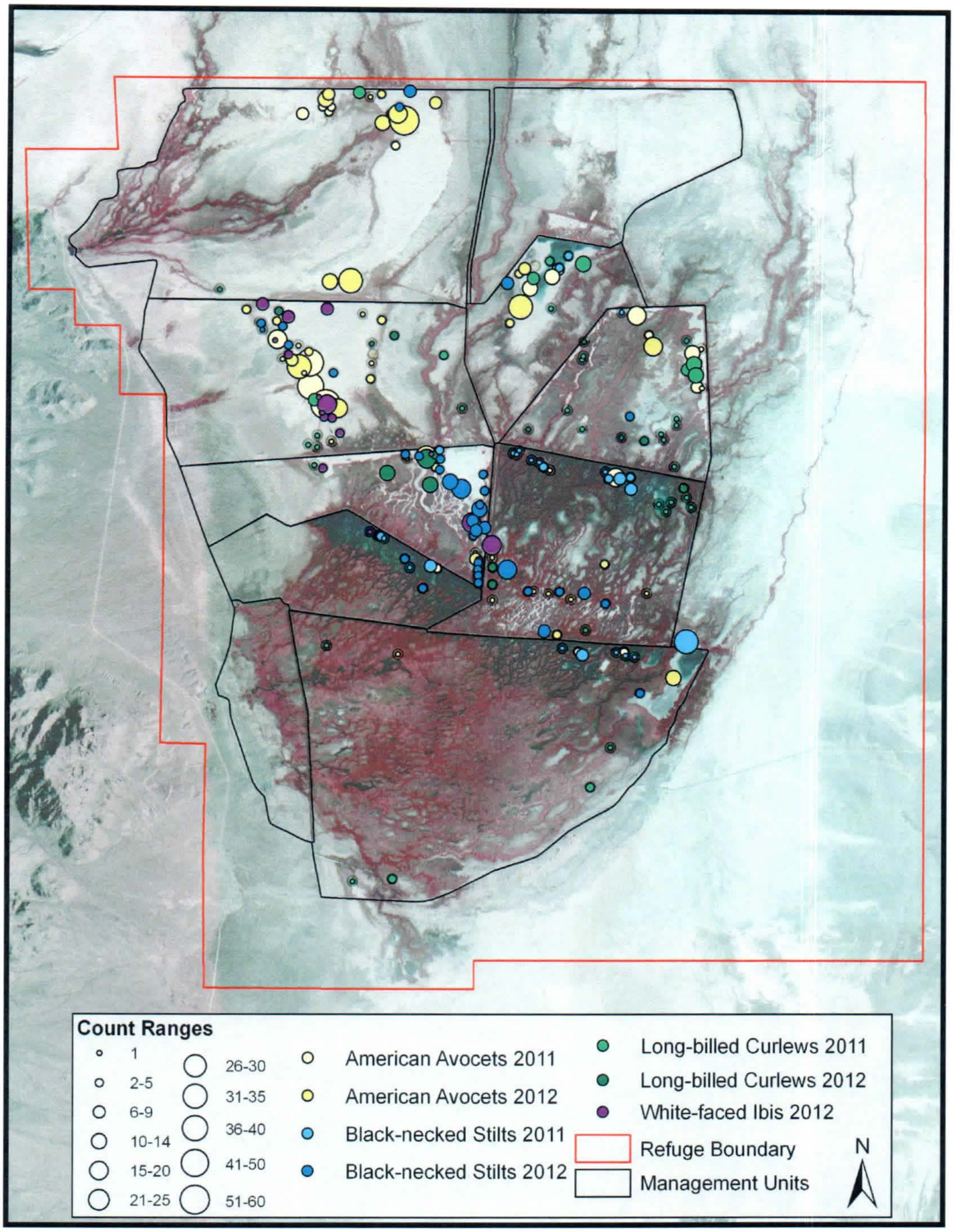
Appendix O.
National Breeding Bird Survey (Callao Route)

Species List	2010	2011	2012
Canada Goose	158	500	30
Gadwall	10	50	6
American Wigeon	0	0	0
Mallard	5	13	0
Blue-winged Teal	0	0	0
Cinnamon Teal	0	0	2
Northern Shoveler	2	0	0
Northern Pintail	17	0	0
Green-winged Teal	30	0	0
Canvasback	2	22	0
Redhead	19	40	2
Ring-necked Duck	0	0	0
Lesser Scaup	4	0	0
Ruddy Duck	0	0	0
Chukar	0	0	0
Ring-necked Pheasant	0	0	0
Pied-billed Grebe	0	1	0
Eared Grebe	7	1	0
Western Grebe	0	0	0
Clark's Grebe	0	2	0
Double-crested Cormorant	0	2	0
American White Pelican	0	3	14
American Bittern	1	2	6
Great Blue Heron	14	3	3
Snowy Egret	1	0	0
Cattle Egret	0	0	0
Black-crowned Night-Heron	2	0	2
White-faced Ibis	0	0	3
Osprey	0	0	0
Northern Harrier	0	0	0
Red-tailed Hawk	0	0	0
Golden Eagle	0	1	0
American Kestrel	0	0	0
Prairie Falcon	0	0	0
Virginia Rail	1	3	0
American Coot	0	1	6

Sandhill Crane	2	0	0
Snowy Plover	2	9	10
Killdeer	3	3	0
Black-necked Stilt	13	2	11
American Avocet	37	6	39
Spotted Sandpiper	2	0	0
Willet	15	0	7
Long-billed Curlew	11	0	7
Wilson's Snipe	0	0	0
Wilson's Phalarope	5	0	16
Franklin's Gull	0	0	1
Ring-billed Gull	0	0	0
California Gull	1	0	1
Caspian Tern	0	5	1
Black Tern	0	0	0
Forster's Tern	0	0	3
Mourning Dove	4	9	0
Burrowing Owl	0	0	1
Short-eared Owl	0	0	1
Common Nighthawk	9	1	2
Western Wood-Pewee	1	0	0
Say's Phoebe	0	2	2
Western Kingbird	9	5	4
Loggerhead Shrike	0	2	5
Common Raven	27	7	14
Horned Lark	17	7	15
Tree Swallow	0	0	0
Violet-green Swallow	0	0	3
Northern Rough-winged Swallow	0	2	0
Cliff Swallow	0	0	2
Barn Swallow	35	9	14
Rock Wren	4	6	2
Marsh Wren	1	1	1
Mountain Bluebird	0	5	0
American Robin	0	0	0
Northern Mockingbird	2	3	6
Sage Thrasher	0	4	1
Common Yellowthroat	22	16	8
Yellow Warbler	2	0	0

Brewer's Sparrow	7	0	0
Vesper Sparrow	0	0	0
Lark Sparrow	0	3	7
Black-throated Sparrow	34	22	30
Sage Sparrow	0	0	0
Savannah Sparrow	0	34	77
Song Sparrow	50	0	0
White-crowned Sparrow	0	0	0
Western Tanager	1	0	0
Black-headed Grosbeak	0	0	0
Lazuli Bunting	0	0	0
Red-winged Blackbird	104	32	43
Western Meadowlark	59	28	46
Yellow-headed Blackbird	81	20	9
Brown-headed Cowbird	0	2	0
Bullock's Oriole	0	0	0
House Finch	0	0	0
Pine Siskin	0	0	0
Lesser Goldfinch	0	0	0
American Goldfinch	0	0	0
House Sparrow	0	0	0
Total Species	**44**	**42**	**42**
Total individuals	**833**	**889**	**463**

Appendix P.
Special Avian Survey RLGIS map



Appendix K.
Coyote Scat Analysis Report (Maier)

See next page.

Summary of Coyote Scat Analysis for Bird Consumption Summer 2011

BROMWYN MAIER AND BRYANNE COLVER

HYPOTHESIS:

It was hypothesized that coyotes were indeed consuming birds on the refuge, and of the samples that would be collected and analyzed, 20% would contain bird remains.

After analysis of 265 samples, it was found that coyotes are eating birds, and of the samples collected, 34.71% contain bird remains.

STUDY AREA:

Study Area Coordinates	
Toploader	
113°23'42.522"W 39°52'56.784"N	Start
113°23'24.263"W 39°52'56.001"N	End 1
113°23'19.829"W 39°52'55.74"N	End 2
Goospu	
113°20'49.325"W 39°51'48.183"N	Start
113°21'3.932"W 39°51'51.052"N	End 1
113°21'10.974"W 39°51'52.356"N	End 2
Winding Road	
113°22'11.75"W 39°51'9.579"N	Start
113°21'59.49"W 39°51'5.145"N	End 1
113°22'11.75"W 39°51'9.579"N	End 2
Mallard	
113°23'3.135"W 39°50'57.32"N	Start
113°23'24.785"W 39°51'0.189"N	End

METHODS:

I Creating Study Areas

1 Select a segment of road on the refuge approximately 600 yards (548.64 meters) in length

2. Walk the length of the road at a slow pace, scanning the area from the middle of the road (to the left) to the shoulder of the road (to the right). All areas that are graveled, up to the first line of dense vegetation, should be scanned
3. Using the shovel, remove all bits of coyote scat, throwing it off the road so that it will not be confused with new scat. If there is confusion over whether or not scat on the road is coyote scat, remove the scat.
4. If clearing the road without aid, walk the length of the segment observing only one half of the road (from the middle of the road to the shoulder on the right). Once the length of the sample area has been cleared, turn and walk back toward the starting point of the sample area, scanning the other half of the road (middle of the road to the shoulder on the right). Thus both sides of the road will be cleared and attention will be equally divided between both halves of the road.

II Collecting Samples

1. Three weeks after clearing the study areas of all coyote scat, return to the study areas and begin collection
2. Walk the length of the road at a slow pace, scanning the area from the middle of the road (to the left) to the shoulder of the road (to the right). All areas that are graveled, up to the first line of vegetation, should be scanned.
3. Using the shovel, pick up all coyote scat and place each new pile of scat in a fresh plastic sandwich bag. Wrapping the scat in tinfoil is also acceptable.
4. Place the plastic bag (or foil-wrapped scat) in a large plastic bag set aside for each study area.
5. When storing the samples, label each study area bag with the name of the study area the samples were collected from, the date they were collected, and "General".

III Analyzing Samples

1. At the lab, remove a sample from one of the study area plastic bags.
2. Empty the contents of the foil or plastic bag into an examination tray
3. Using plastic gloves, a face mask, and protective eyewear to minimize exposure to the feces, pick apart the sample, searching for scales, feathers, fur, insect exoskeletons, and plant remains.
   - Do not mark a sample for bird remains unless at least one feather is found within the scat
   - Do not mark a sample for mammal remains unless at least one hair is found within the scat
   - Do not mark a sample for reptiles/amphibians unless at least one scale is found
   - Do not mark a sample for "other" unless one seed, insect exoskeleton or plant part is found
4. After picking apart the sample so that the inside of the scat has been thoroughly searched, mark on a data sheet all the categories of remains (bird, mammal, reptile/amphibian, other) that were observed within the sample.
   - If plant, egg, or insect remains were found in the sample, identify what "other" was found within the scat and write it down in the "notes" column
5. Keep a separate data sheet for each sample area.
6. After recording the categories of remains found within the scat, do one of the following:

- If the scat contains bird remains, return as much of the sample as possible to the sandwich bag or foil wrapping that the sample was contained within and place the sample in a large plastic bag labeled with the study area name, the date collected, and "Bird."
- If the scat doesn't contain bird remains, dump the examination tray into a large plastic bag labeled with the study area name, the date collected, and "Other"

7 Keep separate post-analysis large plastic bags for each study area

IV Analyzing Data

1 In a Microsoft Excel document, record the categories found within each sample by placing a "1" within each category identified within the sample.

2 Calculate the total number of times each category was found within the samples by study area

3 To get the percentage of samples containing bird remains, divide the total number of times bird remains were observed in a study area by the total number of samples collected in that study area.

RESULTS:

FIGURE 1

Coyote Scat Analysis Summary (by sample area and total)						
Sample Area	Bird	Mammal	Rept/Amp	Other	# of Samples	% Bird
Goospu	22	30	4	17	50	44
Toploader	17	42	3	4	47	36.17021
Mallard	32	113	27	20	124	25.80645
Winding Road	21	36	5	14	44	47.72727
TOTALS	92	221	39	55	265	34.71698

FIGURE 1: This table display s the number of times each category of remains was found within analyzed samples. The percentage of samples containing bird remains are displayed in a separate column.

FIGURE 2

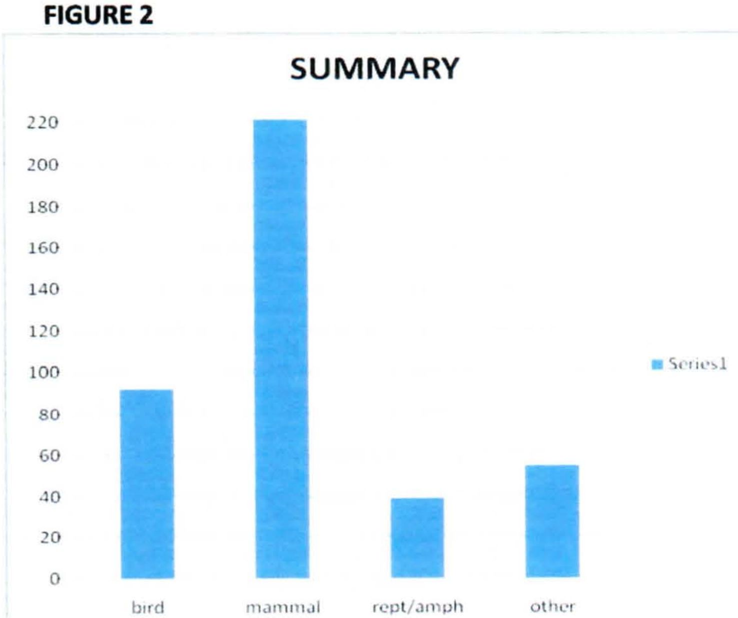


FIGURE 2: This graph displays the total number of times samples contained each category of remains.

URE 3

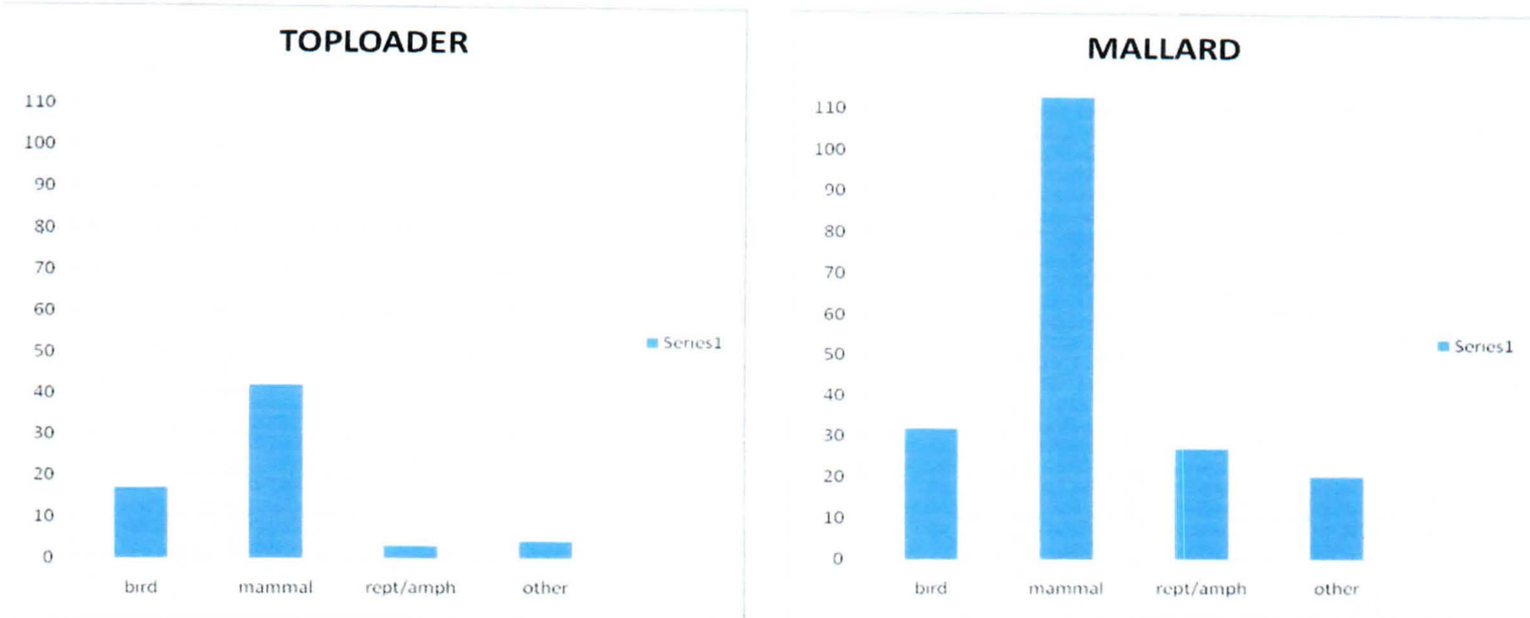
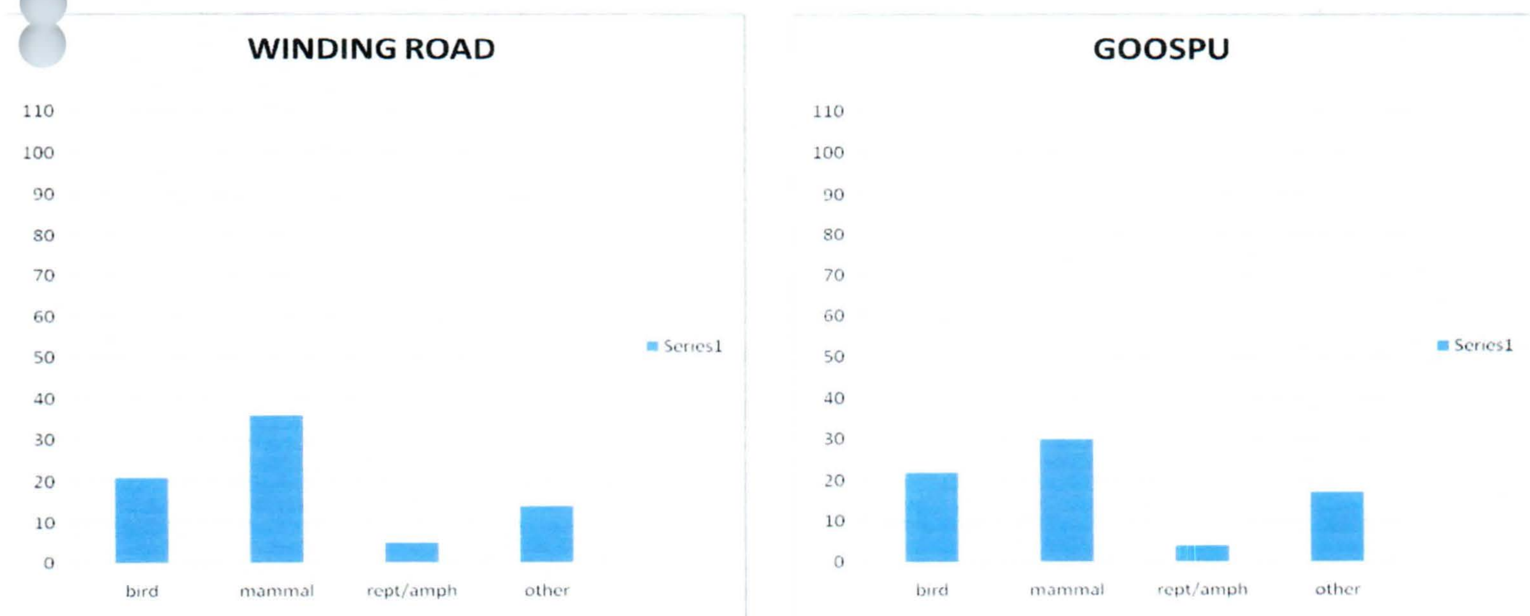


FIGURE 3: These graphs display the number of times each category of remains was found within analyzed samples.



SOURCES OF ERROR:

As a preliminary study, there are several sources of error, due to the fact that the procedure has been previously untried on the refuge and the subject has not been pursued in this manner in the past. Sources of error within this study include:

- Misidentification of digested material: data may have been skewed due to the difficulty in distinguishing digested bird down from digested fur, and digested reptile scales from digested insect skeletons.
- Failure to observe remains while sorting through scat: due to the fact that a single hair or feather, scale or insect exoskeleton determined whether or not a sample was recorded as one containing mammal, bird, reptile or insect, these small pieces of evidence could have been overlooked just by failing to break apart every piece of the scat and thus changed results.
- Inconsistencies in sorting through scat samples: breaking apart and picking through one piece of scat more than another might reveal evidence that wasn't observed in another sample due solely to a less thorough inspection of the scat.
- Failure to remove all previous scat from sample areas: When preparing the road before the scat sampling period, some scat may have been left from months prior to the study, potentially skewing the data in a way that doesn't necessarily reflect coyote diet during the nesting season. This source of error isn't believed to be a major contributor to errors in this study.
- Remains within the scat were not actually ingested: Although considered a less likely source of error, it is possible that items collected within the scat were on the road where the scat was dropped, and were thusly mistaken as part of the scat.
- One sample mistaken for two, or two samples mistaken for one: Scat piles may have been separated by movement of the defecating animal, traffic on the road, or weather conditions, causing samples that were near one another, that were in fact two separate piles of scat, to be mistaken for one sample, or samples that were farther apart, that were in fact parts of the same sample, to be mistaken for two samples.

SUGGESTIONS FOR FUTURE RESEARCH:

If this study was to be repeated in the future, these suggestions might be taken into consideration to improve the study and remove some of the bias inherent in human actions.

- Mark the limits of the study area: While "scanning the road to the first line of dense vegetation" often provided a clear edge to a study area, there were occasions where there was confusion concerning the edge of a study area. The first line of dense vegetation was occasionally dead and fallen, due to chemical spraying or heat, and then it was unclear whether the sample area should expand to the first living vegetation or remain along the line of the dead vegetation. In the future, marking the edges of the sample area with a washable spray paint may prove useful.

- Create a distance for samples to be separated to be considered separate samples: A standardized distance should be established to identify samples as parts of one scat pile or two different, closely placed scat piles. If two pieces of scat are farther apart than this standardized space, they should be considered two separate samples. Unless they are clearly two different samples (one is entirely composed of insect carapaces, and the other is almost completely composed of fur), all samples lying within that distance should be considered one sample. While this won't entirely eliminate the error of one sample being mistaken for two or vice versa, this can help remove some human bias associated with sample collection.

DISCUSSION:

The original motivation for this study was to gain information that would ultimately allow a decision to be made regarding whether or not there was reason to begin coyote population control on the refuge. While this preliminary study did provide a rough picture of what portion of the coyote diet may include birds, along with information to support the position that coyotes are preying upon birds during the nesting season, this study did not provide the information necessary to make a decision regarding coyote population control. To gain a sense of the significance of this study's findings, it would be beneficial to compare the dietary ratio of the coyotes on the refuge to coyotes elsewhere. Only comparison could contribute to an understanding of whether or not the coyotes' bird predation is above what is to be expected in the coyote diet. However, comparison would not reveal whether or not the coyotes of the Fish Springs National Wildlife Refuge (FSNWR) are preferentially seeking nests during the nesting season. On a refuge with a population of ground nesting birds, it is to be expected that birds would make up some portion of the coyote diet. It may even be expected that, in comparison to similar refuges, coyotes found on FSNWR may have a higher proportion of bird in their diet if nests and nesting birds make up a higher proportion of the potential prey base at this refuge compared to similar refuges.

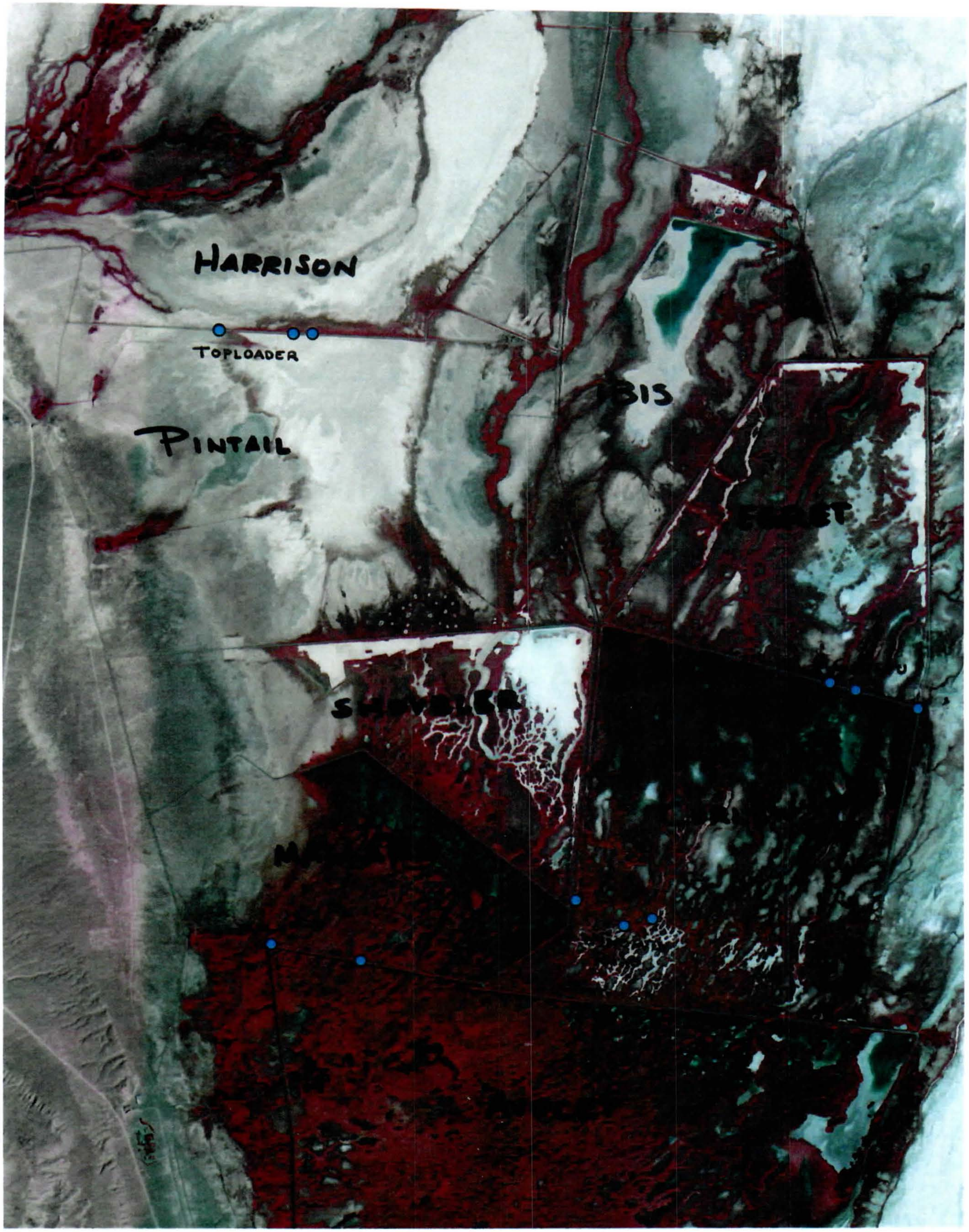
To provide evidence to support the theory that coyotes are preferentially preying upon nests and nesting birds would require a different approach to assessing the FSNWR coyote diet. In wildlife behavior, preference is indicated by an animal using one resource at a rate disproportionate to its availability[1]. For example, if nests and nesting birds made up 20% of the potential prey base for coyotes on the refuge, and bird appeared in the coyote diet 50% of the time, assuming equal availability of all prey, coyotes would be preying upon birds at a rate disproportionate to the availability of the nests and nesting individuals. With data such as this, one could begin to support the theory that coyotes are preferentially preying upon nests and nesting birds. To begin such a study, one might begin nest surveys and pitfall trap surveys to get a clearer sense of the potential prey base available on the refuge, and couple these findings with coyote dietary analysis, perhaps similar to that seen in this 2011 coyote scat survey.

While evidence to support the position that FSNWR coyotes are preferentially preying upon nests and nesting birds would be useful, one would still lack the necessary evidence to make a decision regarding coyote population control. Without a sense of the impact coyote predation is having on the bird populations of FSNWR, one couldn't support the position that coyote predation needs to be controlled. The coyote population on the refuge may consume a hundred birds in a nesting season, but if the bird populations of the refuge are robust enough, coyote predation may not be significantly affecting overall bird population dynamics. Therefore, one might begin a study to see what proportion of the bird populations on the refuge are affected by coyote predation. In the past, studies were conducted on the refuge to get a sense of which predators were leading to nest destruction. Similar studies could be implemented in the future to assess the proportion of nests being destroyed by coyote predation. A clearer picture of bird population dynamics (which is being somewhat addressed at this time through bird count surveys conducted each month) on the refuge would also be essential in understanding the impact of coyote predation on nests and nesting birds on the refuge and making a decision regarding coyote population control.

---

[1] Diego-Rasilla, Fransisco Javier, and Valentin Perez-Mellado. "Home range and habitat selection by Podarcis hispanica (Squamata,." *Folia Zool* 52.1 (2003): 87-98. Web. 1 Aug 2011. <http://www.ivb.cz/folia/52/1/87-98.pdf>.

MAP OF STUDY AREAS



EXAMPLE OF DATA RECORDING

Winding Road--Collected June 18, 2011

	Bird	Mammal	Rept/Amph	Other	Notes
1	x				
2		x	x		
3	x			x	seeds
4		x			
5	x	x		x	insects, seeds
6					
7					
8					
9					
10					
11					
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Appendix K.
2012 nest predator report (Haffele)

See next page.

2012 Fish Springs NWR Predator Report

Prepared by:

Ryan Haffele
U. S. Fish and Wildlife Service
July 25, 2012

Introduction

Predator populations can have profound effects on the population dynamics of their prey, most notably through direct consumption. A less recognized effect is behavioral changes that are caused by the presence of predators, which affect the survival and reproduction of prey species (Nelson et al. 2004). Predators have been identified as the most important cause in reproductive failure for bird species, primarily through the predation of eggs (Ricklefs 1969). Previous studies, however, have found that perceived predation pressure can also impact reproductive investment and success of avifauna. Fontaine and Martin (2006) found increased parental investment of passerines on areas where predators were experimentally removed. Another study found decreased clutch sizes (a surrogate for reproductive investment) of Collared Flycatchers (*Ficedula albicollis*) in areas with experimentally increased predation rates (Doligez and Clobert 2003). Finally, Dassow (2010) found evidence that dabbling duck hens are able to identify and avoid high predator density areas when selecting a nest site.

Mesopredators, like red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), and raccoons (*Procyon lotor*) have been found to have an extreme negative effect on ground nesting bird success, with coyotes typically having less of an impact (Sovada et al. 1995). The predator composition at Fish Springs National Wildlife Refuge (FSNWR), however, is limited due to the extreme environment surrounding the refuge. Coyotes (*Canis latrans*), ravens (*Corvus corax*), and gopher snakes (*Pituophis melanoleucus*) have been identified as the most common predators present (FSNWR Coyote Management Plan 1980), with badgers (*Taxidea taxus*), raccoons, striped skunks, kit fox (*Vulpes macrotis*), and bobcats (*Lynx rufus*) also being seen on rare occasions (FSNWR Annual Report 1966; 67; 69). Understanding predator populations on the refuge is an important consideration when developing management plans to enhance ground nesting bird success.

Monitoring predator populations and activity levels on the refuge can help determine appropriate management actions to increase nest survival. Scat deposition surveys have been found to be correlated with estimates of animal density (Knowlton 1984). Deposition surveys also have the benefit of needing only one observer and being able to collect data over time without an observer present, making it a very practical technique at FSNWR (Henke and Knowlton 1995). There are biases involved with this technique, including a possible reduction in scat deposition due to removal of scats while preparing transects, decomposition of scat, and failure to detect scat. The last bias can be reduced by walking transects twice, once in each direction (see Henke and Knowlton 1995).

FSNWR was established with the primary focus on waterfowl production (FSNWR Marsh Management Plan). Since refuge establishment, predators have had a large impact limiting waterfowl production on the refuge (See 2012 Duck Production Report). Efforts have been made to control the impact of predators on production through predator management, with staff focusing on the removal of striped skunks, coyotes, ravens, and gopher snakes (Table 1). Coyotes were primarily removed through shooting and trapping, with the Animal Damage Control assisting with aerial shooting. Ravens were controlled through shooting, harassment, and eggs poisoned with avicide. Gopher snakes and striped skunks were removed through trapping efforts (FSNWR Animal Control Plan 1990). Despite a concern over the impacts of predation on ground nesting species at FSNWR, very little monitoring of predator populations has occurred. The objective of this study was to: 1) design a monitoring protocol to create an index of predator abundance on the refuge and 2) determine if the predator composition has changed from historical records, primarily the presence of striped skunks and raccoons.

Methods

Scat deposition transects (Andelt and Andelt 1984) were developed to determine a relative index to the predator populations, primarily coyotes, on FSNWR (Figure 1). A total of 5 1-km transects were created on roads within the refuge. Starting and ending locations were determined by selecting random points generated along roads in the refuge in ArcGIS (ESRI, Redlands, California, USA). Each road could only contain a maximum of 1 transect to ensure sampling of the entire refuge. The survey took place in late May to coincide with the nesting season. To perform the scat survey, each transect was walked twice, once from each direction, with observers identifying and removing all scat found on transects. Two weeks after clearing transects, observers walked each transect in both directions again, identifying and counting all scat located on transects. An index to predator populations was then calculated for each species in which scat was found. Indices were calculated as the number of scat deposited per day per km

$$\left(\frac{\frac{\#\ scat\ found}{km}}{day} \right).$$

To positively identify other potential predators that may be present on the refuge, remote camera traps were set up throughout the refuge. A total of 2 cameras were deployed at a time for 11 weeks. Cameras were fastened to steel posts and checked at ~ 2 week intervals. Bait stations consisting of sardines were established in front of each camera to attract predators.

Results

Results from predator surveys were overwhelmingly dominated by coyote. Throughout a total of 5 scat survey transects, 164 specimens were found, 162 of which were coyote. The remaining two specimens belonged to both skunk and red fox. The total deposition rate for all transects was 2.34 scat/km/day. Predator activity was concentrated along the southern end of the refuge; with 117 of the 164 scats being found on transect 4 for an index of 8.35 scat/km/day. All but one of these scats was from coyotes, with the other being identified as a red fox. Transect 3 contained the second-highest abundance of scat with 25, all coyote, resulting in an index of 1.79 scat/km/day. Transect 2 contained 12 scat, all attributed to coyote. The index for transect 2 was 0.88 scat/km/day. Transects 1 and 4 had a total of 4 and 5 scats, respectively, with 1 of the scats on transect 5 being identified as skunk scat. Indices for these transects were 0.29 and 0.43 scat/km/day, respectively. Camera traps were deployed for a total of 11 weeks, with 35 predators being captured by photo. On the camera set in Avocet unit, 9 animals were photographed, all coyote. In Gadwall unit, 1 coyote was captured on film, along with 4 common ravens. In the Handicap Blind area where a camera was placed, 3 coyotes were captured. Within lower Curlew unit, 3 coyotes were caught in the trap, along with 2 ravens. The last trap placed caught 2 coyotes, and 11 ravens.

Discussion

Based on the results found from predator surveys, coyotes have the highest population of all predators on the refuge. Common ravens were also present during the nesting season, which have been found to be efficient nest predators that can limit the productivity of other bird species (Angelstam 1986, Marzluff and Balda 1992). Nest predation has been reportedly high at FSNWR, presumably due to the large population of coyotes and ravens (See 2012 Duck Production Report). Due to the relatively inhospitable environment around FSNWR and the increased habitat diversity and abundance of water on the refuge, common prey items (i.e. lagomorphs, waterfowl, and small mammals) are likely attracted to the refuge, resulting in an increase in predators responding to an increased abundance of prey.

Historically, coyote populations peaked in the fall and winter at FSNWR (FSNWR Annual Report 1960), but indices from current surveys suggest they are abundant during the nesting season. This likely has negative effects on nesting species, as coyotes have been witnessed depredating nests (J. Bourne and E. Pero, personal observation). The primary food source for coyotes in this region is jackrabbits (Clark 1972), however, coyote populations and home range sizes have been shown to fluctuate with prey populations (Clark 1972, Mills and Knowlton 1991). When prey abundances drop below a level that is not energetically advantageous for coyotes to hunt, they will switch to an alternative prey (Bartel and Knowlton 2005). With the abundance of coyotes on the refuge during the nesting season, it is likely that ground nesting birds provide an alternative prey source, making it important to understand their population trends to ensure appropriate management actions are taken to alleviate their overall effect on nesting birds.

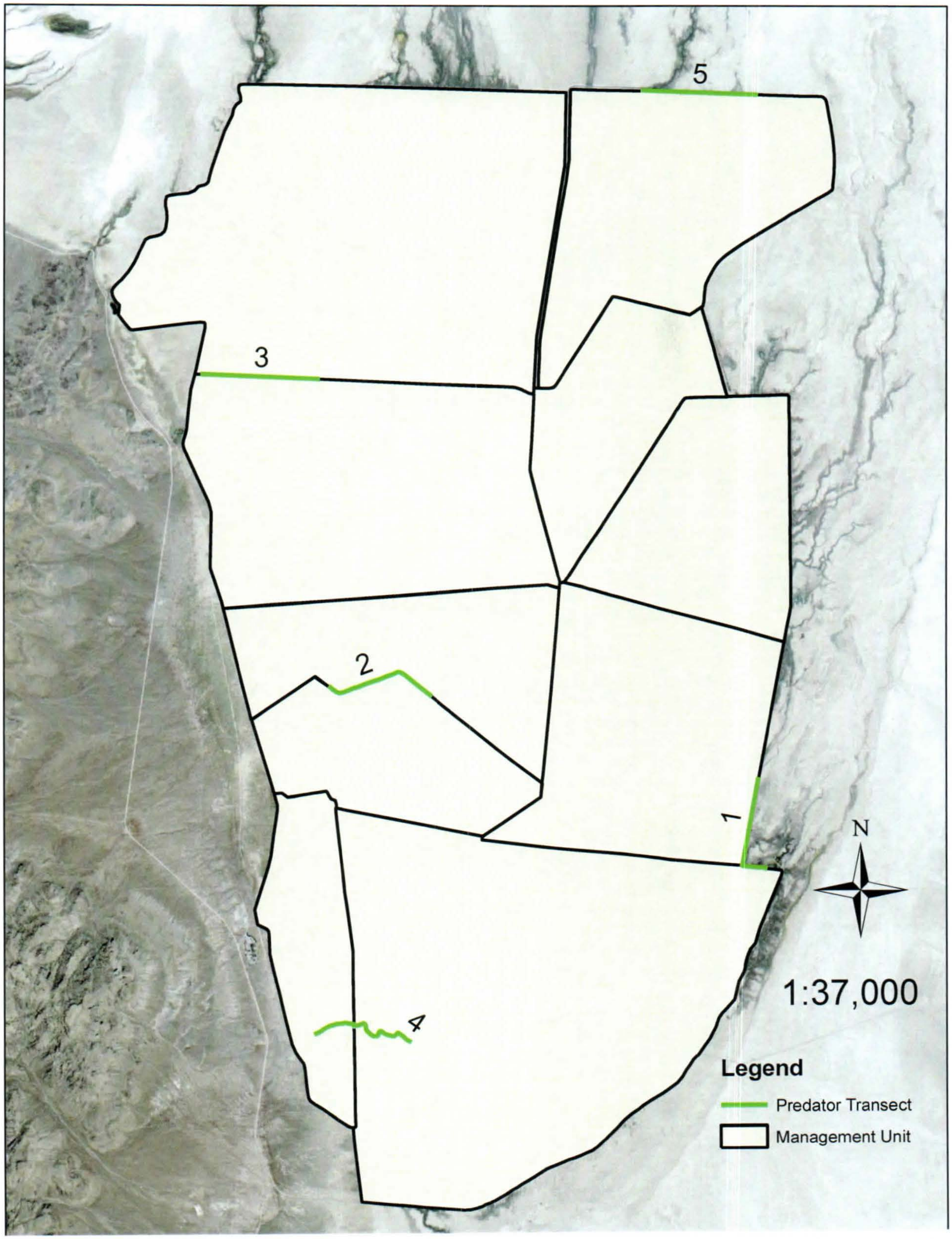
The identification of a skunk and red fox scat on the refuge is intriguing. Striped skunks have been found on the refuge previously, however, intensive management efforts were thought to have decreased the population to a level that would not affect nesting birds (FSNWR Coyote Management Plan 1980). If these mesopredators are present on the refuge, management actions to control the growth of their population may be needed, as they are more efficient foragers of ground nests and may reduce nesting productivity on the refuge even further (Sovada et al. 1995). Further investigation into the presence of these animals should be conducted, as observers conducting the surveys were novices at scat id. Baited camera traps placed in locations near where these scat were found did not capture skunk or red fox to give confirmation of the scat identification.

The data collected this year provides a baseline for predator population monitoring. Future monitoring should be conducted along the same transects to establish trends in populations. These trends can also be analyzed to determine how predator activity on the refuge changes over time. Additionally, surveys should be conducted during the same time period (i.e. nesting season) as seasonal changes in food items may cause bias in scat deposition due to differential digestibility of prey items (Andelt and Andelt 1984). Direct population estimates can be estimated from data collected on transects if scat is collected and sent in for DNA analysis to determine how many different predators deposited scat on the transect (Foran et al. 1997). This technique, however, incurs more cost than simply comparing the indices from each year. Different techniques will need to be used to obtain an index of raven populations, as scat deposition surveys are designed primarily for mammalian predators (Gese 2004). Initiation of point-count surveys or call surveys may be an inexpensive efficient way to determine population trends in ravens on the refuge (Ralph et al. 1993, Luginbuhl et al. 2001).

Year	Coyote	Raven	Gopher Snake	Striped Skunk
1961	1	-	-	-
1964	9	-	-	-
1970	-	-	-	30
1971	9	-	-	-
1974	15	-	-	8
1976	30	-	-	-
1977	15	-	-	10
1979	18	-	-	-
1980	10	-	-	-
1981	6	-	-	-
1982	-	1	7	-
1986	4	-	-	-
1988	-	-	63	-
1991	4	5	-	-
1992	9	5	-	-
1993	11	5	23	-

Table 1. Number of predators removed, by species, through lethal control methods since refuge establishment at Fish Springs National Wildlife Refuge, Juab County, Utah.

Figure 1. Map of scat deposition transects surveyed in 2012 at Fish Springs National Wildlife Refuge, Juab County, Utah.



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Appendix S.

1993 Waterfowl Nesting Success on Fish Springs National Wildlife Refuge

A report prepared by

Bromwyn Maier

Brigham Young University

And

Jeffrey M. Warren

U.S. Fish and Wildlife Service

June 2012

Introduction

The finite rate of population growth (λ) is the product of life-cycle processes such as age- or stage-specific survival rates. These processes, also known as vital rates, vary in time and space and have varying levels of influence on population growth. For example, in ground-nesting birds, nesting success has been found to be an important determinant of recruitment and population growth rate (Hoekman et al., 2002). In a sensitivity analysis of the midcontinent mallard (*Anas platyrhynchos*) population of North America, nesting success demonstrated the greatest influence on λ relative to other vital rates (Hoekman et al., 2002). Population growth in greater prairie chickens is similarly sensitive to changes in nesting success, with the combined product of nesting success and brood survival the primary driver of variation in λ (Wisdom and Mills 1997). Such disproportionate effect of a vital rate to λ can highlight where conservation actions can have the greatest influence on population management.

Understanding of factors that influence vital rates known to be important drivers of population growth is necessary for effectively managing populations. In ground-nesting birds factors such as weather (Harvey, 1971), food availability (Gloutney and Clark, 1991), and nest parasitism (Lokemoen, 1991) have been demonstrated to influence nesting success, largely through abandonment. However, the greatest cause of nest failure in ground-nesting birds is nest depredation (Klett et al., 1988). Nest failure can be caused by depredation in a variety of ways, depending on the behavior and foraging habits of the nest predators in the area. Some nest predators focus their efforts on consuming eggs, while others prey more frequently on hatchlings and adult waterfowl (Sargeant et al., 1993). Not only do predators cause nest failure directly by killing nesting individuals or depredating nests, but their presence can indirectly reduce nesting success. In a study of several passerine species in Arizona experimental predator control resulted in increased parental investment through higher rates of nestling feeding, increased egg size, greater clutch mass, and higher rates of males feeding incubating females (Fontaine and Martin, 2006). Increased predator pressure may reduce these actions as nesting individuals seek to conserve energy in the event that renesting is required, and as individuals attempt to reduce activity that could draw predator attention to the nest (Fontaine and Martin, 2006).

Many studies have explored the role of nest predation on nesting success. Differential effects of individual predator species on nesting success have received considerable attention in the literature. Examples of these studies include those that have explored how nesting success increases in areas inhabited by red fox (*Vulpes vulpes*) when coyotes (*Canis latrans*) are also present (Sovada et al., 1995), and evidence of incidental, rather than purposeful, nest predation by striped skunks (*Mephitis mephitis*) (Vickery et al., 1992). The influence of nest-site characteristics on nesting success has similarly been well documented (patch size [Horn et al., 2005], landscape structure [Bergin et al., 2000], habitat type [Higgins, 1977], nest-site vegetation structure [Crabtree et al., 1989]). However, the majority of nesting success studies have been conducted in the Prairie Pothole Region (PPR) of the United States and Canada, North America's most significant waterfowl breeding ground (Smith et al., 1964). Exploring nest predation processes in dissimilar or unique nesting habitats can help determine how general the processes are. For example, Fish Springs National Wildlife Refuge in the West Desert of Utah includes nearly 10,000 acres of wetland habitat created by artesian springs. In much of the PPR, agricultural development has reduced waterfowl breeding habitat to fragmented islands of wetlands and grassland within a matrix of cropland. Similarly, Fish Springs is a habitat island in the midst of a salt-desert ecosystem, characterized by salt-tolerant vegetation (e.g., *Sarcobatus vermiculatus, Spartina gracilis, Atriplex confertifolia*). The PPR's matrix of agricultural land use favors a broad variety of generalist mesopredators, likely at elevated densities due to the greater and more persistent food resources associated with anthropogenic development (Fedriani et al., 2001; McKinney, 2002). Fish Springs' location in the West Desert results in the surrounding area being relatively inhospitable, limiting the spectrum of mesopredator species present. The suite of mesopredators found at Fish Springs primarily includes bobcat (*Lynx rufus*), coyote, raven (*Corvus corax*), gopher snake (*Pituophis*

melanoleucusl), Great Basin rattlesnake (*Crotalus oreganus lutosus*), and rarely kit fox (*Vulpes macrotis*) and badger (*Taxidea taxus*). This creates a unique situation for waterfowl management and investigations of nesting success.

The mission of the National Wildlife Refuge System is to establish a network of lands and waters for the management of wildlife resources for future generations (USDOI, 2000; USFWS, 2009). Each refuge within the National Wildlife Refuge System is required to prepare and implement a habitat management plan with the overarching purpose of conserving the wildlife, plants and habitats found on the refuge (USDOI, 2000; USFWS, 2009). An important component of this planning process is gathering baseline information on trust species within the area. An investigation of nesting success and the factors affecting it on Fish Springs NWR will provide important information to inform future management and create a comprehensive refuge management plan, addressing the motivations behind the formation of the Refuge: the protection and support of migratory birds (USFWS, 2004).

Study Area

Fish Springs National Wildlife Refuge is located in Juab County, Utah, at the southern end of the Great Salt Lake Desert. The Refuge comprises 17,992 acres, and includes 10,000 acres of spring-fed wetlands. Five main artesian springs at the base of the Fish Springs Range provide water to the Refuge, along with several lesser upwellings. Although the springs vary in temperature and salinity, they are all brackish (2010 mean minimum and maximum specific conductivity 3983 and 6203 μS/cm, respectively) with a minimum annual mean pH of 7.4 and a maximum annual mean pH of 7.9. Mean water temperature for all springs is 23.3° C (SD = 2.2° C), with individual mean spring temperatures ranging from 20.2–26.9° C. Conductivity generally increases in the springs and pools from south to north and from west to east (annual mean of 4002 μS/cm in Percy spring, the most southerly spring; annual mean of 6148 μS/cm in North spring, the most northerly spring) due to an increasing salinity gradient. Dry areas of the Refuge are dominated by a salt-desert shrub community with black greasewood (*Sarcobatus vermiculatus)* and fourwing saltbush (*Atriplex canescens)* as the dominant over story, and inland saltgrass (*Distichlis spicata*) and alkali sacaton (*Sporobolus* *airoides)* as the dominant understory vegetation. Wet areas of the Refuge support species of rushes (*Juncus* spp.), bulrushes (*Schoenoplectus* spp.), spikerushes (*Eleocharis* spp.) and cattail (*Typha* spp.). Common vegetation in these areas include saltgrass, Baltic rush (*Juncus balticus)*, hardstem, alkali and Olney's three-square bulrush (*Schoenoplectus acutus, S. maritimus* and *S. americanus*, respectively), southern and broadleaf cattail (*Typha domingensis* and *T. latifolia*, respectively) and common reed (*Phragmites australis)* (Bolen 1964; USFWS, 2004). Trees are located only at the Refuge office complex, with a small patch of mature trees also established at a picnic area located at one of the springs. On average, the hottest month is July (mean minimum temperature 18.1° C ; mean maximum 35.2° C), with January being the coldest month on the Refuge (mean minimum temperature -7.8° C; mean maximum 4.2° C). The coldest recorded temperature at the Refuge is -28.3° C, but the springs do not freeze over completely (USDOI, 2004). Annual mean precipitation is 20.3 cm, with the majority falling in the spring and fall. May is the wettest month, with an average of 2.7 cm precipitation, contributing 13% of the total average annual precipitation (Western Regional Climate Center, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ut2852). Frost-free days generally extend from late April until mid-October.

Shortly after establishment of the Refuge an impoundment system was constructed, creating nine wetland management units (USFWS, 2004). The impoundment system resulted in creation of semi-permanent wetland habitat (hereafter pools) within each unit. Evapotranspiration results in a significant loss of water from spring through fall in the pools. Evapotranspiration rates increase through the summer, causing a transition in early to mid-June from water accumulation (from the springs and slight precipitation) to water loss in the pools. Since 1988, the impoundment units have been managed through a prescribed schedule of rotational drawdowns. Under this system, certain units are completely drained for an entire year before allowing the unit to resume optimal pool levels. Optimum pool levels are maintained throughout the year in the Avocet, Mallard, Shoveler and South Curlew impoundment units, except when one of these units is selected for drawdown. Pools located north of these units are allowed to dry during the deficit period of the year, with the water levels decreasing during the growing and nesting season.

Methods

Limited information was found in historical documents on methods employed in 1993 for collection of field data. However, in documents on similar searches done in 1992, it was recorded that study sites for nest searching were selected based on known duck productivity the year before. Varied habitats and the high proportion of water (50% of the 10,000 acre area within the nine impoundments is shallow-water marsh or open water) on the Refuge resulted in the selection of several small sample areas for nest searches (USFWS, 2004).

To obtain samples for estimating nesting success among units and species, grassland and dry wetland areas were systematically searched by 2 person crews using cable-chain drags towed by all-terrain vehicles (Klett et al., 1986). For sloughs, islands, emergent habitats and other areas not accessible with ATVs, researchers used an airboat or waded through the areas. In these situations, researchers either dragged a rope between them or beat the vegetation as they walked. Although information on the methods used in 1993 is lacking, the 1992 annual narrative of the Fish Springs Refuge notes that each area was only surveyed once in a similar study in 1992.

All nests found were marked with a flagged stick placed 0.9 to 3.1 meters in front of the nest ("front" being considered the side of the nest the searchers first encountered when moving in the direction of nest searches). For each nest the associated vegetation was noted, distance to water was estimated, and nest initiation date was recorded. Nest initiation date was estimated by field-candling eggs (Weller, 1956). Nests were revisited every 7 to 10 days (with some exceptions) until fate was determined (at least one egg hatched or the nest was destroyed or abandoned). On each visit nest status (active, successful, abandoned, or destroyed) was recorded; for depredated nests predator species (i.e., coyote, raven, snake) was recorded when evidence at the nest site was suitable to make the determination. The location, species and fate of 1993 nests were recorded on hand-drawn maps of the Refuge management units. In 2012, nest locations were digitized in a Geographic Information System (GIS) database (ArcGIS 10.1, ESRI, Inc., Redlands, CA) to estimate distance to nearest road for each nest using the Near Distance tool. Due to the crudeness of the hand-drawn 1993 maps, the calculated distance to road only provided a relative distance from each nest to the nearest road.

Data Analysis

We assessed an *a priori* suite of models to determine the amount of support for each of our hypotheses regarding factors influencing nesting success (Burnham and Anderson, 2002). The strength of support for each model was assessed by ranking models with Akaike's Information Criterion corrected for small sample sizes (AIC*c*) and by calculating the normalized relative model likelihoods (ω_i) for each model (Burnham and Anderson, 2002). The models for distance to road and water were also both log-transformed to test for a threshold effect of distance to each of these parameters on nesting success.

Nest daily survival rate (DSR) was modeled following Rotella et al. (2004). Briefly, daily survival rate was estimated using a maximum-likelihood approach that accounted for bias associated with finding nests at various stages (Mayfield, 1975; Johnson, 1979). The fate of nests between investigator visits, i.e., nest interval fate, was modeled with binomially-distributed errors using R 2.14.0 (R Development Core Team, 2012) with package 'RMark' (Laake, 2012) and program MARK (White and Burnham, 1999). Nests abandoned, damaged or destroyed due to investigator activity were not included in analysis. Once estimates for DSR were obtained, nesting success was calculated as $(\mathrm{DSR})^n$, where n is the average number of days from initiation to hatch for ducks ($n = 35$). The R script used to conduct the analysis of nesting success is provided in the Appendix.

Results

Nest searches were conducted from the second week of May until late June. A total of 97 nests were found and monitored; five nests were not mapped (precluding estimation of distance to the nearest road), resulting in 92 nests used in analysis. Nest initiation dates ranged from 28 April–6 July, with mean and median initiation dates of 1 and 2 May, respectively. Of the nests monitored, 37 were gadwall (*Anas strepera*), 26 were northern pintail (*Anas acuta*), 9 were mallard (*Anas platyrhynchos*), 8 were unidentified teal species, 5 were northern shoveler (*Anas clypeata*), 4 were redhead (*Aythya americana*), 2 were canvasback (*Aythya valisineria*), and 1 was a blue-winged teal (*Anas discors*).

Mean distance from nests to the nearest water was 67 m (SD = 102.9 m; median 20 m), ranging from 0 to 500 m. The mean distance from nests to the nearest road was 122 m (SD = 154.9 m; median 20 m), ranging from 1 to 808 m.

Considerable model uncertainty existed in our *a priori* suite of models with all models being within 2 AIC_c units of the top model (Table 1). A general rule of thumb for model selection using AIC_c is models within 2 units of the top model have substantial support given the data (Burnham and Anderson 2002). Therefore, our *a priori* suite of models explained the observed patterns in nesting success at Fish Springs in 1993 nearly equally well. We focused our inference on the top four models, all of which were within 1 AIC_c of each other, primarily for brevity. Additional nest data should facilitate greater model selection certainty, assuming a model representative of nesting success processes at Fish Springs is within our current model suite.

Our top model indicated nesting success was consistent among species and across the Refuge during the nesting season. The estimate of nesting success from the top model was 4.9% (95% CI 2.2–9.2%), similar to the Mayfield estimate of 5% provided in the 1993 Fish Springs NWR annual narrative (USFWS, 1993). Models within 1 AIC_c unit of the top model included initiation date, distance to road, and distance to water (Table

1). These latter models indicated negative relationships between nesting success and initiation date, distance to road, and distance to water, respectively (Table 2). Species specific nesting success, and threshold effects of distance to road and water were less well supported (Table 1).

Table 1.
Results of models used to explore variation in nesting success during the 1993 breeding season on Fish Springs National Wildlife Refuge, Utah, 1993. Distance to nearest road and water were quantified for each nest; see methods for details. Species-specific nesting success was considered for the most common species found during nest searching: gadwall, northern pintail, mallard, and other.

Model	k[a]	$\Delta AICc$[b]	ω_i[c]
Null	1	0.00	0.225
Nest initiation date	2	0.47	0.178
Distance to road (m)	2	0.53	0.172
Distance to water (m)	2	0.94	0.140
Species	3	1.61	0.101
lnDistance to road	2	1.74	0.094
lnDistance to water	2	1.83	0.090

[a]Number of model parameters
[b]Difference in Aikaike's Information Criterion (corrected for small sample sizes) between each model and the best model (Null)
[c]Normalized relative model weight (Burnham and Anderson, 2002)

Table 2. Estimated effect (and standard error) of predictor variables on duck nesting success at Fish Springs National Wildlife Refuge, Utah, 1993, based on the four most parsimonious nesting success models. Distance to nearest road and water were quantified for each nest; see methods for details.

Model	Intercept (SE)	$\hat{\beta}$ (SE)
Null	2.4 (0.13)	-
Nest initiation date	2.8 (0.33)	-0.009 (0.008)

Distance to road (m)	2.5 (0.17)	-0.001 (0.001)
Distance to water (m)	2.5 (0.15)	-0.001 (0.001)

Discussion

Our re-analysis of nesting success data from 1993 provided the opportunity to explore patterns in variation previously not examined. We tested competing hypotheses regarding drivers of nesting success at Fish Springs National Wildlife Refuge. Considerable model selection uncertainty was apparent in our results, but we still believe important insights can be gained from the results. Moreover, our results will help refine future nesting success work on the Refuge. The unique location of the Fish Springs Refuge requires consideration of the distinctive relationships and behavioral patterns that are especially specific to desert ecosystems. Due to the fact that the majority of nesting failures in the 1993 survey were the result of predation, examining potential mechanistic explanations with an emphasis on predation and predator efficiency is appropriate.

Our top model indicated nesting success was consistent among species and across the Refuge during the nesting season. We estimated nesting success as 4.9% (95% CI 2.2–9.2%) from the best (null) model, consistent with the estimate of nesting success provided in the 1993 Refuge Annual Narrative (USFWS, 1993). It is notable that predator control was conducted in 1993, a continuation of the practice beginning in the mid-1960s. In 1993, predator control occurred just prior to the onset of duck nesting through the end of incubation, removing snakes, coyotes and ravens. In spite of this, nesting success was still low, well below the 15% threshold necessary for population stability (Cowardin et al., 1985).

Some studies have indicated that reducing predator numbers may actually cause predator abundance to increase as the amount of resources available to remaining individuals increases. This can lead to higher survival and reproduction rates for surviving individuals (Knowlton, 1972). Furthermore, the removal of territorial individuals may attract individuals from nearby uncontrolled areas (Knowlton, 1972). However, studies have also indicated that predator control can be effective in improving waterfowl nesting success when done intensively in a small area (e.g. < 300 km^2) (Duebbert and Lokemoen, 1980; Pieron and Rohwer, 2010). Details on the intensity of predator control and the methods for removal that were used on Fish Springs NWR have been lost.

We found weak support for an intra-seasonal decline in nesting success. The West Desert of Utah that encompasses Fish Springs is characterized by a bimodal precipitation pattern (i.e., spring and fall), with a transition from water accumulation to water deficit in mid-June even in spring-fed areas of the Refuge. After spring rains cease, seasonal pools across the West Desert decrease in number and size, and much of the vegetation senesces. For vertebrates, especially those too large to find refuge in microhabitats such as burrows, the need for water grows as the summer progresses and temperatures increase into July (Noy-Meir, 1974). With the decline of seasonal resources, Fish Springs becomes an important source of water and green vegetation for wildlife throughout the area. Coyotes may migrate to the Refuge, drawn by the need for water and density of prey (Moorcroft et al., 2006). Thus, the number of coyotes on the Refuge—and the likelihood that waterfowl nests will be depredated by foraging coyotes—may increase through the nesting season. Emery et al. (2005) found a decline in nesting success during the breeding season within managed nesting cover in the Canadian PPR, with concurrent increases in nesting success in unmanaged cover types. They posited that the different patterns observed during their study could have resulted from differences in prey availability between the cover types and the resultant attraction to predators; small mammal abundance is generally greater in managed cover types later in the summer than in unmanaged types (Pasitschniak-Arts and Messier 1998). Fish Springs NWR may similarly attract increasing numbers of nest predators through the breeding season as water and forage resources become less available in the surrounding landscape.

Furthermore, the negative relationship observed between nesting success and initiation date may be a reflection of changes in coyote food requirements. Reproductive female coyotes have an increased caloric requirement throughout pup rearing (April- August) (Laundré and Hernández, 2003), which coincides with waterfowl nesting on the Refuge and may cause female coyotes to increase the time they spend hunting. Evidence has also shown that coyotes focus hunting effort on the most efficient prey items available (largest energetic return with least effort) (Laundré and Hernández, 2003; Till, 1992) while provisioning young, further supporting the hypothesis that coyotes would travel to areas where larger prey—such as lagomorphs or waterfowl—will be concentrated. The increase in nest predation toward the end of the season also coincides with increases in juvenile coyote mobility and foraging, as offspring begin to actively travel with their parents to learn foraging skills (Laundré and Hernández, 2003).

Nesting success was negatively related to distance to road, although support for these results were also weak. These findings are counter to much of the current available research on waterfowl nesting success, which has indicated nesting success generally increases with distance to habitat edge (Horn et al., 2005). The results observed in this study may be the product of the unique habitat created on the Refuge. Other studies exploring waterfowl nesting success near roads have been done where roadsides are strip habitats, often hemmed in by agricultural fields or development (Bergin et al., 2000). It is possible that the gravel roads of the Refuge create updrafts and wind turbulence that reduces olfactory detection, providing greater protection to nests in close proximity (Dritz, 2010). Also, although traffic on the Refuge is very light, coyotes have been shown to avoid open areas near roads during daylight hours (Roy and Dorrance, 1985), which could reduce foraging near roads. This avoidance may have been enhanced by predator control that was being carried out during and prior to 1993. However, these results should be considered cautiously due to the imprecision of hand-drawn maps and the resultant relativity of nest placement in the digitizing process.

The final model within the top model set considered indicated nesting success declined as distance to water increased. A study in North Dakota had similar results, finding that mallards nesting in marshes had higher success than those nesting in upland habitats (Krapu et al., 1979). Higher nesting success with increasing proximity to water could be the effect of higher and denser vegetative cover near water. Nesting success is positively influenced by vegetation density at the nest site (Schranck, 1972). Dense cover may provide several benefits to nesting waterfowl. Cover may create a microclimate that alters ambient temperature, a factor which influences attendance on the nest (Caldwell and Cornwell, 1975; Stokes and Boersma, 1998). With higher temperatures, more frequent female movements to and from the nest for incubation rests may attract predator attention and increase the likelihood that predators will locate nests. Due to the dryness of the environment at Fish Springs NWR, females lacking the protection of this vegetation-created microhabitat may also show an increased need to leave the nest to re-hydrate.

Higher and denser cover near water can also provide visual and olfactory concealment, reducing the risk of depredation from both avian and mammalian predators (Borgo, 2008; Dritz, 2010). In addition to reducing detection, studies have also noted that denser cover can slow or decrease predator searches and efficiency, decreasing the likelihood of discovery during the foraging activities of mammalian predators (Bouffard et al, 1987; Schranck, 1972). This would seem especially true of Fish Springs NWR, where predators that are known to prefer hunting in wetland areas—such as raccoons (*Procyon lotor*)—are not known to occur.

Although considerable uncertainty was evident in model selection during this study, results suggests that nest initiation date, distance to road and distance to water are worthwhile hypotheses to consider in future studies of waterfowl nesting success on Fish Springs National Wildlife Refuge. Additional data could provide a clearer understanding of their importance as drivers of nesting success on this refuge. Ultimately, this information could assist refuge managers in the future as they consider habitat improvements and predator control in their attempts to improve waterfowl production on the Refuge.

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Appendix

R code used to analyze the 1993 Fish Springs National Wildlife Refuge duck nesting data.

```
#### RMark analysis of Fish Springs nesting success 1993 & 2012 ####
## JM Warren; 5/9/2012
## Will need to update for 2012 at the end of the field season.

##Open RODBC package to link to the database
library(RODBC)

##Link to the .mdb file; this will need to be updated for each person running the models
channel<-odbcConnectAccess("C:\\Documents and Settings\\jewarren\\Zone
Biologist\\Refuges and Offices\\Fish Springs\\Nesting study\\Fish Springs Nest
Data.mdb")

##Extract the Access tables and put into a data frame.

fsnest<-sqlFetch(channel,"NestIntervalDataRMark")
names(fsnest)
close(channel)

##The earliest nest found was on May 11th 1993 (131).
##The last day a nest was viable was August 10th, that is the last day July 30th 1993
(207).
##This results in 76 'occasions' for the nest survival models.
```

```
##Both of these dates need to be updated for 2012 if earlier or later dates occur.

##Drop nests that do not have a distance to road value
fsnest<-na.omit(fsnest)

##Treat Year as a factor
fsnest$NestYear<-as.factor(fsnest$NestYear)

##Group nests based on species (gadwall, pintail, and other)
fsnest$spp<-"gadw"
fsnest$spp[fsnest$NestSpecies=="NOPI"]<-"nopi"
fsnest$spp[fsnest$NestSpecies %in%
c("MALL","Teal","TEAL","CANV","BWTE","NOSH","REDH")]<-"other"
fsnest$spp<-as.factor(fsnest$spp)

##Log-transform distance to road and distance to water to test psuedo-threshold forms of
each
fsnest$lDistH2O<-log(fsnest$DistH2O+0.5)
fsnest$lDistRd<-log(fsnest$DistRd)

##Examine a summary of the dataset and its structure
summary(fsnest)
str(fsnest)

##Process the data
fsnest.process<-process.data(fsnest, model="Nest", begin.time=1, nocc=81,
groups=c("NestYear","spp"))
fsnest.ddl<-make.design.data(fsnest.process)

#Figure of nest initiation date summary by year
summary(fsnest$Init[fsnest$NestYear==1993])
summary(fsnest$Init[fsnest$NestYear==2012])
boxplot(fsnest$Init~fsnest$NestYear, xlab="Year", ylab="Julian Date", cex.axis=1.5,
cex.lab=1.5, ylim=c(140,200))

#Figure of clutch size summary by year
summary(fsnest$CS[fsnest$NestYear==1993])
summary(fsnest$CS[fsnest$NestYear==2012])
boxplot(fsnest$CS~fsnest$NestYear, xlab="Year", ylab="Clutch Size", cex.axis=1.5,
cex.lab=1.5, ylim=c(0,12))

##A function for evaluating a set of competing models
run.fsnest <- function()
{
#1. Constant daily survival rate (DSR)
null<-mark(fsnest.process, fsnest.ddl)
```

```
#2. DSR varies by year
#year<-mark(fsnest.process, fsnest.ddl,
model.parameters=list(S=list(formula=~NestYear)))

#3. DSR varies by time
time.trend<-mark(fsnest.process,
fsnest.ddl,model.parameters=list(S=list(formula=~Time)))

#4. DSR varies by time each year (a year and time interaction)
#time.year<-mark(fsnest.process, fsnest.ddl,
model.parameters=list(S=list(formula=~Time*NestYear)))

#5. DSR varies by species (gadw, nopi, other)
spp<-mark(fsnest.process, fsnest.ddl, model.parameters=list(S=list(formula=~spp)))

#6. DSR varies with distance to water
dist.water<-mark(fsnest.process, fsnest.ddl,
model.parameters=list(S=list(formula=~DistH2O)))

#7. DSR varies by distance to road, psuedo-threshold functional form
dist.water.pt<-mark(fsnest.process, fsnest.ddl,
model.parameters=list(S=list(formula=~lDistH2O)))

#8. DSR varies with distance to road
dist.road<-mark(fsnest.process, fsnest.ddl,
model.parameters=list(S=list(formula=~DistRd)))

#9. DSR varies by distance to road, psuedo-threshold functional form
dist.road.pt<-mark(fsnest.process, fsnest.ddl,
model.parameters=list(S=list(formula=~lDistRd)))

#Return model table and list
return(collect.models() )
}

fsnest.results<-run.fsnest() #Runs the models above

#View the model results in a table
fsnest.results
```

Appendix T.
2012 Waterfowl Nesting Production Report (Haffele)

See next page.

2012 Waterfowl Nesting Study at Fish Springs National Wildlife Refuge

A Report Prepared by:

Ryan Haffele
U.S. Fish and Wildlife Service
July 19, 2012

Introduction

The breeding period is most critical for temperate nesting duck population dynamics as most mortality and all production occurs (Johnson et al. 1992). Vital rates that are affected during this period of the annual cycle (nest success and adult hen survival) have been shown to have the most influence on population changes of the midcontinent mallard (*Anas platyrhynchos*), and presumably, other upland nesting ducks with similar life history traits (Hoekman et al. 2002). Predators have been found to be the main cause of mortality to nests and hens during the breeding period (Ricklefs 1969), accounting for more than 70% of nest failures in most studies (Sovada et al. 2001, Emery et al. 2005). Since the North American Waterfowl Management Plan (Environment Canada et al. 1986; NAWMP) was established with the main goal of increasing duck populations to the levels of the 1970s, managers have focused their efforts on increasing nest success. Most management to date has been focused on increasing suitable nesting cover (Williams et al. 1999, Emery et al. 2005) and attempts to control predator populations through direct intensive predator management (i.e. lethal removal; Sovada et al. 2001).

Recent studies have shown that increased amounts of perennial cover on the landscape have a positive influence on nest success (Stephens et al. 2005, Arnold et al. 2007). Planted cover has also been shown to be the best management practice to increase early season nest success (Emery et al. 2005), with earlier hatched young being more likely to be recruited into the fall population (Dzus and Clark 1998, Dawson and Clark 2000). Management strategies that increase perennial cover on the landscape provides a practical management activity in regions like the Prairie Pothole Region (PPR), where soils and climate are suitable to such activities. At Fish Springs National Wildlife Refuge (FSNWR), however, climate and soil limitations restrict managers from planting typical perennial cover stands like in the PPR, as salt tolerant vegetation is needed to survive in the salt desert ecosystem. Thus, typical management practices used to increase nest success by increasing nesting cover are likely rendered ineffective at FSNWR.

An alternative management practice used to increase nest success has been intensive predator management. This intensive management includes the exclusion of predators from quality nesting habitat (Lokemoen et al. 1982) and the removal of predators via trapping and shooting (Greenwood 1986, Sargeant et al. 1995). Predator removal has historically been focused on mesopredators like red fox (*Vulpes vulpes*), striped skunk (*Mephitis mephitis*), and raccoons (*Procyon lotor*), which have been found to have a greater impact on nest survival than coyotes (*Canis latrans*; Sovada et al. 1995). Predator composition at FSNWR does not have the complexity of other waterfowl production regions, however, with the most abundant predators being coyotes and ravens (*Corvus corax*). Removal of avian predators, like ravens, is difficult and often ineffective (Parker 1984).

The effectiveness of predator removal at increasing nest success has been equivocal, with some studies indicating increased localized success (Garrettson and Rohwer 2001, Pieron and Rohwer 2010) while others found no effect of predator removal on nest success (Greenwood 1986, Beauchamp et al. 1996, Dassow 2010). Additionally, Amundson (2010) indicated areas with increased nest success due to predator removal did not increase local population sizes due to decreased duckling survival in predator removal areas. With variable results thus far, there is great uncertainty as to the effectiveness of predator removal as a management tool to increase nest success.

Currently, FSNWR is in the process of creating a Habitat Management Plan (HMP) to guide the management of trust resources on the refuge. In order to write and implement the HMP, baseline data regarding trust resources currently on the refuge is needed. A wealth of historical data on duck production at FSNWR is available, however, no data or monitoring has occurred since 1993. The purpose of this study was to determine the current duck production on FSNWR with the goal of using the information gathered to guide management to maximize duck production on the refuge.

History of Duck Production at Fish Springs

FSNWR was established as an inviolate sanctuary for migratory birds, with previous management focusing on waterfowl production (FSNWR Marsh Management Plan, FSNWR Comprehensive Conservation Plan). Since establishment, refuge employees have estimated waterfowl production (number of ducklings fledged to flight stage) on the refuge using a variety of techniques (i.e. brood counts, line-transect nest searches, hand dragging, ATV dragging). This data provides a synopsis of production since the refuge was established.

Prior to the establishment of the impoundment system on the refuge, duck production was estimated to be low (McKnight 1969), with very little open water present on the refuge. An impoundment system was created in the early 1960s to increase the attractiveness of the refuge to breeding ducks. To estimate the duck production that was occurring on the refuge, a nesting study was conducted on the refuge in 1960 to gather initial data. No nests were found during nest searches, however 7 nests [6 mallard, 1 cinnamon teal (*Anas cyanoptera)*] were found during other refuge tasks and by the muskrat trapper (FSNWR Annual Narrative 1960). After this initial study, production during the years of impoundment establishment (1960-1964) was estimated using brood counts. Counts were conducted every 4-5 weeks from June to August. Much of the refuge was drained during these years to facilitate dike and road construction. In 1960, 42 broods were identified; 35 mallard, 3 cinnamon teal, 2 redhead (*Aythya Americana*), and 2 pintail (*Anas acuta*; FSNWR Annual Narrative 1960). Brood counts indicated that approximately 500 ducklings hatched in 1961 and 1962, with the primary species being mallard, green-winged teal (*Anas crecca*), cinnamon teal, and redheads (FSNWR Annual Narrative 1961; 1962). In 1963, estimates of production increased to 640 ducklings with the primary species again being mallards, cinnamon teal, and redheads (FSNWR Annual Narrative 1963). Production was estimated to be similar in 1964, with redhead numbers increasing and the first gadwall (*Anas strepera*) brood being identified (FSNWR Annual Narrative 1964).

The impoundment system was completed in the summer 1964 and all impoundments were inundated that winter (FSNWR Annual Narrative 1964). Brood counts were again used to estimate production from 1965-66. In 1965 production estimates nearly doubled to 1,120 ducklings (FSNWR Annual Narrative 1965), with similar estimates in 1966 at 1,056 ducklings (FSNWR Annual Narrative 1966). Production estimates were quite high after impoundment establishment compared to other spring fed salt marshes in the area prompting the initiation of an intensive nesting ecology study to determine the causes of the increased productivity. This study took place from 1967-1968 and was directed by a graduate student from Utah State University. Throughout the duration of the study, 312 nests of 9 species were found, with the predominant nesting species being mallard, cinnamon teal, and redhead. Apparent nest success ($\frac{\#\ of\ nests\ found\ that\ were\ successful}{total\ number\ of\ nests\ found}$) during the study was 63%, with predators accounting for the majority of nest loss (25%). Using a combination of brood counts and nest survival data, production estimates during the study were 2,445 and 3,595 ducklings in 1967 and 1968, respectively. Reasons for the increased production at the refuge were not entirely known, however low predator activity and increased invertebrate populations due to recently flooded habitat were cited as likely causes (McKnight 1969). To maintain duck production on the refuge, McKnight (1969) recommended that water levels in management units be periodically drawn-down to increase invertebrate populations to provide food for nesting hens and broods.

After the completion of the nesting study, management to promote duck production focused on full-pool management, keeping pools at optimal levels for as long as possible throughout the year. During this time, production estimates were again estimated using brood counts. Starting in 1969, counts were conducted weekly opposed to every 4-5 weeks as previously completed (FSNWR Annual Narrative 1969). This method continued from 1969-1974. Production estimates decreased during this time period, from a high of 2,375 in 1969 to 700 in 1974 (FSNWR Annual Narrative 1969; 70; 71; 72; 73; 74).

A new method (hereafter; pair count method) for estimating duck production on the refuge was initiated in 1975 (FSNWR Annual Narrative 1975). This method used a combination of three techniques to calculate an overall production estimate for the refuge. The techniques used included; pair counts to estimate the breeding population size, nesting surveys to determine nest success, and brood counts to estimate brood survival. Production was then calculated as; (# breeding pairs – nest failures) X (average class I brood size). This was considered the initial production on the refuge. Brood mortality was then calculated as; (average class I brood size – average class III brood size). This mortality rate was then subtracted from the initial production estimate to calculate overall production on the refuge. Using this method production estimates increased dramatically with 1975 estimates at 3,568 ducklings and 1976 estimates at 7,270 ducklings (FSNWR Annual Narrative 1976). Production estimates again decreased over the next few years, dropping to 4,500 in 1977 and 4,400 in 1978 (FSNWR Annual Narrative 1977; 78). Estimates from this method may be biased high, as an important assumption of this method is that all nesting pairs counted attempt to nest. This assumption is unlikely to be met, as studies have shown that not all sexually mature adult waterfowl breed each year (Sedinger et al. 1995), with one study estimating 85% of mallards initiate nests (Coluccy et al. 2008). Additionally, pair counts may have included pairs of breeding ducks that were still migrating to other breeding grounds north of the refuge, thus overestimating the true breeding population of the refuge.

The decline in production estimates continued in 1979, with an estimated 2,137 ducklings produced on the refuge (FSNWR Annual Narrative 1979). During this year, a new method, distance sampling using line transects (hereafter; transect method), was tested for trying to get a more accurate estimate of duck production. This method involves walking designated transects searching for nests and measuring the perpendicular distance of each nest from the transect. These distances were then used to estimate a nest density corrected for detection probability for the refuge using Program TRANSECT (Laake et al. 1979). Production was then calculated by; (estimated nest density X available nesting habitat X calculated nest success X average class IIc/III brood size). This method was tested on two study plots in 1979 and expanded in 1980 (FSNWR Annual Narrative 1979). Results from 1979 yielded small sample sizes and were not used to calculate production. After expanding the method in 1980, sample sizes were still too low to estimate production, and the pair count method was utilized again. This estimated production at 2439 ducklings with nests found using the transect method having a success rate of 54%.

To increase nesting habitat and nesting success on the refuge for waterfowl (primarily geese), man-made pothole islands were created in 1979 and 1980 in the Pintail, Ibis, Gadwall, and Harrison units. Blowouts were created using dynamite to make the potholes with nesting islands in the middle of the blowouts (FSNWR Annual Narrative 1979). Other potholes were created by digging trenches to create islands in patches of baltic rush (*Juncus balticus*). These islands were created in suitable nesting habitat [i.e. baltic rush and salt grass (*Distichlis spicata*)]. Islands made in Gadwall and Harrison suffered heavy erosion from wind action despite seeding the island with saltgrass. Due to the erosion of previously created islands, all potholes created after 1979 were larger and created in shallower water to try and alleviate erosion problems.

In 1981 the transect method was fully implemented in all units except Gadwall and Egret. A total of 65 miles of transects were walked 3 times by staff throughout the nesting study. A total of 62 nests were found with an apparent nest success of 58%. Sample sizes were again deemed too small to get an accurate measure of production, and the pair count method was again used. This method estimated 4,744 ducklings produced (FSNWR Annual Narrative 1981).

In 1982, the transect method was used to estimate production for all species for which staff located nests of. A total of 30 nests were found using this method with an apparent success rate of 77%. Production for species that were observed during pair count surveys but no nests were located [canvasback (*Aythya valisineria*), green-winged teal, and ruddy duck (*Oxyura jamaicensis*)] was estimated using the pair count method. Overall production for the refuge was estimated by adding the production of all species together, resulting in an estimate of 2,661 ducklings produced. Additionally, to determine the effects of various management actions to increase nesting on the refuge, primarily nesting potholes, an intensive nesting study was conducted. This included hand dragging 20 acre plots where pothole islands had been created in patches of baltic rush using a 65 foot heavy rope. A total of 14 nests were found during this operation, with 4 of the pothole islands being utilized by nesting hens (FSNWR Annual Narrative 1982).

Staff continued to use the transect method to estimate duck production for species where nests were found on the refuge from 1983-1985. Like 1982, production for species that no nests were located for but were observed during pair counts was calculated using the pair count method. The number of nests found during transect surveys continued to decline during this time period, dropping from 28 in 1983 to only 8 in 1985. Production estimates for 1983 was 2,924 ducklings (FSNWR Annual Narrative 1983). In 1984, production was calculated using both the transect method and the pair count method due to low nest numbers. The transect method estimated 2,753 ducklings, while the pair count estimated 1,850 ducklings (FSNWR Annual Narrative 1984). In 1985 the production estimate was 2,311 ducklings. After 1985, the transect method was abandoned due to low sample sizes and the occurrence of beaten paths that had been formed from walking transects over the previous years, which was felt may have affected duck nesting or predator activity (FSNWR Annual Narrative 1985).

Production was again estimated using the pair count method in 1986 and 1987. Production estimates were 2,730 ducklings in 1986 (FSNWR Annual Narrative 1986) and 3,550 ducklings in 1987 (FSNWR Annual Narrative 1987). Another new method was used to estimate production in 1988, Hammond's estimation formula on brood count data (hereafter; Hammond's method). Hammond's method helps reduce operational bias when surveying for Class III broods, which has been found to be high in published brood sizes (Hammond 1970, Cowardin and Johnson 1979). By reducing operational bias, more precise estimates of production should be obtained. Production calculated using this method yielded an estimated 1,130 ducklings produced (FSNWR Annual Narrative 1988).

Duck production on the refuge appeared to be declining and well below historical levels. To try and reverse recent trends, staff altered water management on the refuge in 1988, implementing the rotational draw-down system recommended by McKnight (1969). Prior to this, the main management activity to provide suitable habitat for duck production was full pool management, where water levels within each pool were kept at optimal levels for as long possible throughout the year. Pool levels still decreased each year due to evaporation, but no pools were intentionally drawn-down as they were in the new system. The goal of the rotational draw-down was to increase invertebrate production, providing more food for nesting and brood rearing activities. With this, 2 units were drawn down each year to promote mineralization and restore nutrients within wetlands to increase invertebrate production. Priority pools in Shoveler, Mallard, Avocet, and Curlew were also identified for nest production. Northern pools were not considered a priority for duck nesting, as they provide very little duck nesting habitat (FSNWR Marsh Management Plan).

Starting with the 1989 field season and continuing through 1993, production estimates for the refuge were estimated using standard prairie style nest dragging techniques. This involved two all-terrain vehicles (ATV's) dragging a 100 foot, 5/16 inch chain over vegetation to find duck nests. After location, nests were revisited every 7-10 days until fate (successful, depredated, or abandoned) was determined. Nest success was determined using the Mayfield Estimation Method (Mayfield 1975). These estimates were then expanded to pair counts and brood counts to get an estimate of production (FSNWR Annual Narrative 1989).

Staff selected search plots on the refuge by selecting areas that provided the best nesting cover and also had a high number of breeding pairs in the immediate area. Plots were selected in Ibis, Shoveler, Mallard, Curlew, Avocet, and the Springs units, totaling an estimated 400 acres. Due to the high interspersion of water and islands, ATV use was restricted to accessible areas. Areas that could not be searched with ATVs were searched using the beat out method. Plots were searched 2 times during the nesting season, with the exception of plots that proved to be too difficult to search due to the terrain and were dropped after the initial search.

A total of 60 duck nests were located in 1989, with 46 of them providing suitable data for nest success analysis. Nest success using the exposure method was 9%, while apparent nest success (for comparison to earlier years before Mayfield method) was 33%. Total production was estimated at 588 ducklings, well below estimates using other methods (FSNWR Annual Narrative 1989). In 1990, searching efforts located 91 nests, however, the majority of these nests (53) were found incidentally as hens flushed from nests when vehicles passed on the roads and not from actual nest searching activities. Nest success increased to 20% this year, possibly due to an increase in predation on colonial nesting species on the refuge. Overall production was estimated at 1,378 ducklings (FSNWR Annual Narrative 1990). Nest production again declined in 1991, with only 41 nests being located with a success rate of 12%. Overall production was estimated at 737 ducklings (FSNWR Annual Narrative 1991). In 1992, 78 nests were located with a success rate of 18%, and an overall production estimate of 1,695 ducklings. The final year of nesting studies on the refuge occurred in 1993 with 97 nests being located with a success rate of 5%. Production estimates for the year were 230 ducklings (FSNWR Annual Narrative 1993). Nesting studies were no longer conducted on the refuge, as staff felt they had a good enough understanding of duck production on the refuge and turned their management focus to other species. The average Mayfield nest success estimate during the nest dragging years was 12%, despite active control of predators on the refuge. Predator control included the shooting, trapping, and snaring of coyotes, trapping and relocation of gopher snakes, and harassment and shooting of ravens (FSNWR Animal Control Plan 1990).

After the completion of nesting studies, the 12% nest success average was used in accordance with brood counts and pair counts to estimate production in 1994, with an estimated 754 ducklings produced (FSNWR Annual Narrative 1994). The last year with any record of nest production estimates was 1995. Again, the 12% nesting success average was used with pair counts and brood surveys to estimate production, with an estimated 937 ducklings produced (FSNWR Annual Narrative 1995).

Methods

Drag plots were established within each management unit of the refuge for nest searching (Figure 1). Plots were established by creating 160 acre grids over each management unit in ArcGIS (ESRI, Redlands, California, USA) and randomly selecting one grid per unit to search. Units that were drained for management purposes (Egret and Curlew) and contained no water were not searched this year. I systematically searched all suitable nesting cover in each drag plot. Nests were located using teams of 2 dragging a 50 m cable-chain behind all-terrain vehicles (Klett et al. 1986). Speeds were kept between 3-8 km/h by keeping ATVs in low gear allowing drivers to stay in a straight line and watch the cable drag (Klett et al. 1986). Dragging at speeds faster than 8 km/h increases the likelihood of the chain passing over a nest without flushing the hen. I searched for nests between 0700 and 1400 to maximize the probability of the hen being on the nest (Gloutney et al. 1993). I alternated the starting location of fields for each drag to prevent the same area of the field being searched during the same time of day, reducing the possibility of a hen being on an incubation break during subsequent searches. Due to the numerous sloughs and islands interspersed within the landscape, I systematically searched all islands and vegetation where ATVs were unable to access. These searches consisted of 2-4 individuals searching each island on foot, on occasion with the assistance of a dog. I marked each nest found with a 1-m wooden lathe painted orange to allow easy visualization in the field by searchers. The wooden lathe was placed 10-m north of the nest and numbered to give each nest its own unique identification. Orange flagging was tied to vegetation near the nest bowl at each nest to assist with relocation. Nests were monitored on 7 day intervals until fate was determined (e.g., successful, depredated, abandoned). I determined the clutch size and incubation status at each visit. Incubation status was determined with a simple field candler (Weller 1956) made from 1 ½ -inch radiator hose. I recorded the date, field, species and Universal Transverse Mercator coordinates for each nest. After each visit, the nests were covered using material from the nest and a marker in the form of an X made out of vegetation was placed on top. If the X was found undisturbed on the next visit, I considered it abandoned due to investigator disturbance and censored it from survival analysis. I calculated the daily survival rate of nests using the Mayfield method (Mayfield 1975). Due to a small sample size, modeling to determine factors having the most influence on nest success was not possible. I assumed a 35-day exposure period (Klett et al. 1986) to convert DSR to point estimates of nest success.

Results

A total of the 8 nests were found at FSNWR through nest searching efforts including; 2 Mallards, 3 Gadwalls, 1 Northern Shoveler (*Anas clypeata*), 1 Canvasback, and 1 Cinnamon Teal. Of the 8 nests located, 3 successfully hatched, resulting in a daily survival rate of 0.969. The estimated Mayfield nest success rate was 33.61%. Hens nested in similar vegetation, with 4 nesting in baltic rush, 3 nesting in alkali sacaton (*Sporobolus airoides*)/baltic rush, and 1 nesting in saltgrass. Nests were placed, on average, 204.3 ± 59.26 (SD) m from roads and 94.0 ± 22.77 m from water. The average vegetation height for nests was 37.5 ± 4.63 cm with an average visual obstruction of 28.75 ± 4.87 cm and a litter depth 3.19 ± 0.90 cm.

Discussion

Duck production appears to be at an all-time low at FSNWR. Comparisons to the most recent nest production studies (1989-1993) on the refuge indicate nest success has increased on the refuge, however, the low number of nests found does not likely provide an accurate estimate, leaving any inference from the results very weak. Long-term trends of production estimates on the refuge show a climax of production in the 1970's with a continual decline until estimates were stopped in 1995 (Figure 2). This trend, however, cannot be interpreted as the actual trend in production as direct comparisons between years using different methods is not appropriate, making any inference about the effectiveness of management practices weak. For example, since both water management and the method used to calculate duck production changed in 1988, it is not possible to accurately determine if trends in duck production are a result of the management action or the method used to estimate production.

Due to the lack of nests found in this study, brood surveys were conducted during bi-weekly avian surveys. These surveys were not meant to serve as a production estimate, rather to try and identify if more hens were nesting on the refuge than implied by nest searching efforts and went undetected. These surveys resulted in a minimum (maximum cannot be determined due to inability to differentiate broods from one survey to the next because no individuals were marked) of 10 broods on the refuge. This is likely an underestimate of broods on the refuge as surveys were conducted from roads while completing other tasks, making it unlikely to census all broods, especially dabbling duck broods which prefer to rest and forage in emergent cover (Ringelman and Flake 1980). Despite the deficiencies in survey methods, the low number of broods observed suggests this study provided a relatively accurate sample of nesting activities on the refuge. There are many possible factors that may be limiting duck production on the refuge, including poor nesting cover, heavy predation pressure, or limited food availability.

Quality nesting cover is an essential component of waterfowl habitat (Baldassarre and Bolen 2006). Nesting cover provides protection from predators (Duebbert 1969) and helps control the microclimate around the nest-site (Gloutney and Clark 1997), with denser cover typically providing greater benefits than less dense cover (Schrank 1972). Due to the harsh climate and soil conditions at FSNWR, the composition of vegetation is limited to species that have adapted to local conditions. This prevents managers from planting typical nesting cover, like in the PPR, that have been shown to provide benefits for duck production (Emery et al. 2005).

The majority of suitable nesting cover, as perceived by anecdotal evidence of nest locations, is made up of saltgrass, baltic rush, and emergent marsh vegetation (FSNWR Annual Narrative 1976). Rush species (*Juncus* spp.) have also been found to be a preferred nesting cover in other areas (Keith 1961). The extent of these vegetation types is limited on the refuge, however, with patches of each type found interspersed with other non-suitable nesting vegetation like pickleweed (*Salicornia virginica*), common reed (*Phragmites australis*), and iodine bush (*Allenrolfea occidentalis*). This interspersion creates a matrix of suitable habitat on the landscape, rather than large continuous blocks of habitat which are thought to more beneficial to duck production than small isolated patches (Ball et al. 1995, Reynolds et al. 2001). Nesting densities are likely increased in the matrix of suitable habitat which may attract predators through a numerical response (Holt 1977). If predators find higher densities of nesting hens in certain habitat patches, they may develop a search image for nests in these habitats (Nams 1997), increasing predation risk for hens on the refuge and limiting production. Thus, it is possible that a lack of suitable nesting cover is limiting production on the refuge.

A lack of nesting cover is likely not the only factor limiting duck production at FSNWR. Consistent predation pressure from the primary predators (coyote, raven, and gopher snakes (*Pituophis melanoleucus*) on the refuge may be impacting production as well. Predators have been found to be the driving force in the evolution of avian breeding biology, as predation accounts for the majority of nest losses (Ricklefs 1969, Martin 1993, Lima 2009). This predation pressure is thought to impact nest success and nest-site selection, with hens selecting optimal nest-sites to increase fitness (Sargeant 1972, Greenwood et al. 1995). Results from this study showed the highest Mayfield nest success rates recorded on the refuge, however, it also showed the fewest number of nests located on the refuge. The increased success this year may have been a result of fewer hens nesting on the refuge, allowing hens that did nest in the area to select the safest nesting locations available. This should be interpreted with caution, however, as the small sample size likely did not give a good representation of nest success for the refuge.

Since modern techniques to estimate nest production were initiated on the refuge (i.e. nest dragging, Mayfield Method), nest success and production has been low, averaging ~12% (See History of Duck Production at FSNWR). These estimates were attained even when predator control methods were conducted. These control methods included the removal of coyotes and ravens before nesting was initiated and throughout the duration of the nesting season (FSNWR unpublished data). This heavy predation pressure may have impacted the number of hens nesting on the refuge. Previous studies have found that perceived predation pressure can impact reproductive investment of avifauna. Fontaine and Martin (2006) found increased parental investment of passerines on areas where predators were experimentally removed. Another study found decreased clutch sizes (a surrogate for reproductive investment) of Collared Flycatchers (*Ficedula albicollis*) in areas with experimentally increased predation rates (Doligez and Clobert 2003). Finally, Dassow (2010) found evidence that dabbling duck hens are able to identify and avoid high predator density areas when selecting a nest site. If nesting hens are able to identify perceived predation pressure, then the high predation rates on the refuge may have resulted in fewer hens nesting on the refuge.

Another factor that may be limiting production on the refuge is food availability. Egg production and incubation is very costly to nesting hens, resulting in lower body mass and body condition (Ankney and Afton 1988). Hens that are in better body condition (i.e. more nutrient reserves) are more likely to successfully hatch a clutch (Gloutney and Clark 1991). Nesting efforts have been found to fluctuate with water levels, presumably due to a lack of food available to hens and broods (Krapu et al. 1983). The primary food resource for nesting hens and broods are invertebrates (Kaminksi and Prince 1981, Ankney and Afton 1988), therefore, management efforts emphasizing an increase in food availability should focus on increasing invertebrate abundances.

With the impoundment system in place, an adequate water supply is available during the nesting and brood rearing season at FSNWR. Water levels were historically maintained at optimal pool levels for as long as possible throughout the year, with the southern priority nesting pools having very little fluctuation (FSNWR Marsh Management Plan). The implementation of a rotational draw-down system on pools in 1988 was focused on increasing food availability by increasing invertebrate populations. Initial studies examining the impact of the draw-down system suggested an increase in invertebrate abundance on pools that were allowed to dry and then flooded again (FSNWR unpublished data). Management has remained unchanged since the implementation of the draw-down system, making it unlikely that food availability has changed substantially since these initial studies. Monitoring efforts of invertebrate populations was terminated in 1997, however, and the long term effect of this management practice is unknown. Re-evaluating the food availability on refuge pools is needed to ensure management efforts are providing an adequate food supply for nesting waterfowl.

Management Implications

Duck production remains extremely low at FSNWR, despite production being the main priority for the refuge. It is possible that the one year of data collected for this study is an anomaly, and production is greater on the refuge than indicated. Future monitoring is needed to accurately assess production on the refuge and determine appropriate management actions. Increasing the amount of suitable nesting cover may help increase production, however, it is unlikely that an increase is possible due to the extreme local conditions. Another option to increase production is predator control. Previous efforts to increase production using this technique appeared futile, however, if predator control is initiated, more intensive removal efforts of coyotes and ravens than have occurred in the past are likely needed to have an impact on nest survival. Future research is needed on the impacts of the rotational draw-down system on invertebrate populations to determine if food availability is limiting duck production. Based on recent data and the results of this study, FSNWR does not appear to provide the adequate resources for high levels of duck production. Management of the refuge may be better served to provide habitat during important migration periods (i.e. spring migration).

Figure 1. Map of nest drag plots within management units for the 2012 duck nesting study at Fish Springs National Wildlife Refuge, Utah.

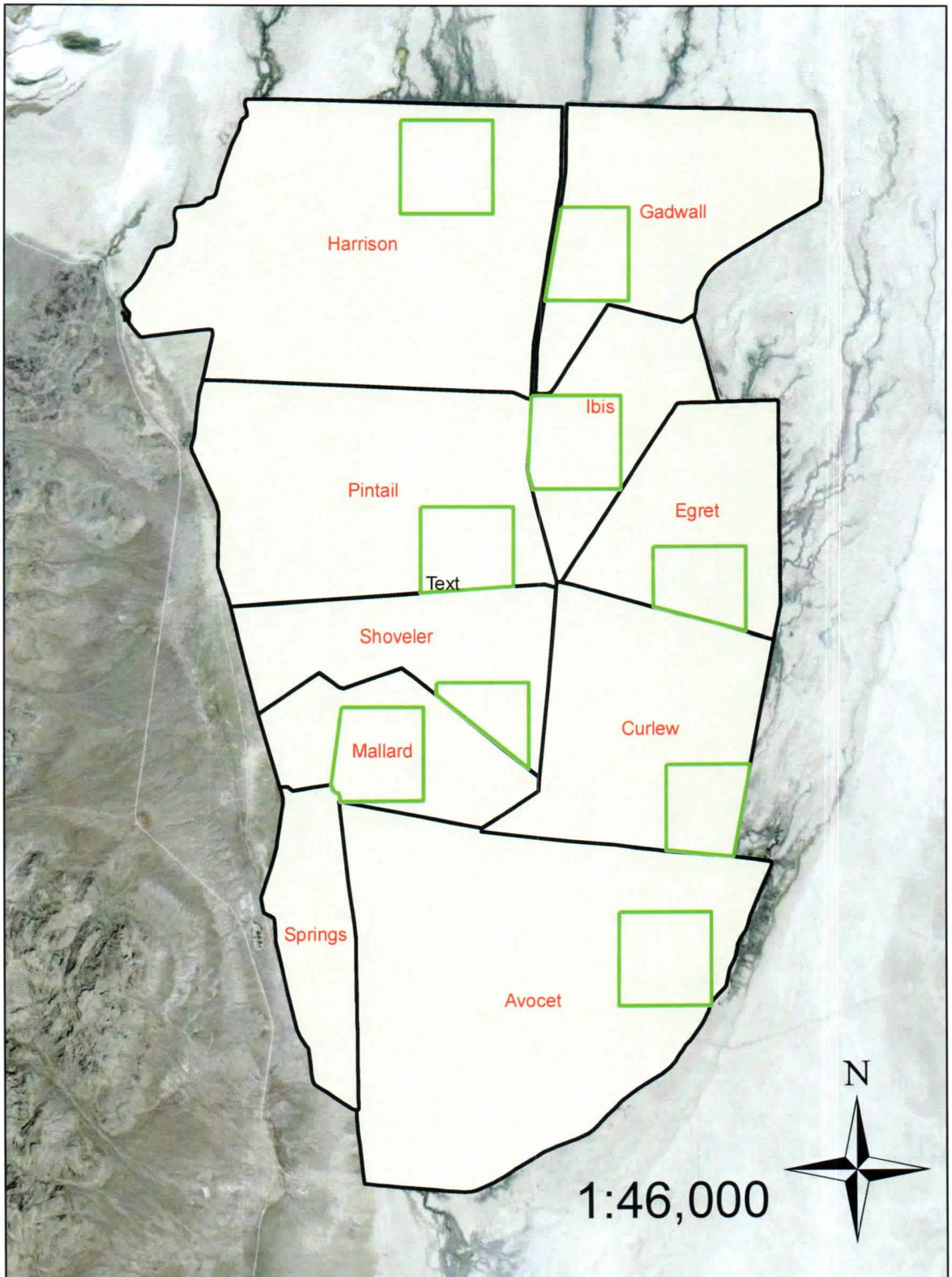
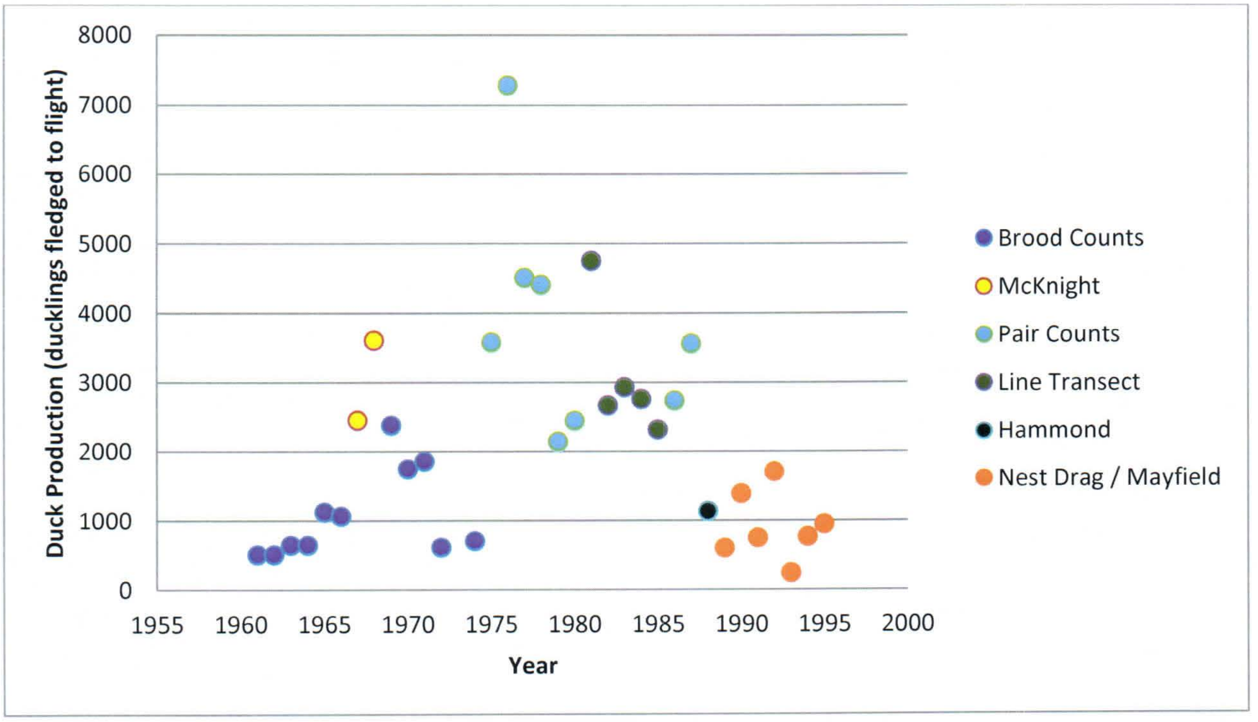


Figure 2. Duck production (number of ducklings fledged to flight stage) estimates, displayed by method, from 1960-1995 on Fish Springs National Wildlife Refuge, Utah. (Brood count estimates used the number of class III broods found during the summer. McKnight method used a combination of brood counts, nest success, and nest density to estimate production. Pair counts estimated production by multiplying the number of breeding pairs counted in spring by the average nest success and brood survival during the nesting season. The line transect method used distance sampling to estimate nest densities and multiplied the densities by the amount of nesting cover available, nest success, and brood survival to obtain a production estimate. Hammond's method used a modified brood count method. Nest drag / Mayfield method found nests through nest dragging with all-terrain vehicles and used the Mayfield method (Mayfield 1975) to calculate nest success. This estimate was then multiplied by the number of breeding pairs and brood survival to get a production estimate).



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Appendix U.

2012 RLGIS/NVCS habitat mapping project - Fish Springs NWR

Project Type: Inventory

Focus Category: Habitat

Geographic Scale: Refuge

Purpose:
Complete National Vegetation Classification System (NVCS) habitat mapping inventory at the Fish Springs NWR (17,992 acres) to support HMP and IMP development. An accurate spatial inventory and representation of vegetation data is critical to the planning efforts of resource management. HMP writing was initiated under contract beginning February 2012. Also, pending water rights applications by the Southern Nevada Water Authority (Las Vegas) for use of regional ground-water resources greatly threaten the Refuge's water rights for a spring-fed water supply that support a 10,000 acre wetland complex; lack of habitat inventory and sufficient monitoring put the Refuge at high risk in meeting its trust resource responsibilities, as well as other management mandates.

Methods:
Use of vegetation description keys per the NVCS standard; use of NAIP imagery for on-screen digitizing in Refuge Lands GIS (RLGIS); aerial imagery uploaded onto mobile Trimble GeoXT GPS units for field mapping applications; hardcopy imagery also taken to field; areas walked systematically and pre-digitized polygons identified and/or modified and coded to alliance level on hardcopy map; minimum mapping area 2 x 3 meters; on-screen digitizing and attributing completed in RLGIS; subsequent accuracy assessment. All Refuge habitat mapped to NVCS Alliance Level (dominant vegetation) using RLGIS. Field training provided and methods guided by regional I&M GIS manager, HAPET GIS specialist, and I&M zone biologist.

Budget:
<u>I&M funds</u>
$23,600 contracted to Brigham Young University for field mapping services.
$30,724 salary costs for mapping technicians.
<u>Station</u>
$55,124 total costs over 2011 and 2012, including staff salary, support costs for 960 volunteer hours, supplies and equipment.
<u>Partners</u>
$5,000 approximate in-kind contribution from Dept. of Army Dugway Proving Grounds environmental staff, and Utah Division of Wildlife staff.
<u>Total</u>
$83,724

Figures 1 & 2 following:

Figure 1. Fish Springs NWR mapped to the alliance-level of the National Vegetation Classification System (17,992 acres 95% complete).

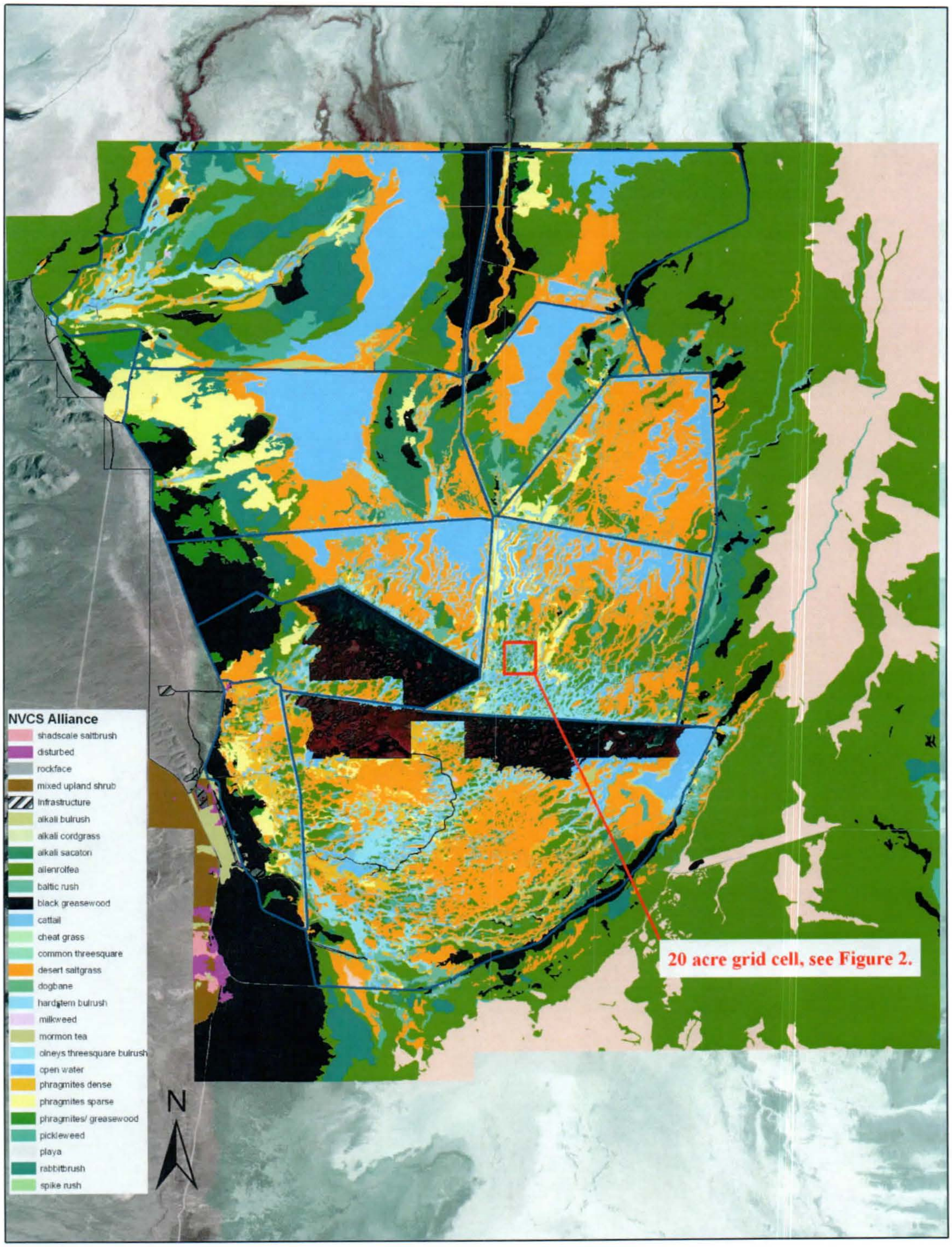
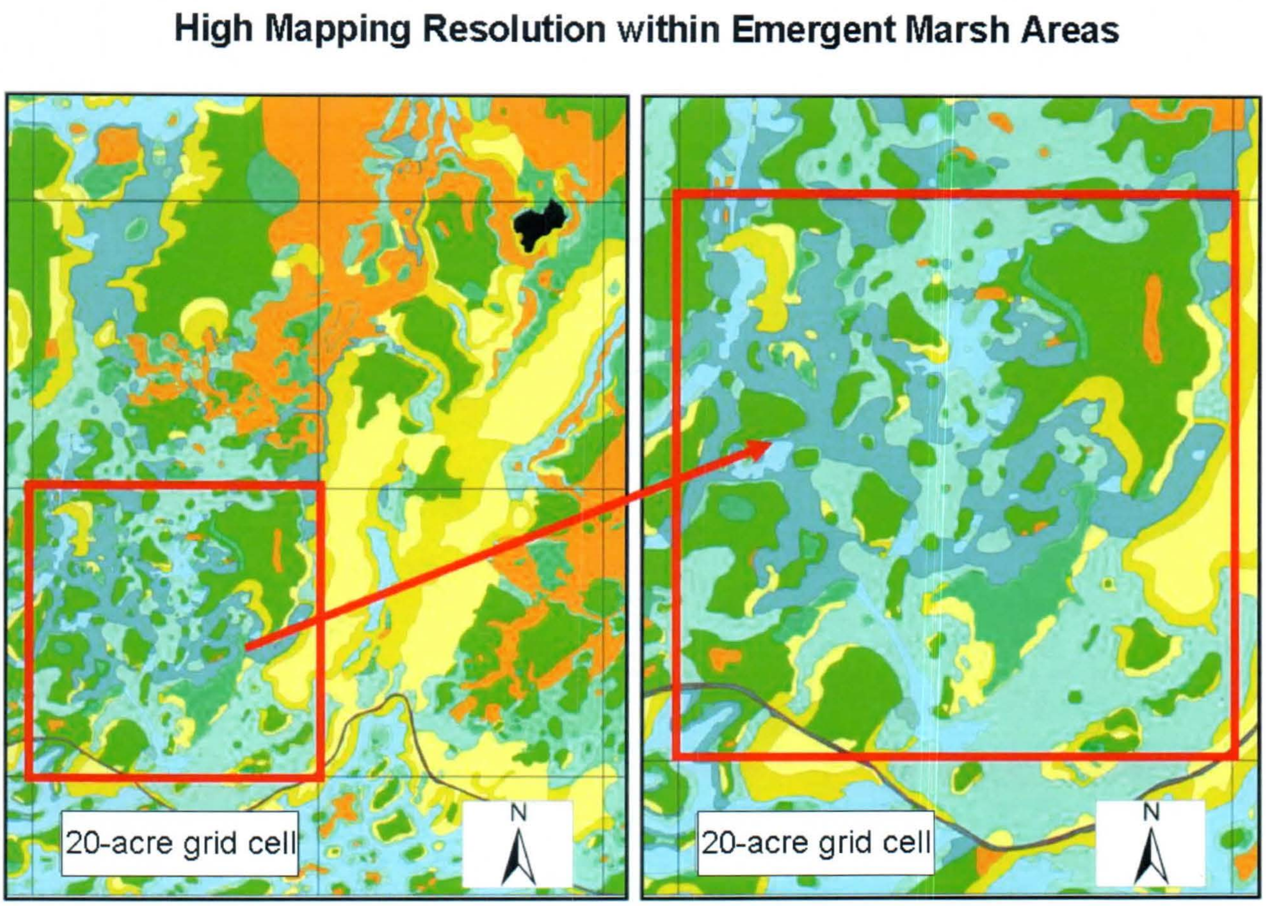


Figure 2. Example of high mapping resolution necessary to capture unique heterogeneity of vegetation within the spring-fed wetland complex.



Appendix V.
(In draft) HMP Habitat Goals and Objectives

Habitat Goal: *Improve and maintain habitats for nesting and wintering migratory birds and other wildlife populations of the Bonneville Basin.*

Semi-permanently Flooded Wetlands and Open Water Objective

Over the 15 year period following HMP approval, provide flooded wetland habitat comprised of semi-permanent marsh and open water in order to provide food and cover for migrating, breeding, and overwintering migratory birds and other wildlife by:

1. Annually managing the four southern main impoundment pools (Avocet, Mallard, Shoveler, and West Curlew) and the first impoundment pool of Harrison Sloughs on a rotational drawdown cycle to maintain X-acres of semi-permanent marsh, including:

    a. X-acres of emergent marsh area with at least 80% cover by native bulrush and less than X-% cover of dense stands of cattail and common reed to provide migrating and breeding cover and foraging habitats for priority species such as American bittern, Virginia rail, over-water nesting ducks, and colonial nesting birds.

        i. X-acres of these total acres to be managed ice-free during the overwintering season to provide cover and foraging needs of priority species such as the American bittern and Virginia rail.

    b. X-acres of flooded open water areas with an average of 0.5 to 2-foot deep, including at least 85% cover of submerged aquatic vegetation dominated by muskgrass and widgeongrass over the growing season, to provide migrating and breeding foraging habitats for priority species such as redhead, northern pintail, gadwall, wigeon, and long-billed dowitcher swan.

        i. X-acres of these total acres to be managed ice-free during the overwintering season to support resting and foraging needs of priority species such as tundra swan, redhead, gadwall and northern pintail.

Seasonally-flooded and Open Water Objective

Over the 15 year period following HMP approval, provide seasonally flooded wetland habitat comprised of flooded wet meadow and open water in order to provide food and cover for migrating, breeding, and overwintering migratory birds and other wildlife by:

1. Annually manage the six northern main impoundment pools (Harrison, Gadwall, Pintail, Ibis, Egret, and Curlew) on a rotational drawdown cycle to provide seasonal open water containing a minimum of 50% cover (when flooded) of submerged aquatic vegetation dominated by muskgrass and widgeongrass over the growing season to provide brood rearing, foraging

and cover habitats for priority species such as redhead, American avocet, long-billed dowitcher, and tundra swan.

2. Annually provide X-acres of flooded areas within Curlew and Egret units between late winter through late spring with 60-80% canopy cover of short grasses dominated by saltgrass to provide foraging habitats for migrating and nesting shorebirds including long-billed curlews.

3. Annually manage natural slough sections within Harrison, Gadwall, and Pintail units (X-acres), and braided marsh areas within the interior of Avocet unit (X-acres), as seasonal wetlands using summer drawdown to provide 60-80% emergent plant cover and 20-40% open water to provide migratory and breeding habitat for species such as northern pintails, gadwalls, Virginia rail, and American bittern.

Partial Drawdown Shoreline-Mudflat Objective

Over the 15 year period following HMP approval, annually manage the four northernmost impoundment pools (Harrison, Gadwall, Pintail, Ibis) on a rotational basis, as well as the full extent of the Fish Springs wash, from April through November to provide receding non-vegetated shorelines, shallow sheetflow, and saturated mudflat habitats for the availability of invertebrates to foraging priority shorebirds, such as snowy plover and American avocet, during the migration and breeding seasons.

Wet Meadow Objective

Over the 15 year period following HMP approval, annually provide saturated wet meadow habitat containing short grasses generally less than 3 feet tall with at least 90% cover dominated by saltgrass, Baltic rush, and alkali sacaton and less than 10% cover of common reed to provide forage and cover for priority breeding shorebirds and waterfowl such as long-billed curlew, mallard, cinnamon teal, gadwall, northern pintail, and northern shoveler.

Overwintering Habitat Objective

Over the 15 year period following HMP approval, annually manage the four southernmost impoundment pools during the overwintering season on a rotational basis to provide areas of ice-free open water containing SAV within three impoundment pools to support resting and foraging needs of priority species such as tundra swan, redhead, gadwall and northern pintail.

Springs Objective

Over the 15 year period following HMP approval, annually maintain the artesian springs and associated deep pool habitat to sustain a water flow from the spring pools to the impounded units and to maintain at least 80% cover by algae and submerged aquatic vegetation including widgeongrass, spiny naiad, pondweeds, and coontail in order to support the full life cycle of least chub and foraging habitat for other priority species such as tundra swan, gadwall and northern pintail.

Wet Shrublands Objective

Over the 15 year period following HMP approval, maintain wet shrubland habitats of Fish Springs NWR including:

1. X-acres of intermittently-flooded playa located along the eastern and southern refuge boundary consisting of alkali mudflat and scattered islands of sparse vegetation dominated by iodinebush (less than 10% overall cover) throughout the year to provide foraging and nesting habitats for priority shorebirds species such as snowy plovers and long-billed curlews.
2. X-acres of seasonally-flooded or saturated wet shrubland dominated by iodinebush (10% cover or greater) interspersed with herbaceous

groundcover including alkali sacaton, saltgrass, seepweed, and pickleweed to provide migration and nesting habitats for priority shorebird species, snowy plover and long-billed curlew.

3. X-acres of saturated wet shrubland dominated by greasewood (10% cover or greater) and interspersed with herbaceous groundcover including saltgrass and other native species to provide migration and nesting habitats for priority landbird species such as sage thrasher and Brewer's sparrow.

Upland Shrublands Objective

Over the 15 year period following HMP approval, maintain X-acres of upland shrublands dominated by native shrub species including Mormon tea, fourwing saltbush, and rabbitbush and a lack of invasive shrub species such as squarrose knapweed to provide breeding and migrating habitat for the priority landbird species such as Brewer's sparrow.

Ecological Integrity Goal: *Perpetuate the native biodiversity and physical characteristics of the Bonneville Basin as represented on Fish Springs NWR.*

Least Chub Objective

Over the 15 year period following HMP approval, improve and maintain suitable habitat at selected sites for a minimum of 3 years as measured by the Utah Ecological Integrity Index for least chub repatriation.