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Descriptive noxious and invasive weed survey and integrated weed management framework of the Inland Sea Shorebird Reserve

Amy L. Barry
The University of Montana

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A Descriptive Noxious and Invasive Weed Survey and
Integrated Weed Management Framework
of the Inland Sea Shorebird Reserve

By

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B.S. Geography
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A thesis presented in partial fulfillment of the requirements for the degree of

Master of Science in Environmental Studies

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Approved By:

Chairperson

Dean, Graduate School

S-20-03
The Inland Sea Shorebird Reserve (ISSR) is a wetland mitigation site owned and managed by Kennecott Utah Copper Company (KUCC) to compensate for wetland loss due to mining operations. Construction began in May 1996 and concluded in January 1997, the ISSR is approximately 3,700 acres of protected wetlands located on the southeast portion of the Great Salt Lake. Prior to wetland establishment this area had been subjected to numerous human disturbances ranging from off-road vehicle activity to decades of grazing impacts.

Due to the devastating effects noxious and invasive weeds have on landscapes a systematic weed survey was conducted in the ISSR. Questions asked were: 1) Were the weed infestations correlated to habitat types found in the Reserve, 2) Did the weeds react to one another, and 3) What role, if any was the surrounding vegetation playing with the invading weeds.

The focus of this survey was to map noxious and invasive weed species found in the Inland Sea Shorebird Reserve (ISSR) between the months of June to August 2002. Location data was collected on six weed species; Russian knapweed (*Centaurea repens*), Bull thistle (*Cirsium vulgare*), Scotch thistle (*Onopordum acanthium* L.), Whitetop (*Cardaria draba*), Phragmites (*Phragmites australis*), and Tamarisk [saltcedar] (*Tamarix ramosissima*). No field data was collected on cheatgrass (*Bromus tectorum*) due to its overwhelming presence in the Reserve. However, it was included in the integrated weed management plan outline because of its invasive nature.

Once field data was obtained maps were created to illustrate distribution and dispersal patterns of each weed in relation to natural features and habitat types found in the Reserve. This will assist the ISSR manager in implementing the integrated weed management plan by outlining areas that should be treated first and prioritizing goals. Infestations where eradication is a feasible goal versus areas that containment is the most that can be realized.

The concept of integrated weed management has been around for a few decades, but the application has not been as pervasive. Historically weed management has taken the form of herbicide applications in the hope to eradicate the undesired plant species. Obviously that approach has failed. Principles of integrated weed management shift the focus to the resulting plant community. Redirecting the focus to what is desired will help recreate a diverse and species rich plant community.

Weed species that are good candidates for eradication should be tackled first. Scotch thistle, bull thistle, and phragmites can be treated with non-herbicide methods. Areas infested with whitetop and Russian knapweed needs to be prioritized from small to large patches. Small areas could be effectively be eradicated with herbicide treatment and revegetation, while large patches need to be contained with continual herbicide applications. Tamarisk is best treated by root removal and treatment may coincide with cheatgrass tilling to minimize disturbance to area.

Ultimately, the ISSR will have the ability to designate which infestations to tackle first, the most effective herbicide treatment for each weed species, and the native and adapted plants that should be used for revegetation efforts.
ACKNOWLEDGEMENTS

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"The invasion of noxious alien species wreaks a level of havoc on America's environment and economy that is matched only by damage caused by floods, earthquakes, mudslides, hurricanes, and wildfire" (Bruce Babbit at the Science in Wildland Weed Management symposium 1999).

Protected areas have unique management obstacles when the goal is to preserve the very quality that warranted preservation. One of these pressing issues is noxious and exotic weed invasions. Invader weed species have been slowly and systematically altering the landscape of North America. This is evident in the Inland Sea Shorebird Reserve (ISSR) located along the southeastern edge of the Great Salt Lake. The ISSR (Map 1, page 48), is a mitigation site owned and managed by Kennecott Utah Copper Company (KUCC) to compensate for wetland loses in relation to current mining operations. The area now known as the ISSR has a long history of human created disturbances. Prior to KUCC taking control of this property, grazing had been a long-standing practice along the shoreline of the Great Salt Lake and vehicle access has not always been restricted in this area. Also, natural disturbances such as flooding have been regular events in this region as well. As Sheley and Petroff report (1999) weeds prefer highly disturbed areas such as waterways, trailheads, roads, and grazed areas. All these disturbances have created an environment ripe for weed invasions. This survey focused on the presence of noxious weeds and particularly aggressive exotic weed species and their effect on the ecology of the Reserve.

Legally, a noxious weed is designated by a federal, state, or county government as any plant found to create an injury to public health, agriculture, recreation, wildlife, or property. Any weeds identified that fall into that category can be considered for official noxious weed classification. Legal classifications of noxious weeds differ from state to state. In the case of Utah, noxious weed classifications also vary from county to county. Due to the variable status noxious weeds receive from state to state, in this study references to exotic and noxious weeds are indistinguishable. The deleterious effects on ecosystems are similar. The weed survey conducted at the ISSR included some weeds with particularly invasive qualities that lacked legal
classification at the governmental level. While the Reserve is home to a multitude of weed species, only six were selected for the mapping process. Weeds present in the Reserve that have been declared noxious by the state of Utah are: 1) Russian knapweed (*Centaurea repens*), 2) Whitetop (*Cardaria draba*), and 3) Scotch thistle (*Onopordum acanthium* L.). Invasive weeds that are not officially designated as "noxious", but were included in the survey include: 4) Bull thistle (*Cirsium vulgare*), 5) Tamarisk [saltcedar] (*Tamarix ramosissima*), and 6) Phragmites (*Phragmites australis*).

Field Bindweed [morning glory] (*Convolvulus arvensis*) was found present in the Reserve and is on Utah's official noxious weed list. However, field bindweed was excluded from the survey as it was only found in two locations within the Reserve and each patch was represented by one plant. Due to the absence of field bindweed it does not appear to pose a serious threat of becoming a menace and overtaking the Reserve. Normally field bindweed aggressively reproduces by roots and seeds as a single plant can produce up to 34 individual plants in approximately six months (Zollinger and Lym 1992). In conditions where field bindweed is competing with native plants and grasses it can survive serious drought conditions as its root system can extend for up to 5 to 9 meters (Westra, et al 1992). In the ISSR, field bindweed is in stern competition with other aggressive weed species that are more adept at challenging for the small supply of water. It may be that the field bindweed is being outcompeted by the surrounding invasive weeds and therefore is not reproducing at its potential. Although field bindweed can be an extremely problematic weed at this point it is not so for the Reserve.

Cheatgrass (*Bromus tectorum*) is also found in the Reserve. This weed is an aggressive exotic weed species even though it is not officially considered “noxious” by the state of Utah. Cheatgrass was excluded from the survey due to its overwhelming presence throughout the habitat types in the Reserve, but included in the management outline for the same reason.

The purpose of this descriptive study is to identify and map noxious and invasive weeds in the ISSR that pose a threat but are still not so pervasive as to defy management regimes and to
use the study results to develop an integrated weed management plan that can direct the focus of the Reserves plant community toward ecological restoration. KUCC reclamation efforts have recreated a wetland area that is contiguous with other protected areas along the shoreline of the lake. As it stands, currently most of the shoreline is now under some protective status, as the Audubon Society and the Nature Conservancy own adjacent property. The opportunity exists to expand the theories of weed management to other properties to achieve a more natural plant community for most of this riparian habitat. Weed surveys will assist the Reserve management in accurately determining areas infested with invasive species. Once infested areas are identified, goals of prevention, eradication, and control can be more efficiently accomplished. An integrated weed management plan is a critical step to attaining control over serious weed infestations.
CHAPTER 2
LITERATURE REVIEW

This literature review provides a general view of how noxious and invasive weeds became
dilemmas, what facilitates their spread, and how they are altering the environment. Literature on
each specific weed surveyed in the ISSR will be elucidated more specifically in the weed
management outline.

The majority of exotic plant species made their way to North America for ornamental
purposes. Invasive plants that originated mostly in Europe and Asia have quickly spread
throughout the entire United States. Native species have not evolved to contend with the arsenal
that invader plants possess. Many of the weeds we are currently combating developed in the
eastern hemisphere, where a long history of intensive disturbance has resulted in highly
competitive weed species (Sheley et al. 1999). Once introduced to North America they found
easy routes to infest rangelands, wetlands, and other ecosystems via human disturbances.

Historically, the abundance of native forage in western landscapes was seen as an unlimited
resource. This outlook, along with other human created disturbances (domestic livestock,
grazing, fire control), has created conditions that have allowed invader plant species to spread
rapidly (Bedunah 1992). Although natural disturbances produced significant deviations in native
populations, essentially the plant communities were in an ecological equilibrium (Whittaker
1965). Human interactions and management of the land have severely altered this stability. Until
recently the concern over noxious weeds was primarily focused on their effects to croplands and
livestock production (Bedunah 1992, Schwaller 2001). This principle viewpoint is now being re-
evaluated as the scrutiny of impacts from invader species is broadened to encompass overall
ecological health.

The invasion of noxious weeds threatens the delicate balance of healthy ecosystems. Any
weed that is identified by federal, state, or county governments to be detrimental to public health,
agriculture, wildlife, public or private property, and recreation is legally defined as a noxious
weed. The primary characteristic of a weed is its ability to thrive in habitats disturbed by human
activity (Zimdahl 1993 pp.18). The very guidelines for noxious weed designation are intrinsically
connected to localities of human disturbances. The ecological effects are also a serious
component of invasions, but are not always fully considered in official classification.

Noxious weed infestations affect the ecological value of the land by altering nutrient and
water cycles, transforming soil structure, reducing forage for wildlife, and diminishing the
economic value of the land (Olson 1999). America's history with weed control has been centered
on their detrimental effects on agricultural and livestock productivity. Consequently, most
literature and scientific studies have focused on exterminating the weed during the crop-growing
season (Zimdahl 1993 pp. 21). Once weeds began to be identified as poisonous, and thereby
harmful to cattle, attention for weed control was turned to a broader view of rangeland
management. Previous to this discovery, grazing lands were managed by revegetating with
exotic grass species that proved to be no competition for the ever-growing weed infestations. The
unencumbered invasion resulted in a 75% reduction in grazing capacity (Sheley 1999). This
management directive served to alter the complex ecosystems of rangelands, forests, and
wetlands by replacing the native grasses with exotic species for continued grazing, thereby
providing the optimal scenario for weed invasions.

The influence of invasive weeds is threatening the biological diversity and natural functions
of U.S. rangelands (Sheley and Petroff 1999). Noxious weeds displace native species and reduce
plant diversity by aggressive competition, allelopathy (ability to suppress growth of surrounding
plant species through release of toxic substances), fierce seed production and viability, rapid
growth rates, and a lack of natural enemies (Olson 1999). For instance, knapweed species can
produce from 400 to 25,000 seeds per plant (Watson and Renny 1974). The sheer number of seeds
and the duration of seed germination help create long-term seed viability that allows weed seeds
to remain in a plant community for decades (Davis et al. 1993).
Areas that are heavily infested are disrupting the natural cycles by massively decreasing plant variety. It is generally accepted that plant diversity is the most favorable scenario to allow maximum energy flow through the system as well as nutrient and water cycling (Sheley et al. 1999). Once monocultures of invasive weeds establish in an area the intensity of nutrient cycling disruption is a complex series of effects invader species utilize to permeate and restrict native plant populations. Adverse results tend to cascade throughout the habitat; one example of how weeds may affect ecosystem structure is by altering soil composition through increased erosion. Consequently, water infiltration may be reduced and runoff increased on sites heavily dominated by noxious weeds (Lacey and Olson 1991). Also, noxious weeds generally have sparse plant canopies, allowing for greater evaporation from the soil surface and reducing levels of soil water for energy uptake by native grasses and roots thereby hindering native seedling survival (Lauenroth et al. 1994). Noxious weeds also reduce soil nutrient availability and disrupt the nutrient cycle by possessing higher uptake rates and slower decomposition time (Olson 1999) than more desirable plants. More particularly pertaining to watersheds, reduced water infiltration and increased runoff have drastic effects on the ecosystem. These impacts can alter essential seasonal water flow and water availability for surrounding wildlife and plants.

Studies have shown that native vegetation stabilizes soils from degradation while invasive species do not always perform that function. When noxious weeds overtake sensitive riparian habitat and displace native plants, soil can become quickly eroded, resulting in adverse effects to waterways. Prevention is the key to maintaining the ecological integrity of riparian areas as most weed seeds float and spread rapidly through the water. However, establishment of weeds along waterways is a natural event when periodically disturbed by flooding events and channel movement (Sheley, et al. 1995). Noxious weeds tend to endure through those disturbances while other species are destroyed.

Many of the ecological conditions that apply on rangelands can be transferred to wetland areas. Noxious weeds are severely altering the balance of wetland areas, modifying the structure

Fundamentally, all parts of an ecological system are integral to its health and survival. As animal species co-evolve with native plants for cover, forage, and shelter they become dependent on the plants' survival and have a difficult time altering their needs and habits quickly enough to adapt (Olson 1999). Some experts consider nonnative species to be the largest threat to biodiversity, second only to habitat destruction (Westbrooks 1998).

As invasive weeds have not evolved with a particular habitat in North America, they tend to alter the natural disturbance cycles. Impacts of noxious weeds are compounded not only by their presence, but also by biological behavior. From the mid-west to the western coasts cheatgrass has been found in over 95% of the counties. This extremely aggressive noxious weed has increased the frequency of fire, as it is a highly flammable plant. Studies have shown that cheatgrass areas usually burn every 3 to 5 years whereas native plants displaced by cheatgrass typically burn every 60-110 years (Olson 1999). The difference in the timetable of fire disturbance is severely altering ecosystem balance. Conversely, other noxious weeds such as knapweed tend not to be affected by fire.

The effects of noxious weed infestations are countless, that is why weed management plans are critical. In the past, the primary focus of weed control has been eradication through the use of herbicides and secondarily through biological control. These efforts are not working to permanently eliminate undesirable plants, as herbicide use must be continued year after year in order to maintain a semblance of containment over the invasive plant species. New methods and management combinations need to be utilized in order to achieve some control over this ever-growing problem.

In protected areas or habitats designated with special management directives ecological restoration or rehabilitation is usually an overall goal. A new and evolving viewpoint of integrated weed management needs to be taken in reference to noxious and exotic weed infestations and restoration efforts. An integrated weed management plan can offer an
amalgamation of strategies to establish a semblance of control over the weeds and revegetate the landscape to restore some of the ecological balance being lost to weed monocultures. Integrated weed management plans employ the initial use of herbicides, but also focus on the theory of plant succession when revegetating a landscape to ensure the maximum level of plant competition with the noxious weed. Integrated weed management plans can benefit areas such as the ISSR that have exotic weed infestations (that may not be legally considered noxious) altering the ecology. Successful ecological restoration efforts must focus on controlling menacing riparian weeds that alter stream flows and clog waterways as part of the management agenda. The focus for weed control needs to extend beyond official noxious weed designations and include invasive species that are severely altering the ecosystem.
CHAPTER 3

DESCRIPTION OF THE INLAND SEA SHOREBIRD RESERVE

The Inland Sea Shorebird Reserve (ISSR) is a Wetland Mitigation Bank Service Area for Kennecott Utah Copper Corporation (KUCC). Created between May 1996 and January 1997 the Reserve is located on the Southeast corner of the Great Salt Lake and is approximately 3,700 acres of wetland area extending east from the lake. Due to the geography and configuration the Great Salt Lake has created a unique wetland habitat. Friends of the Great Salt Lake describe the expanse of wetlands and their importance.

Wetlands are among the most biologically productive systems in the world. Those of the Great Salt Lake Ecosystem occupy approximately 400,000 acres, or nearly 3/4 of all wetlands in Utah, which in total comprise just over 1% of the state. Periodic flooding provides the benefits of nutrient dispersal and plant revitalization. Wetland services include seasonal floodwater storage and ground water recharge, water purification, wildlife habitat, and recreational opportunities. The marshes, playas, and upland vegetation zone serve as critical buffers to outside disturbances. About half (200,000 acres) of Great Salt Lake wetlands are currently protected to some degree (FOGSL 2003).

The ISSR provides a vital link to the wetland habitat along the Great Salt Lake shoreline. Starting at the north end of the lake 74,000 acres are protected by the Bear River Migratory Bird Refuge managed by the U.S. Fish and Wildlife Service, south of that is 3,400 acres owned by The Nature Conservancy named the Great Salt Lake Shorelands Reserve and adjacent to the northern end of the Reserve is the 1,400 acres Gillmor Sanctuary maintained by The Audubon Society (FOGSL 2003).

Historic use had degraded the wetland value of this property prior to mitigation efforts by KUCC. Settlement of the Salt Lake valley resulted in cattle grazing along the shores of the Great Salt Lake, which opened the door for the ecosystem imbalance found now. Prior to grazing activity at the ISSR, perennial grasses and shrubs were plentiful along the Great Salt Lake. Since native perennial grasses do not have vigorous seed production and do not easily recover from grazing (DiTomaso 2000) this practice has severely altered this region. As areas became overgrazed annual winter grasses and exotic grasses were introduced specifically for cattle foraging. Native perennial grass plants and other native plants were quickly replaced on rangelands, not only in Utah, but also throughout the country (Young and Longland 1996), laying
the groundwork for the oncoming invasion. The disturbance created by the cattle and
subsequent grass replacement made the invasion of more aggressive weed species easily
accomplished. Along with other human activities, the disturbances in the ISSR were tremendous
in regards to constancy. Prior to KUCC's creation of the ISSR human activity (i.e. vehicle use,
grazing) versus natural events (i.e. flooding, drought) defined disturbances in the area. KUCC
described the initial plan for revitalizing the site.

The Operational Plan for the Mitigation Site consisted of two phases. Phase 1 included site access
control, cleanup, and livestock removal to restore and preserve existing habitats. Phase 1 access
control was secured through the installation of fences, gates, and signs along site boundaries.
Grazing leases were terminated and all livestock was removed from the site. Additionally, debris
deposited during high lake levels was cleaned up and hauled to an appropriate off-site landfill.
This phase also included a detailed environmental baseline/pre-construction inventory consisting
of vegetative, avian, soil, and hydrological surveys. Cleanup, site preparation and site planning
was coordinated with National Audubon Society's Gilmore Sanctuary which is adjacent to the
KUCC property. The intent was to develop a contiguous track of land with similar management
objectives.

Phase 2 provided for water delivery system improvements, water rights, and other site
modifications necessary for the enhancement and creation of aquatic habitats. Approximately
10,500 feet of dikes, up to 4 feet in height, were constructed to impound water in five ponds. The
total acreage of ponded water is 322 acres. The ponds were constructed to be seasonally supplied
with water delivered from the North Point Canal. Elevations of the ponds are managed to provide
shallow flooded and exposed mudflats. Management of shallow water and mudflats provide
significant food, nesting and resting opportunities for migratory and resident shorebirds.

The resulting environment in the ISSR is a combination of habitat communities. Based on a
vegetation community study conducted at the ISSR by Sterner (1997) the habitat communities
that were identified were palustrine emergent wetlands (Photo 1, page 56), saline playa, riparian
scrub and scrub-shrub wetlands (Photo 2, page 56), open water, alkali scrub-shrub, grassland,
and roadside and other disturbed areas (Table 2, page 43).

The creation of zones (Map 1, page 48), facilitated data gathering and exhibits varying habitat
types that affect weed infestations and spread. While the delineation of zones did not prove
critical in weed location, it will be helpful to reference weed data mapped for access purposes.
The following is a brief description of habitat types found in each zone. Table 2 (page 49)
provides detail of habitat types identified in each zone (Map 1, page 48).
Zone 1: This area is the largest zone and the most diverse of habitat types. Palustrine emergent wetlands, riparian scrub-shrub wetlands, alkali scrub-shrub, open water, saline playas, grasslands, and roadside disturbances characterize the habitat community in this zone.

Zone 2: Habitat communities in this zone ranged from roadside disturbance, riparian scrub-shrub wetland, alkali scrub-shrub, grassland, open water, and saline playa. The northern section of this zone was primarily dominated by grassland and alkali scrub-shrub, while the southern end was mostly saline playas and open water.

Zone 3: Habitat communities in zone 3 are categorized as saline playas, open water, alkali scrub-shrub, grassland, and roadsides. The Lee Creek is a natural feature located at the southwestern part of this area and was inaccessible due to the amount of water. A large ditch runs southeast to northwest and when the creek is backed up with a large quantity of water the ditch takes the excess water. Areas on the eastern portion are typically grasslands and alkali scrub-shrub zones and saline playas extend south from the 700-north access road marking the edge of zone 3.

Weed management is part of the long-term management goals for the Reserve. Developing an integrated weed management plan for the ISSR would benefit the wildlife and ecological health of the Reserve for future productivity. An integrated weed management plan not only looks at short-term weed control, but also uses theories of plant succession to restore and revitalize areas with native and more desirable plants. Utilizing competition from native plants can be a tool to combat future infestations and continued spread of several noxious weed species. Therefore, while the management plan will include recommendations for weed removal through herbicide use, it will also focus on establishing a native plant community using plant succession to attain long-term weed control and ecological restoration. Developing strategies that enhance the ability to establish desired plant communities may provide landowners and public land managers with a sustainable method for managing noxious weed-infested rangelands (Jacobs et al. 1999). An integrated approach to noxious weed management could benefit all aspects of land
management whether that land is privately owned, publicly managed, or established Reserves and refuges.

Following creation of the ISSR a marked increase in bird activity has been documented at the site. Approximately 150,000 migratory shorebirds and waterfowl (Photos 3-5, pages 55-57), visit the ISSR every year (Kennecott 2002). Overall, between 2 and 5 million shorebirds that represent 36 different species visit the Great Salt Lake and the surrounding wetlands each year (Kennecott 2002). However, the same brackish waters and surroundings that lure birds and other wildlife also provide prime habitat for noxious weeds. As areas with previous disturbances and ditches decrease biodiversity and choke out native plant populations (Sheley and Petroff 1999) the need to address the noxious weed infestations is part of the next step to rehabilitating the wetland ecosystem. Efforts to increase bird and wildlife (Photo 6, page 58), activity will be enhanced by focusing on the weed control and restoring the native plant community.
Mapping weed populations is essential in any effort to control or eradicate noxious infestations. Weed surveys can demonstrate infestation patterns that identify targeted areas for control efforts and promote long term monitoring of the site. Any weed management efforts could not proceed without some form of mapping to identify and assess the severity of the infestation. The results of weed mapping can demonstrate the dynamic nature of weed invasions and play an important role in attempts to restore the ecosystem.

The weed survey for the ISSR was conducted during the months of June through August of 2002. This timeline coincided with the end of the flowering period for one weed mapped (whitetop) and the beginning of flowering for many others (Russian knapweed, thistle). The flowering timeline for additional weeds also fell within this period, making it easier to identify infestation patches.

While a multitude of mapping techniques are available, I chose to perform a systematic weed survey using geographic information system (GIS) capabilities. The systematic weed survey allows for better information on distribution and infestation patterns across any given landscape (Johnson 1999). A Garmin GPS 12 hand-held unit was used to collect point data throughout the ISSR. Weed species were digitally marked and corresponding field notes were taken to determine specific size and density of each infestation. Table 1 (page 42) illustrates the criteria used to identify density and size.

Using natural features as dividing lines, the Reserve was split into three separate segments and then each section was mapped. Starting at the Googin Drain (which serves as the northern boundary of the Reserve) moving southward to the North Point Consolidation Canal, became the first area surveyed, hereafter referred to as zone one. The land between the canal and the original 700-north road marked the second area and became zone two. The 700-north road to the southern fence line is the boundary for zone three. Each zone not only had natural features
providing for an ideal dividing point, but also exhibited vegetation characteristics. This provided a distinct opportunity to ascertain if any infestation was behaving differently in each zone and if differing habitat communities are affecting the weed populations. Starting north and working south each area was mapped by systematically walking the perimeter of ponds, marshes, canals, infestations and roads (Map 2, page 49). Zones allowed for a more organized approach to data collection and also correspond to best access routes for future management.

Once GPS data and field notes were concluded maps were compiled to reflect different levels of infestation. Point data shows smaller patches of varying density. Polygons demonstrate infestations ranging from 1 acre to 5 acres of mostly moderate to high density. Infestations that followed features such as roads, ditches, waterways, and ponds were also connected to illustrate their dispersal patterns (Maps 2-6, pages 49-55). Once data manipulation was complete a base map was scanned to provide feature identification and accurate map projection throughout the ISSR. These maps will serve as the guiding data set for the integrated weed management outline.

All identified weeds were mapped individually with the exception of thistle. In 1997, a complete vegetative study was conducted (Sterner) of the ISSR. That compilation identified two thistles present in the Reserve; bull thistle and wavyleaf thistle (*Cirsium undulatum*). As the current survey was carried out, three different thistles were found present in the Reserve. All thistles were mapped together and did not appear to overlap in location of infestation. Bull thistle was positively identified and recorded as present along the North Point Consolidation Canal. Remaining thistles have not been accurately identified and samples should be taken to determine absolutely their identity. Photos of the two thistles were taken to a botanist working for Yellowstone National Park to aide in identification. The thistle found along the roadside disturbance is thought to be scotch thistle and will be treated as such in this survey. Their size, structure, and pod formation all point to a scotch thistle plant, but no positive determination can be made based on photos. The third thistle was found in sporadic satellite patches in each zone in the ISSR. Based on its size, location, and density of infestation it is possible that the third
thistle species is of native origin. Typically native thistles do not form monocultures or dense infestations and the unidentified thistle follows such a dispersal pattern. For purposes of this study the unidentified thistle is mapped, but not examined further.
CHAPTER 5

RESULTS

Weed distributions were somewhat different in each zone habitat. Some weed locations and density could be correlated to varying habitat types found throughout the reserve while others could not. Results are separated by species and then by zone to better illustrate infestation locations and associated habitat types.

**Whitetop** – Whitetop (Photo 7 and 8, page 59), was present in each habitat type represented in zone 1. The northern section is comprised mostly of riparian scrub-shrub wetlands, open water, saline playas, and alkali scrub-shrub and road disturbances. Whitetop was scattered throughout these habitat communities. Infestations in the northern half of zone 1 were classified as less than 0.1 acre to 0.1 to 1 acres in size and densities ranging from trace to moderate. Moving to the southern end of zone 1 whitetop becomes more prevalent and the dominant weed surveyed. Size of infestations increased when habitat type changed to grassland and alkali scrub-shrub vegetation communities. South of the open water areas in zone 1 adjacent alkali scrub-shrub habitats were dominant. Most present in this area was greasewood; whitetop infestations were more scarce. Moving closer to the North Point Consolidation Canal, the whitetop infestation was classified as greater than 5 acres in size and density was moderate to mostly high. One particular relationship developing in this area was the interaction between the whitetop and Russian knapweed. This association is focused on more closely in the discussion of Russian knapweed. Whitetop was present throughout zone 2 with infestations ranging in size from less than 0.1 acres to greater than 5 acres and density from trace amounts to high. One area near an access road leading to a trailhead has become a dense monoculture infestation and no other plants were present throughout the area. The alkali scrub-shrub habitat is more diverse in vegetation than zone 1. Most notable was the increase in greasewood and iodinebush found together. Greasewood was the primary shrub found in zone 1 and whitetop infestations were of trace density in that region. Moving to zone 2 whitetop is found throughout the alkali scrub-
shrub area. However, no determination can be made that this mixture of shrubs is the reason for the difference in whitetop infestation densities. Again, whitetop is found throughout zone 3 with particular presence in the eastern portion infesting the alkali scrub-shrub and grassland areas. No infestations were found near the saline playas and only small satellite patches were located toward the western edge. Infestations ranged from less than 0.1 acres to 1 to 5 acres and density was rated as trace to moderate (Map 3, page 50).

**Russian knapweed** – Russian knapweed (Photo 9 and 10, page 60), infestations were present throughout zone 1. In the northern section, it was mostly found along the Goggin Drain in small patches ranging from less than 0.1 acre to 0.1 to 1 acres in size and density from trace to low. Other scattered patches were found along the roadside disturbances. This pattern of low-density infestation begins to change along the main road to the east and a bordering ditch as the Russian knapweed becomes larger in size from 1 to 5 acres and density becomes high. A large monoculture patch of Russian knapweed is found in this riparian scrub-shrub wetland. In the adjacent grassland and alkali scrub-shrub habitat toward the western edge of the North Point Consolidation Canal Russian knapweed becomes more prevalent as another large monoculture is present. Both of these large infestations are surrounded by dense stands of whitetop. The relationship between both of these species seems to demonstrate that whitetop is out-performing the Russian knapweed (Photo 8 and 11, pages 59 and 61), and possibly keeping the spread of those Russian knapweed infestations from spreading. However, that cannot be definitively stated as it is unknown which weed was present first. Perhaps the Russian knapweed is just starting to push out the whitetop, instead of being contained. Russian knapweed is present throughout the majority of zone 2 with the exception of the western end. Infestations ranged from less than 0.1 acres to 1 to 5 acres and density was classified as trace to moderate. Only one dense stand was located toward the northern edge of zone 2 near the access road. Russian knapweed was found in the same eastern areas adjacent to the main access road. Sizes ranged
from less than 0.1 acres to 1 to 5 acres with density at trace to moderate. Russian knapweed was fairly scattered and no monocultures were found or large, dense infestations (Map 4, pages 51).

**Tamarisk [saltcedar]** - Compared to the rest of the ISSR, Saltcedar (Photo 12 and 13, pages 61 and 62), is most present in zone 1. It is primarily found along the Goggin Drain riparian scrub-shrub wetland habitat. The tamarisk infestation along the drain is over 5 acres in size and density was rated as high. Other scattered shrubs were located throughout zone 1, but were in areas no longer close to standing water. When the water level of the Great Salt Lake rises this area is prone to flooding. These high water events may explain the presence of the solitary tamarisk bushes strewn through this area. Tamarisk roots can extend deep into the ground reaching a low water table, which could also explain tamarisk shrub survival in current, dry grassland areas.

Only four locations of tamarisk were surveyed in zone 2. These shrubs were isolated from standing water and may be remnants of previous flooding. Two larger tamarisk trees were found at the edge of a roadside disturbance and may have been transported there during previous human activities. Few tamarisk shrubs were located in zone 3. Several were found on the western edge of the playa as it became the beach area for the Great Salt Lake. Their presence is possibly connected to flooding stages. They did not appear to be large in size, but were in the same vicinity of each other. The other tamarisk plants are located at the edge of an access road leading to the 700-north road. They flank the road and are fairly large in size. A dry canal with dying phragmites stands is located near these tamarisk shrubs and their presence may be explained by the old water source (Map 5, page 52).

**Thistle** - On the southern edge of the North Point Consolidation Canal in an open water habitat community a large incursion of bull thistle (Photo 14, page 62), is found. This infestation ran the length of the canal and was categorized as a moderate to high density. Dispersal is most likely associated with the water movement in the canal as the thistle plants are overlapping the water area. Along the main access road extremely large thistle plants were found. These plants have been tentatively identified as scotch thistle (Photo 15, page 63), but further verification is
recommended. This scotch thistle infestation is relegated to the roadside disturbance. Possible native thistle (Photo 17, page 64), is found sporadically throughout the reserve along saline playas, grasslands, and alkali scrub-shrub areas. Patches were made up of small plants less than 0.1 acres in size and generally fewer than 5 plants at any given site (Map 7, page 54).

**Phragmites** – Phragmites (Photo 16, page 63), are present surrounding the palustrine emergent wetlands, open water, and saline playas. Typically the phragmites were concentrated in highly dense patches of varying size that ranged from 0.1 acres to greater than 5 acres based on the dimension of the pond or wetland area. Only along the saline playas would the phragmites density decrease to moderate or low. The sporadic water availability to saline playas and the timing of the growing season could explain this. One notable infestation occurred near the main access road where a ditch has been constructed to provide water to various ponds. The construction was engineered to simulate sheet water action. Phragmites have established in this palustrine emergent wetland area as a dense patch of 1 to 5 acres in size. This patch could possibly create problems for the water delivery system as the ever-growing phragmites reed clogs the ditch. Dispersal of phragmites in zone 2 was found to match the pattern in zone 1. Stands defined the edge of open water ponds that were found in several places throughout zone 2. Phragmites stands were not associated with the saline playas that comprised the southwestern portion of the area. Phragmites stands were extremely dense on the western edge at the end of the 700-north access road near Lee Creek. The stands and the open water made it impossible to map the actual size of the infestation, but density was high. Phragmites have also established themselves along the southern fence line marking the end of the ISSR. Access to the fence at the western end was not possible, but the location of the fence was marked at the entrance gate. This infestation was high in density and size ran the length of the property. Other patches were found at the edge of open water areas and a small dying infestation was located near the tamarisk trees noted above. This phragmites stand bordered the end of a dried up ditch and appeared to be dying back on its own (Map 6, page 53).
The original question of habitat types effecting infestation was true for some species and false for others. Some weeds such as, phragmites or tamarisk were relegated to certain habitat types because of their physiology. In those zones they were found in plentiful numbers. The two weeds found in most abundance in the Reserve were whitetop and Russian knapweed. There were small sections of scrub-shrub lands where a noticeable absence or reduced density of the overall presence of whitetop was indicated. However, this discovery did not translate into a predictable pattern. Even though the differing habitat zones did provide a diverse set of conditions they were not enough to contain the proliferation of whitetop and Russian knapweed.

Overall, the mapping illustrated the widespread infestation of Russian knapweed and whitetop, suggesting a close relationship between the two that has affected dispersal patterns. Russian knapweed is characterized as a noxious weed that typically forms monocultures (Benz, et al. 1999). However, the infestation patterns in the ISSR reveal that whitetop may be the more aggressive weed of the two. Only two dense monoculture patches of Russian knapweed were found in the Reserve. In both instances the patches were surrounded by dense monoculture infestations of whitetop, which appeared to be halting the Russian knapweed from spreading. There is no proof or certainty that the whitetop is actually controlling the Russian knapweed or if the Russian knapweed is starting to overtake the whitetop. It is unknown when the Russian knapweed began its infestation in the Reserve and it may be just starting to establish its presence.

The landowner is currently grazing cattle on that property where most of the same weeds are present. The bitter taste of Russian knapweed usually deters cattle grazing (Benz, et al. 1999) while whitetop is a palatable feast. Consequently that property has a plethora of dense Russian knapweed monocultures and very little whitetop. This relationship should be investigated further and both weed species should be simultaneously treated in any management and control efforts.
CHAPTER 6
RECOMMENDATIONS

Principles of Integrated Weed Management

It is estimated that over 100 million acres of land in the United States are already infested with established noxious weed communities. This number continues to grow by 8 to 20 percent annually equaling a loss of 3 million acres per year (Pulling Together 1997). Weeds are rapidly becoming the most pressing issue for both private and public land managers (Lane 2000). Surveys conducted by the Department of the Interior have shown that exotic weeds have invaded over 17 million acres of Western public lands and remaining wildlands are being overtaken at a rate of 4,600 acres per day (Schwaller 2001). The intensity of this invasion is now recognized in every facet of land uses and management. Efforts to eradicate and control noxious weeds are progressing as we begin to understand fully the deleterious ecological effects beyond livestock grazing and cropland production. Traditional treatment methods focus only on the symptoms of weed infestation and prescribe the continued use of herbicides to kill weeds. Integrated weed management differs from conventional strategies by addressing the inherent causes of weed infestation (Lane 2000) and recognizing the importance of the resulting plant community (Jacobs et al 1999). The goal of integrated weed management is to find practical solutions that may result in long-term effective control of noxious weeds (Public Works 2000). Any management goals that focus solely on killing the weeds will not be effective, especially for large-scale or severely dense infestations (Jacobs et al 1999). In order to create an effective weed management plan attention must be directed to the resulting plant community. This viewpoint may be the key to achieving long-term control of noxious weed invasions. Plant competition is an important part of integrated weed management plans and can complement more acceptable weed control methods.

Many have speculated that plant diversity is a key component to combating invasion, however, in the past, weed management efforts have been focused primarily on controlling weeds, and little attention was given to existing or eventual plant communities (Sheley et al.
Over the past 50 years assertions have been made to suggest that diverse plant communities are inherently more stable and less susceptible to invasion (Stohlgren et al. 1999). However, concentrating solely on species richness has been an inhibitor in achieving a functioning plant community. Studies have indicated that resource availability and soil moisture are crucial elements in sustaining native plant populations and become principle determinants of invasion (Wiser et al. 1998, Robinson et al. 1995). Integrated management approaches that fail to examine resource availability are neglecting a mechanism that helps determine invasibility (Naeem et al. 2000). Thus, the nature by which noxious weeds alter soil composition and water availability becomes an integral part of establishing a function diverse plant community.

Ecologically based rangeland weed management is founded on the principle that plant communities change over a period of time until they reach climax (Sheley et al. 1999). The processes and mechanisms that drive succession (designed disturbance, controlled colonization, and species performance) are not completely understood, but theoretically could be utilized in long-term invasive plant species control. In the past, weed management strategies have used designed disturbance (herbicides, timed grazing, burning) simply to control weed infestations. An ecologically based weed management plan uses the created disturbance to shift the processes driving succession to a more desirable direction (Sheley et al. 1999). An integrated approach concentrates on filling niches and provides for early and late successional plants to discourage massive reinvasion of the noxious weeds, thereby working towards ecological restoration, balance, and long-term control.

Integrated weed management plans for riparian areas do not differ in theory. Each environment has some uncontrollable element in weed invasions. The uncontrollable avenue for seed dispersal through waterways cannot be overcome. However, the infestations along critical conduits must be dealt with by undertaking an integrated approach so that the spread and density of each infestation can be limited. Once infestations have taken hold in sensitive habitats efforts to control and revegetate the waterway should be undertaken. Recovery of riparian areas
generally occurs faster than other habitats. The soil usually has enough moisture to allow native and more desirable revegetation efforts to take hold. Unfortunately there is still much to be done on research regarding riparian areas and weed management. Studies are lacking on control efforts where moving water is a factor in weed dispersal.

**Weed Management Outline**

To begin any management effort, goals must be clearly established. In integrated weed management (IWM) the goal should be based on developing and protecting the desired plant community (Goodwin and Sheley 2002), thereby, shifting the focus from simply eliminating weeds to attempting to restore the ecosystem. Phase 3 of the operational plan for the mitigation site by KUCC only identifies weed control as one of the management objectives. However, the Reserve manager is interested in revegetating with natives to try and restore some of the native plant community (Table 4, page 45). Therefore, the IWM needs to identify native shrubs, grasses, and forbs that represent all growing seasons to increase year round competition with the undesirable weed species. While revegetation of more desirable plants is the end goal, steps need to be outlined in order to achieve that objective.

Goodwin and Sheley (2002) outline parts of IWM as; 1) prevention and early detection, 2) detecting and eradicating individual weed introductions early, 3) eradicating small patches, and 4) management large infestations. Prevention is the most cost effective of weed control. The weed surveys help identify areas that are relatively weed free and of high ecological value. Those areas should be watched carefully to prevent weed infestations from starting. At the same time small satellite patches can usually be eradicated and focused on first. Thus, high priority areas can be expanded through effective monitoring and eradication procedures. The most important element of prevention is limiting seed dispersal. Through an IWM and initial use of herbicides seed production and dispersal can be reduced. Also, eradicating small infestations and controlling larger ones can be an effective method to controlling seed dispersal.
Early detection is an extension of prevention. Monitoring can be easier to institute after an initial mapping survey is completed. Relatively weed free areas should be scheduled for annual observation. If new weed growth is discovered, it can be immediately targeted for eradication.

The next step is eradicating small patches. Counter to intuition smaller infestations should be targeted first in the effort to contain further spread of the weed. This is a long-term effort as most noxious and invasive weed species have seed dormancy rates that require diligence for many years to ensure full eradication. Most small satellite patches can be eradicated if attacked early and strongly. The ISSR has many small patches, ranging from less than 0.1 acres to 1 acre, that would be ideal places to start eradication efforts.

Lastly, the IWM needs to focus on managing large infestations. Unfortunately, most patches that are dense monocultures will most likely never be eradicated. Efforts to control and contain those patches are the focus of IWM. Control methods can range from mechanical, chemical, cultural (revegetation), or biological in nature. Integrated weed management plans draw on a multitude of control methods in attacking the weeds and providing for long-term solutions. In the case of the ISSR's desire to revegetate with native plants Goodwin and Sheley (2002) recommend following these steps to achieve successful revegetation:

- Determine if revegetation is necessary based on weed and desired plant cover (consider revegetation when desired vegetation cover is below 20%);
- Designing a proper seed mix and preparing a proper seedbed, if feasible and/or necessary;
- Enhancing seedling establishment by removing weeds, increasing seeding rates, excluding livestock; and
- Properly managing established vegetation.

While mapping is the first component of creating a weed management plan, an understanding of undesirable weeds is also an essential element. Each of the six weeds surveyed have different life histories, dispersal patterns, population dynamics and therefore each has diverse control efforts. A brief literature review of the mapped noxious and invasive weeds behavior and current control methods will help clarify the direction of the weed management plan. This information is necessary to decide on which methods would achieve the desired results in each step of the IWM
approach. Control efforts for each weed have been outlined to highlight which control or eradication methods have proven most effective with no thought to overlapping treatment.

Russian Knapweed (*Centaurea repens*)

**Life history and population dynamic**

Russian knapweed is a highly competitive, perennial, noxious weed. Through its allelopathic abilities it tends to establish dense monoculture stands (Whitson 1999). Infestations generally increase through its creeping root system versus proliferation by seed production (Watson 1980). This has made Russian knapweed the most persistent of the knapweeds (Bottoms 1989). Species within the genus *Centaurea* probably represent the most significant threat to rangelands in the northern intermountain region. They are highly competitive in a wide range of habitats (DiTomaso 2000) making this weed particularly difficult to control.

**Control efforts**

The primary plant species providing most competition to Russian knapweed appears to be perennial grasses (Whitson 1999). Use of herbicides prior to attempted establishment of grasses is paramount along with tillage of surface residue. This is important to quicken the decomposition of the Russian knapweed allelochemicals, which accumulate with the knapweed foliage. However, chemical control of Russian knapweed is typically temporary and requires consistent reapplications to thwart re-invasion. Studies done by Benz et al (1989) compared two Russian knapweed sites two years after treatment. One plot was chemically treated and then seeded with grasses to obtain a 66 to 93% control rate. The alternate site was treated with the same chemical application alone and only showed a 7% control rate. Consequently, all plots where Russian knapweed was suppressed and then reseeded had 3 to 18 times greater grass seed cover than unseeded plots, demonstrating that reseeding is a critical component to Russian knapweed control and restoration/reclamation. Treating Russian knapweed infestations prior to reseeding attempts is an important part of the integrated management approach (Whitson 1999)
Bull Thistle (Cirsium vulgare)

Life history and population dynamic

Bull thistle is a European native and was likely introduced to North America during colonization and has become the most widespread thistle in western North America (Mitich 1998). Bull thistle tends to thrive in recently disturbed areas such as ditches, roads (Forcella and Randall 1994) and grazed areas (Michaels 1970). The ISSR has been a perfect habitat for thistle invasion as a recent study indicated that rosette plants occurred twice as much in grazed areas as ungrazed (Beck 1999). Bull thistle is typically a biennial plant that only reproduces by seed. The main source of seed distribution occurs from water, animal and human activities (Beck 1999). Studies indicate that the majority of bull thistle seeds fall within 1 yard of the plant (Michaux 1989) making infestations occur in clusters unless some other distribution method is at work. Following dispersal, seeds generally are found right below the surface and can viably remain there for 1 year or longer (Forcella and Randall 1994). Typically, thistle plants do not sprout from the rosette until their second year in which seed production begins (Forcella and Randall 1994). Germination studies conducted in the laboratory have concluded that higher temperatures are a factor in significantly increasing seed germination and that bull thistle is less sensitive to low water potential (Lincoln 1981). Environmental factors that invite thistle invasions and promote the propagation exist abundantly in the ISSR. Normally, bull thistle germination occurs after the autumn rains or in the spring when soil temperatures begin to rise (Forcella and Randall 1994). Flowering transpires mid- to late summer, but can last until the first frost.

Control efforts

Since thistle is monocarpic and reproduces from seed alone the chances for full eradication are good. Prevention is the first line of defense when dealing with thistle. It is relatively easy to stop thistles from dispersing seeds by manual cutting or herbicide use. There are a few herbicides that can effectively handle bull and scotch thistle, including clopyralid, dicamba, MCPA, picloram, 2,4-D, metsulfuron, and chlorsulfuron. Timing of application will determine
the best herbicide to use (Table 3, page 44). If manual methods are to be utilized any removal that severs the root below the surface will kill the weed (Beck 1999). However, an essential component of treatment includes revegetation, particularly with grasses. Treatment should be consistent for a number of years to account for seeds left from plants of previous years. Also, the bull thistle infestations are found along the North Point Consolidation Canal so diligence in stopping seed production should equal prevention of water dispersal of seeds.

**Scotch thistle (Onopordum acanthium L.)**

**Life history and population dynamic**

Scotch thistle is officially listed as a noxious weed by the state of Utah. It has earned that distinction through an aggressive production of seeds with long viability. Scotch thistle found its way to North America from Europe and Asia and now occupies areas with high soil moisture in especially dry climates. It is particularly known for its association with plant communities dominated by cheatgrass or downy brome (Beck 1999). The ISSR creates the perfect habitat for scotch thistle invasions. Young and Evans (1972) have noted that dry habitats where native grasses have been displaced by downy brome create favorable sites for Scotch thistle. The presence of Scotch thistle is most abundant where soil moisture is highest. In these environments Scotch thistle is restricted to gullies, draws, and roadside burrow pits. Locations of Scotch thistle in the Reserve correspond to roadside disturbances and areas of downy brome infestations.

**Control efforts**

The elements and human activities help transport scotch thistle seeds. However, the majority of seeds fall nearby the parent plant resulting in clusters of thistle infestations. Therefore, management of scotch thistle is much the same as with bull thistle (Table 3, page 44). Since the scotch thistle infests the roadsides and access is easy, eradication of this noxious weed could be achieved.
**Whitetop (Cardaria draba)**

**Life history and population dynamic**

This noxious weed is adapted to grow in open, unshaded and moist areas. Typically whitetop is found in disturbed areas that are dominated by other invasive plant species, such as Russian knapweed (Selleck 1964). Propagation of whitetop is a two part attack as spreading occurs rhizomatically as well as through an aggressive seed production. Whitetop generally blooms in May with seed production occurring one month later (Sheley and Stivers 1999). It continues to grow until the first frost, so if conditions are favorable whitetop has been known to bloom twice in one season, thereby doubling its already massive seed production. Whitetop can produce up to 850 seeds per flowering stem and seeds are spread primarily by wind. Any seeds that become buried are viable for about three years (Sheley and Stivers 1999). Whitetop also has a highly aggressive root system that can go as deep as 30 feet by the third growing season after initial germination (Mulligan and Findley 1973). The vertical root system develops lateral roots that eventually become vertical again and reach even further depths. Both root systems produce buds, which can develop into rhizomes and shoots (Sheley and Stivers 1999).

**Control efforts**

Within an integrated weed management plan treatment for whitetop needs to be separated into two categories; containment of large-scale infestations and small-scale eradication. Efforts to contain large-scale infestations include a commitment to annual treatment of the perimeter of each patch. Usually this occurs on an annual basis depending on the herbicide selected. In the case of whitetop control the use of metsulfuron application in the spring when rosettes are growing (usually March to May) is recommended. Whitetop will also grow again in the fall so applications at this regrowth can also be effective. Sheley and Stivers (1999) recommend applying metsulfuron “with at least 10 gallons of water per acre (125 l/ha) and to use a nonionic surfactant”. Studies have not demonstrated any single treatment that has proven to be an effective, long-term control method. Using an IWM approach is critical in trying to restore areas
overtaken by whitetop. Along with chemical treatments the use of cultural control techniques would be appropriate. Corns and Frankton (1952) conducted surveys in whitetop control throughout Alberta finding that flooding can effectively control whitetop, but requires submersion from May to September. Whether a natural flooding event would be sustained for the required length of time necessary is unknown. Whitetop plants also spread by producing shoots that can form at any part of the root system. One plant can manufacture more than 450 shoots in a single years time. Competition from other plants can reduce this reproduction to less than 50 shoots per year (Sheley and Stivers 1999). To control whitetop a comprehensive integrated plan will be necessary to utilize all the control methods available.

**Phragmites (Phragmites australis)**

Life history and population dynamic

*Phragmites australis* is better known in North America as a common reed plant. This weed is actually considered a keystone species in Europe and is a critical part of the wetland habitat. Once introduced in North America, it has taken on a different life. Although it is typically found in freshwater wetlands, it is also known to inhabit brackish and saltwater marshes (Frederick 2000). The scope of phragmites tolerance to salt levels allows it to occupy wetlands ranging from freshwater lagoons to brackish or saline coastal wetlands (Mauchamp 2001). Phragmites spread mainly through rhizomes to eventually cover large areas and shade out competitors with a dense, tall canopy that often results in a monoculture (Frederick 2000). The infestations in the ISSR demonstrate the ability of phragmites to tolerate fluctuating levels of salty water. However, studies show that phragmites have a salt tolerance level that, when exceeded, can drastically reduce and effectively control dense stands.

Studies conducted reveal that phragmites stands have limited seed viability that slows its reproduction. However, this low rate of reproduction from seed is offset by rhizomitous extensions. Once phragmites populations become established, if left unchecked, they can live for long periods of time and continue their spread through the root system (Haslam 1972).
Control efforts

In the effort to control or eradicate phragmites, studies (Thursby 2002, Bart 2002, Mauchamp 2001) have discovered the reed has a low tolerance of salt. Although, it is salt tolerant and may grow in soils where the salt concentration of interstitial water reaches 40 or 50 °/oo. Phragmites stands that were treated with increased salinity actually decreased by 50% (at 7.5 °/oo when compared to freshwater) and 7-100% mortality depending on population dynamics, occurred at 15 and 20 °/oo (Mauchamp and Mesleard 2001). Using salinity tolerance studies the phragmites infestations could easily be treated by increasing the salt content in the waterways. Considering the natural salinity present from the Great Salt Lake this would fall in line with the habitat. All phragmites populations in the Mauchamp and Mesleard study recovered after the initial 25-day salinity exposure as they were then flushed with freshwater. Therefore, consistent salinity monitoring would be called for if long-term phragmites control were to be accomplished. Removal efforts in refuges and Reserves purchased by The Nature Conservancy have shown success when dealing with phragmites. “Unlike many other invasive species, which often have high reproductive capabilities, Phragmites can be eliminated region by region in restoration situations simplifying its removal. Often once control of Phragmites stands has been achieved native communities (Table 4, page 45), can return and have an excellent chance of recovery” (Marks et al.1993). It is conceivable that eradication is possible for phragmites in the ISSR.

Herbicide use can also to help control Phragmites (Table 6, page 47).

Tamarisk [saltcedar] (Tamarix ramosissima)

Life history and population dynamic

Tamarisk first came to this country from the Middle East and was used to prevent soil erosion and provide ornamentals for gardens. Quickly escaping, tamarisk has spread over the entire U.S. competing for cottonwood/willow habitat. It has been designated as one of the 10 worst noxious weeds in the U.S. (Grubb 2002). Information by the U.S. Forest Service and National Park Service has identified tamarisk habitat as “establishing in disturbed and
undisturbed streams, waterways, bottomlands, banks and drainage washes of natural or artificial
water bodies, moist rangelands and pastures, and other areas where seedlings can be exposed to
extended periods of saturated soil for establishment. Saltcedar can grow on highly saline soils
containing up to 15,000 ppm soluble salt and can tolerate alkali conditions [as well]” (Muzika and
Swearingen 2003). Tamarisk is suited to a variety of habitats and conditions for its survival. It
grows as a shrub or small tree 15 to 20 feet in height. Tamarisk is classified as a deciduous tree
and this has become an advantage to environmental stress conditions, such as drought. Tamarisk
trees can reduce their surface area and thereby reduce the amount of transpiration loss making
this noxious weed very suited for desert conditions (NAU 2003).

Studies have shown that tamarisk easily uses more groundwater than native plants thereby
displacing more desirable riparian plant species. Due to the extensive root system that can reach
deep ground water reserves, native plants have trouble competing with tamarisk trees and
shrubs for water. The root system consists of a primary root, which can grow vertically up to 30
meters, and additional roots that can grow horizontally up to 50 meters. Tamarisk has a very high
evapotranspiration rate, extracting up to 200 gallons of water per day (AEN 1996). Studies
conducted by Northern Arizona University suggest,”tamarisk is thought to out-compete the
native vegetation and reduce the diversity of animal species in riparian habitats. It also increases
fire cycles by the abundance of its leaf litter and clogs river channels, causing floods” (NAU
2003).

Tamarisk seeds do not survive for long and can germinate within 24 hours, even while still
floating on the water. Tamarisk weeds also reproduce from a deep and extensive root system
(Grubb, et al. 2002). And the seed germination process is not dependent on light, but does
require saturated soil for 2-4 weeks, open sunny ground, and no competition from other seeds

Tamarisk has a direct adverse effect on wildlife. The Agricultural and Environmental News
article on Alien Invaders (1996) highlighting tamarisk plants define this relationship,
The tamarisk also impacts wildlife because it is unpalatable to most animals. In turn, animals concentrate on other plants, speeding up the invasion process of the tamarisk even more by over browsing of native species. The leaves of the tamarisk keep most insects away because of the salt. The lack of insects keeps birds away. Birds also find the tree unattractive because the tamarisk does not provide edible seeds or fruits. In a previous study, fewer species of birds were found to nest in the tamarisk than in the native riparian vegetation. On average, there were 21 species found in the tamarisk and 36 in the cottonwood/willow over the same time frame. Animals, like antelope and deer, avoid tamarisk thickets because they block access to the river and may conceal predators.

Control efforts

Due to the seriousness of tamarisk invasions, numerous studies have been conducted to control its spread. Herbicide use alone has not produced any long-term control of tamarisk and it must be approved for use near water (Grubb, et al. 2002). Altering the levels of the water near the infestation is a promising method. Along the Gila River in Arizona, dropping the water table helped control tamarisk and other riparian vegetation. Other studies have shown that “submergence for 28 months has provided 99 percent control of saltcedar where plants were inundated for one entire growing season, and over half of the next two growing seasons” (Grubb et al. 2002). This would give the more desirable plant species the opportunity to become established.

The most feasible and effective method of control is root plowing 12-18 inches below the surface to make sure the root crown has not been left to regenerate. Regrowth of saltcedar is forceful as it can grow up to 9 feet in one season (Sheley 1996). Dicamba, 2,4-D, Tebuthiuron, and Imazapry are effective herbicides, but only when used with other mechanical methods such as, cutting, root, plowing, burning, or mowing. Any mechanical method used must be followed up by use of herbicide to eliminate regrowth. Revegetating with more desirable grasses and shrubs will help exclude the tamarisk plants from reestablishing while at the same time enhancing the ecosystem by providing a more suitable habitat for the migratory birds and waterfowl that are returning to the ISSR.
Cheatgrass (Downy brome) (*Bromus tectorum*)

Life history and population dynamic

While this weed was not mapped, because of its pervasiveness in the ISSR, Cheatgrass will be discussed. Cheatgrass has its origins from south-central Asia and early invasions occurred along railroads as seeds were unknowingly transported. From there, cheatgrass spread through wheat fields and by 1997 had infested over 95% of lands from the Midwest to the Pacific Ocean (Mosley, et al 1999). The ubiquitous nature of the seed makes the potential for invasion almost limitless. Even in the most unfavorable conditions cheatgrass produces viable seeds to perpetuate itself (Mosely, et al 1999). While most strains for cheatgrass are fairly similar, the flexibility of the overall plant allows it to invade sites and thrive under numerous environmental conditions. It outcompetes perennial species and grasses so thoroughly that repeated attempts to reseed areas fail to the aggressive competition of cheatgrass (Mosley, et al 1999). The most notable disturbance in western lands that has opened the door for cheatgrass has been grazing. However, downy brome can become a dominant invader in areas without the disturbance of overgrazing (Whitson & Koch 1998) making it one of the most prevalent invaders facing North America.

Control efforts

Once cheatgrass has become firmly established in an area its eradication is not likely to be achieved. Weed management goals for cheatgrass should be focused on control. Studies have shown (Mosley et al, 1999) that “control efforts are effective only when combined with other techniques that establish perennial plants.” Attempts to control cheatgrass without revegetating with desirable plant species will only result in the return of the cheatgrass and perhaps even more undesirable plants.

The herbicide sulfometuron has shown potential for cheatgrass control when followed by reseeding (Mosely et al, 1999). Sulfometuron is applied in the spring or fall and perennial grasses can be seeded the following year.
Native Plant Recommendations for Revegetation

The majority of control efforts for the weed species identified in the ISSR are predicated on revegetation efforts as well. Providing adequate competition in the revegetation process is a key element in a successful weed management plan. This is accomplished by selecting a variety of plants from perennials to shrubs and grasses. Native and adapted plants to this region have been selected for the ISSR. Table 4 (page 45) provides a list of native and adapted plants of this region identified as possible candidates for revegetation in the ISSR. Based on the information in Table 4 the ISSR currently is home to 8 native species. Consequently, there are many desirable plants to choose from (Table 4) that will perform well in the conditions found in the ISSR. Revegetation will not only help in providing some form of weed competition, but will also enhance the ecological productivity of the Reserve.

Studies done by Westminster College in Salt Lake City, Utah have also shown that iodinebush, saltgrass, pickleweed, and greasewood all play important ecological functions in the Great Salt Lake ecosystem. All four of these plant species are present in the ISSR and even though they are not considered native or adapted they seem to play an important role in the small mammal and bird populations along the Great Salt Lake. Deer mice and Ord kangaroo rats are the primary feeders of these shrubs and are an important food source for the migratory bird populations (Vest 1962). According to the weed surveys conducted in the ISSR, they may also function in some part to stop weed monocultures.
CHAPTER 7
CONCLUSIONS

As noxious and invasive weeds continue their spread across North America, the fight to eradicate and control them is an imperative endeavor. The deleterious effects of noxious and invasive weed species are an issue that needs more attention. Historically, weed management has focused solely on the effects weeds cause to agricultural crops and grazing lands. That focus must be broadened to include effects on basic ecological functions and services. Diversifying plant communities is critical if long-term control is to be attained. Whitetop, Russian knapweed, bull thistle, scotch thistle, phragmites, and tamarisk have become serious problems in the Inland Sea Shorebird Reserve and their spread has created a myriad of management issues in the effort to restore the wetlands along this section of the Great Salt Lake. As KUCC enters the maintenance phase of its operation plan the issue of weed infestations is an important goal to continue the success achieved by this wetland.

The results of mapping conducted in the ISSR demonstrate associations between weed species and, for management purposes, those relationships need to be monitored. For dense patches of weeds the management plan may have to treat different weed species simultaneously and downgrade goals from eradication to containment, such as the whitetop and Russian knapweed infestations. While the exact association between those species is unclear, the IWM plan should work to contain those dense areas concurrently to stop the spread of either plant. Developing an integrated weed management plan will help control the noxious and invasive weed populations and instigate the restoration of the Reserve to a healthy and desirable plant community. Whatever weed treatment is conducted on weed populations it is imperative to follow through with revegetation to achieve a diverse plant community that will provide the most amount of competition for the noxious weeds.

As most of the shoreline along the Great Salt Lake becomes protected, the opportunity to extend restoration efforts is immense. Through these efforts the riparian ecosystem can resurface
and help sustain the migratory bird population and wildlife communities. The opportunities for habitat rehabilitation are promising.

Summary of recommendations for IMP and management implications

With the overwhelming presence of invasive weeds in the Reserve the goals of the management plan may need to be altered depending on the infestation being targeted. Large-scale restoration is improbable at this point, but reestablishing a more desirable, native plant community can be achieved. The management plan will have to focus on prevention, eradication of smaller patches, and containment of larger infestations. Altering the management goals for each section and weed will be crucial in arriving at those goals. Also, a commitment to revegetation of the Reserve is essential if long-term weed control is the target. Without those efforts the noxious and invasive weeds in the ISSR will continue to spread and take over, resulting in decreased ability to sustain a diversity of plant life and wildlife. See table 5 (page 46) for a summary of treatment and revegetation recommendations.

Management of these noxious and invasive weed species should be organized by the following:

1) Scotch thistle and bull thistle – these are the best candidates for eradication and should be targeted first. Manually cutting down plants to prevent seed production for 3-5 years should effectively eliminate their presence in the Reserve. Spot-checking thereafter will determine if they are reestablishing their presence.

2) Phragmites is the next best candidate for eradication. By altering the salinity level in the waterways most affected can result in 100% mortality. The length of time the salinity levels must be increased is unknown. As studies indicated returning saline levels to normal after 2 weeks resulted in phragmites recovery. Revegetation is a critical part of long-term management to prevent phragmites from returning.

3) Whitetop and Russian knapweed infestations need to be prioritized as the smaller patches can be eradicated and once they are removed the focus can shift to the larger sections. In those areas, the best that can be hoped for is containment with continual herbicide treatments and revegetation efforts.

4) The root removal of tamarisk may be coincided with the tilling of cheatgrass in some areas to minimize disturbance to the ISSR.

Since the ISSR is part of the wetland mitigation bank process the Bureau of Reclamation has guidelines to ensure continual improvements are made to the Reserve. In order to comply with those requirements a plan aimed at weed management must be submitted to the Bureau. This
survey and weed management plan will help KUCC meet the requirements of improving the
ISSR. As cost is a large component of ecological restoration and needs to considered when
undertaking any effort. However, overall cost of herbicides was not factored into
recommendations, only their performance for individual weed species control. The additional
cost of revegetation may actually prove cost effective as continual herbicide treatments become
unnecessary for the majority of the Reserve.

Future Research

The association occurring between Russian knapweed and whitetop plants in the Reserve
would be an interesting project. There are many studies of each weed individually, but nothing
to elucidate their behavior when relating to each other. The majority of literature indicates
Russian knapweed to be one of the most aggressive spreaders in the weed community further
studies would be helpful to determine the validity of that statement in the Reserve. While both
weed species reproduce with vigorous seed production and rhizomatically it is Russian
knapweed that possesses the alleopathic ability to release toxins into the soil to suppress the
growth of surrounding vegetation. This ability sets it apart from the whitetop and may be the
determining factor that identifies Russian knapweed as the more aggressive weed.

Also, given the aggressive nature of field bindweed researching why it is not performing well
in the Reserve may elucidate on future control methods. Finally, positive determination of the
unidentified thistle (Photo 17, page 64) is important to discover if it is truly native or if it is a non-
native species.
Literature Cited


Westminster College. Important ecological role of selected plants along the Great Salt Lake. www.westminstercollege.edu. Site visited 4-10-03.


Table 1: Description of size and density of weeds mapped

<table>
<thead>
<tr>
<th>Size:</th>
<th>Density:</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than 0.1 acre</td>
<td>T = less than 1% cover (trace; rare)</td>
</tr>
<tr>
<td>0.1 to 1 acre</td>
<td>L = 1% to 5% cover (low; occasional)</td>
</tr>
<tr>
<td>1 to 5 acres</td>
<td>M = 5% to 25% cover (moderate; scattered)</td>
</tr>
<tr>
<td>greater than 5 acres</td>
<td>H = 25% to 100% cover (high; dense)</td>
</tr>
<tr>
<td>infestation follows road,</td>
<td></td>
</tr>
<tr>
<td>ditch, ponds</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2: Description of habitat communities

<table>
<thead>
<tr>
<th>Vegetation and Habitat Communities found in the Inland Sea Shorebird Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Palustrine Emergent Wetlands</strong> - The U.S. Fish and Wildlife Service defines palustrine emergent wetlands as communities that are characterized by erect, rooted, herbaceous hydrophytes (excluding mosses and lichens), which are present for most of the growing season in most years. Wet meadows and marshes are two types of palustrine emergent wetlands occurring throughout the ISSR. Wet meadows are saturated on a seasonal basis, usually during the wetter months of spring; whereas, marshes are saturated more-or-less year-round.</td>
</tr>
<tr>
<td><strong>Saline Playa</strong> - Saline playas are defined as areas that have ponded water during the growing season, are underlain by hydric soils, and have less than 20 percent vegetal cover. Saline playas are a common vegetative community type occurring throughout the ISSR, and are one of the dominant community type occurring in the area. Typically, saline playas are sparsely vegetated with hydrophytic plant species including forbs, such as pickleweed (Salicornia europaea), graminoids such as alkali sacaton (Sporobolus airoides), and shrubs such as iodinebush (Allenrolfea occidentalis).</td>
</tr>
<tr>
<td><strong>Riparian Scrub and Scrub-Shrub Wetlands</strong> - Riparian scrub-shrub wetlands typically comprise a narrow band of wetland and riparian vegetation associated with water channels. This wetland community occurs in and next to the Goggin Drain. The riparian scrub-shrub community is comprised of shrub overstory and a herbaceous understory. The riparian scrub-shrub wetland zone around the Goggin has tamarix (Tamarisk ramosissima) as the major shrub occupying in this area. The understory vegetation can range from prickly lettuce (Lactuca serriola), red goosefoot (Chenopodium rubrum), and various graminoids such as foxtail barley, and cheatgrass (Bromus tectorum). Vegetal cover ranges from approximately 20 to 70 percent in the overstory and approximately 80 to 100 percent in the understory. The riparian scrub area is the vegetation that occurs around most of the other canals and ditches that are found in the ISSR. This vegetation can be a very broad range of plants from graminoids to forbs. Some of the most common of these plants are spikerush (Eleocharis palustris), small flowered guara (Gaura parviflora), alkali bulrush Scirpus maritimus, and povertyweed (Iva axilaris).</td>
</tr>
<tr>
<td><strong>Open Water</strong> - Areas of open water occur throughout the ISSR. Generally, open water areas are elevationally low, closed basins, which come from pond surface runoff and water from gated ditches connected to the North Point Consolidation Canal. In addition, near-surface groundwater also may be a hydrological source. The most common plants found in open water at the ISSR are ditchgrass (Ruppia maritima), and duckweed (Lemna minor). Most open water areas are vegetated along their perimeters with palustrine emergent vegetation. Some emergent plants that do occur are hardstem bulrush, alkali bulrush, olney threesquare, and spikerush.</td>
</tr>
<tr>
<td><strong>Alkaline Scrub-Shrub</strong> - The alkali scrub-shrub community occurs on the upper elevations throughout the ISSR. This community is usually adjacent to saline playa, wet meadows, or grassland communities. Vegetation of alkali scrub-shrub communities consists of two strata: a shrub layer and a herbaceous layer. The shrub layer is made from such plants as greasewood (Sarcobatus vermiculatus), iodinebush, shadscale saltbrush (Atriplex confertifolia), and Gardner saltbrush (Atriplex gardneri). The herbaceous layer can be a wide variety of plants the most common ones are prickly lettuce, curlycup gumweed (Grindelia squarrosa), and various graminoids such as redtop (Agrostis stolonifera), and cheatgrass. Vegetational cover provided by shrubs can be from approximately 20 to 80 percent and the height of the shrub species varied from one to three feet. Vegetational cover in the forb and graminoid layer varies from approximately 60 to 90 percent.</td>
</tr>
<tr>
<td><strong>Grassland</strong> - Grasslands occur in the ISSR adjacent to saline playa, wet meadow, and alkali scrub-shrub communities. Greasasslands are dominated by forbs and graminoids that form a vegetation cover that ranges from 60 to 90 percent. Among the most common plants are various wheat grasses (Agropyron cristatum, and A. intermedium), Indian ricegrass (Oryzopsis hymenosoides), and cheatgrass. Vegetation cover by shrubs is less than 10 percent. Variation in vegetational cover in certain areas may be due to disturbances resulting form past practices of livestock grazing.</td>
</tr>
<tr>
<td><strong>Roadsides and other disturbed areas</strong> - This community has a very wide variety of plants. This is usually because of the ability of these plants to take advantage of disturbed ground. Most of these plants are non-native weeds and are generally non-desirable. Some of the most common ones that occur at the ISSR are summer Cyprus (Kochia scoparia), bassia (Bassia hysopifolia), sunflower (Helianthus annuus), and ragweed (Ambrosia psilostachya). Another common weed that is considered noxious by the state is Russian knapweed (Centaurea repens).</td>
</tr>
</tbody>
</table>
Table 3: Herbicide and rates to control bull and scotch thistle

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Rate (lb/ai/ac)</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clopyralid</td>
<td>0.13 to 0.5</td>
<td>Apply to rosettes in spring or fall</td>
</tr>
<tr>
<td>Clopyralid + 2,4-D</td>
<td>0.2 + 1.0 to 0.3 + 1.5</td>
<td>Apply to rosettes in spring or fall</td>
</tr>
<tr>
<td>Dicamba</td>
<td>0.5 to 1.0</td>
<td>Apply to rosettes in spring or fall if good growing conditions exist</td>
</tr>
<tr>
<td>2,4-D</td>
<td>1.5 to 2.0</td>
<td>Apply to rosettes in spring</td>
</tr>
<tr>
<td>2,4-D + dicamba</td>
<td>1.0 + 0.5</td>
<td>Apply to rosettes in spring</td>
</tr>
<tr>
<td>Picloram</td>
<td>0.13 to 0.25</td>
<td>Apply to rosettes in spring or fall</td>
</tr>
<tr>
<td>Chlorsulfuron</td>
<td>0.047 (0.75 oz ai)</td>
<td>Spring from bolting to bud stages; add a non-ionic surfactant</td>
</tr>
<tr>
<td>Metsulfuron</td>
<td>0.19 (0.3 ox ai)</td>
<td>Spring from bolting to bud stages; add a non-ionic surfactant</td>
</tr>
</tbody>
</table>

### Table 4: Listing of native and adapted plants to Inland Sea Shorebird Reserve region

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Plant name</th>
<th>Plant type</th>
<th>Plant name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Grasses</strong></td>
<td><em>Andropogon scoparius</em> – Little Bluestem</td>
<td><strong>Perennials</strong></td>
<td><em>Achillea millefolium</em> – Yarrow</td>
</tr>
<tr>
<td></td>
<td><em>Bouteloua gracilis</em> – Blue Gramagrass</td>
<td></td>
<td><em>Asclepias tuberosa</em> – Milkweed¹ *</td>
</tr>
<tr>
<td></td>
<td><em>Oryzopsis hymenoides</em> – Indian Ricegrass *</td>
<td></td>
<td><em>Agastache cana</em> – Double Bubblemint</td>
</tr>
<tr>
<td></td>
<td><em>Stipa comata</em> – Needlegrass</td>
<td></td>
<td><em>Berlandiara lyrata</em> – Chocolate Flower</td>
</tr>
<tr>
<td></td>
<td><em>Callirhoe involucrata</em> – Poppy Mallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Shrubs</strong></td>
<td><em>Amorphanana</em> – Dwarf Indigobush</td>
<td></td>
<td><em>Cryptantha humilis</em> – Cryptantha</td>
</tr>
<tr>
<td></td>
<td><em>Artemisia species</em> – Sage² *</td>
<td></td>
<td><em>Delosperma starburst</em> – Starburst Iceplant</td>
</tr>
<tr>
<td></td>
<td><em>Arctostaphylos patula</em> – Manzanita</td>
<td></td>
<td><em>Echinacea purpurea</em> – Purple Cone Flower</td>
</tr>
<tr>
<td></td>
<td><em>Atriplex species</em> – Saltbrush</td>
<td></td>
<td><em>Erigeron species</em> – Cutleaf Daisy³ *</td>
</tr>
<tr>
<td></td>
<td><em>Ceanothus species</em> – Ceanothus</td>
<td></td>
<td><em>Erigonum species</em> – Buckwheat</td>
</tr>
<tr>
<td></td>
<td><em>Cercocarpus intricatus</em> – Little Leaf Mountain Mahogany</td>
<td></td>
<td><em>Gaillardia aristata</em> – Blanket Flower</td>
</tr>
<tr>
<td></td>
<td><em>Ceratotheca (Eurotia) lanata</em> – Winterfat</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Chamaebatiaria millefolium</em> – Rabbitbrush⁴ *</td>
<td></td>
<td><em>Gilia aggregata</em> – Scarlet Gilia</td>
</tr>
<tr>
<td></td>
<td><em>Cowania mexicana</em> – Cliffrose</td>
<td></td>
<td><em>Guara lindheimeri</em> – Guara⁵ *</td>
</tr>
</tbody>
</table>
| | *Ephedra viridis* – Green Ephedra (mormon tea) | | |}

---

1. *Asclepias speciosa*, Showy Milkweed is species found in ISSR
2. *Artemisia tridentata*, Big Sagebrush is species found in ISSR
3. *Erigeron speciosus*, Fleabane Daisy is species found in ISSR
4. *Chrysothamnus nauseosus*, Rubber Rabbitbrush and *Chrysothamnus viscidiflorus*, Low Rabbitbrush are species found in the ISSR
5. *Guara parviflora*, Small flowered Guara is species found in ISSR
6. *Oenothera hookeri*, Evening Primrose is species found in ISSR
Table 5: Summary of recommendations for each weed mapped in the ISSR

<table>
<thead>
<tr>
<th>Weed species</th>
<th>Recommended control</th>
<th>Native revegetation options</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Russian knapweed</strong>&lt;br&gt;(Centaurea repens)</td>
<td>Picloram or clopyralid will control Russian knapweed for 3-5 years. Site will be reinvaded if grasses are not established. Following herbicide treatment site needs to be cleared of all Russian knapweed plant residue by tilling soil. This will help remove allelopathic chemicals left over from treated plants.</td>
<td>Russian knapweed is sensitive to light competition. Revegetation efforts should take that into account for best results. Grasses, shrubs &amp; perennials: see Table 4</td>
</tr>
<tr>
<td><strong>Bull thistle</strong>&lt;br&gt;(Cirsium vulgare)</td>
<td>Clopyralid, dicamba, MCPA, picloram, 2,4-D, metoluron, and chlorsulfuron are all good for controlling thistle. See table 3.</td>
<td>Perennial grasses are good to provide initial competition for sites infested with thistle. Grasses: see Table 4</td>
</tr>
<tr>
<td><strong>Scotch thistle</strong>&lt;br&gt;(Onopordum acanthium L.)</td>
<td>Clopyralid, dicamba, MCPA, picloram, 2,4-D, metoluron, and chlorsulfuron are all good for controlling thistle. See table 3.</td>
<td>Perennial grasses are good to provide initial competition for sites infested with thistle. Grasses: see Table 4</td>
</tr>
<tr>
<td><strong>Whitetop</strong>&lt;br&gt;(Cardaria draba)</td>
<td>Metsulfuron at 0.12 to 0.45 oz, active ingredient per acre (8.4 to 31.5 g ai/ha) should be applied in the spring, to regrowth before bud stage, or to fall regrowth before the first frost. Apply metsulfuron with at least 10 gallons of water per acre and use a nonionic surfactant.</td>
<td>Use of a nitrogen fertilizer will help revegetation of grasses and slow the whitetop reinvasion. Grasses, shrubs &amp; perennials: see Table 4</td>
</tr>
<tr>
<td><strong>Phragmites</strong>&lt;br&gt;(Phragmites australis)</td>
<td>Increasing the salinity in the waterways of the Reserve could be a non-intrusive method of eradicating phragmites stands. Stand reduction of 7-100% mortality can occur at 15 and 20 °/oo. Also, seed germination is affected by increase salinity levels. Also, use of wipe on application of glyphosphate or imazapry can be used (Table 6).</td>
<td>Since phragmites inhabits waterway areas appropriate plants should be considered for revegetation. Grasses &amp; shrubs: see Table 4</td>
</tr>
<tr>
<td><strong>Tamarisk [saltcedar]</strong>&lt;br&gt;(Tamarix ramosissima)</td>
<td>The most effective method of tamarisk removal is root plowing in hot, dry weather. Any regrowth should be treated with any of the following: Dicamba, 2,4-D, tebuthiuron, and imazapry. Any of these herbicides are effective, but only when used with other mechanical methods such as burning, cutting, mowing, or root plowing</td>
<td>Since tamarisk inhabits waterway areas appropriate plants should be considered for revegetation. This will help exclude saltcedar seedlings from reestablishing. Grasses &amp; shrubs: see Table 4</td>
</tr>
<tr>
<td><strong>Cheatgrass</strong>&lt;br&gt;(Bromus tectorum)</td>
<td>Sultometuron has shown potential in controlling cheatgrass, but only when followed by aggressive reseeding of more desirable grasses and perennials. Treatment should be applied in the spring or fall and perennial grasses can be seeded the following year.</td>
<td>Perennial grasses and perennial plants are good choices to provide some competition for cheatgrass. Grasses &amp; perennials: see Table 4</td>
</tr>
</tbody>
</table>
Table 6: Herbicide options for control of phragmites

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Effect</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spray application Glyphosate</td>
<td>Total control in first year, followed by a slow recovery.</td>
<td>Non-target plant effects severe.</td>
</tr>
<tr>
<td>wipe-on application Glyphosate</td>
<td>38% control in the first year. total recovery in 3 years.</td>
<td>50% most effective application rate.</td>
</tr>
<tr>
<td>wipe-on application Imazapyr</td>
<td>75% control in the first year. total recovery in 3 years.</td>
<td>25% most effective application rate.</td>
</tr>
</tbody>
</table>

Frederick 1996 p 3.
Map 2: Description on zone 1, 2, and 3 in the ISSR
Map 3: Whitetop (*Cardaria draba*) infestation

**Whitetop (*Cardaria draba*)**

![Map showing Whitetop infestation](image-url)

- **Whitetop 1 to 5 acres - low density**
- **Whitetop 1 to 5 acres and > 5 acres - moderate density**
- **Whitetop infestation following feature**
- **Whitetop 1 to 5 acres and > 5 acres - high density**
- **Whitetop 0.1 to 1 acre**
Map 4: Russian knapweed (*Centaurea repens*) infestation

**Russian Knapweed (*Centaurea repens*)**

- Russian knapweed 1 to 5 acres - moderate density
- Russian knapweed 0.1 to 1 acre
- Russian knapweed infestation following feature
- Russian knapweed 1 to 5 acres - high density
Map 5: Tamarisk [saltcedar] (*Tamarix ramosissima*) infestation

Tamarisk (*Tamarix ramosissima*)

Tamarisk 0.1 to 1 acre
Tamarisk infestation following feature - high density
Tamarisk.shp
Map 6: Phragmites (*Phragmites australis*) infestation

**Phragmites (Phragmites australis)**

- Phragmites 0.1 to 1 acre
- Phragmites infestation following feature
- Phragmites 1 to 5 acres - high density

1 0 1 Miles
Map 7: Scotch thistle (*Onopordum acanthium* L.) and Bull thistle (*Cirsium vulgare*) infestations

Scotch thistle (*Onopordum acanthium* L.) and Bull thistle (*Cirsium vulgare*)

- Bull thistle 0.1 to 1 acre
- Scotch thistle 0.1 to 1 acre
- Bull thistle infestation following feature
- Thistle (unknown) 0.1 to 1 acre
- Thistle.shp

1 Mile

54
Map 8: All weed species mapped in point data form
Photo 1: View of constructed pond facing Antelope Island NW

Photo 2: View of pond and riparian scrub-shrub wetland habitat facing SW
Photo 3: Barn owl

Photo 4: Waterfowl in the North Point Consolidation Canal
Photo 5: Variety of migratory birds (flock of Pelicans) in open water pond SW

Photo 6: Skunk in alkali scrub-shrub habitat
Photo 7: Whitetop (*Cardaria draba*) post bloom

Photo 8: Whitetop field in alkali scrub-shrub habitat
Photo 9: Russian knapweed (*Centaurea repens*) emerging bloom

Photo 10: Russian knapweed field in alkali scrub-shrub habitat
Photo 11: Russian knapweed with whitetop surrounding it

Photo 12: Tamarisk [saltcedar] (*Tamarix ramosissima*) single shrub
Photo 13: Tamarisk [saltcedar] infestation along Goggin Drain

Photo 14: Bull thistle (Cirsium vulgare) pre-bloom plants along NPCC
Photo 15: Scotch thistle (*Onopordum acanthium* L.) emerging bloom

Photo 16: Phragmites (*Phragmites australis*) dense stand along canal
Photo 17: Unidentified thistle thought to be native