A Walk on the Wild Side: Conceptual Master Plan and Vegetation Management Plan for the Ogden Nature Center

Beth G. Pyle
Utah State University

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A WALK ON THE WILD SIDE: CONCEPTUAL MASTER PLAN
AND VEGETATION MANAGEMENT PLAN
FOR THE OGDEN NATURE CENTER

By Beth G. Pyle

A thesis project submitted in partial fulfillment of the
requirements for the degree
of
Master of Landscape Architecture (Plan B)
in
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Beth G. Pyle
"Men have forgotten this truth," said the fox.
"But you must not forget it. You become responsible, forever, for what you have tamed. You are responsible for your rose..."
"I am responsible for my rose," the little prince repeated, so that he would be sure to remember.

*The Little Prince*, Antoine de St. Exupéry
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ABSTRACT

This report provides an introduction describing: 1) Ogden Nature Center site planning history; 2) background of the problem a) lack of a conceptual master plan which responds to current management objectives, b) lack of a vegetation management plan, and; 3) thesis objectives and methodology for the creation of conceptual master plan and vegetation management plan for the Ogden Nature Center. Chapter 2 presents a written discussion of the Ogden Nature Center site inventory drawings and site analysis. Chapter 3 delineates strategies for management of weedy vegetation including: a general discussion of management techniques, general criteria for the selection of weedy species to manage, species specific criteria for the selection of weedy species to manage, a section describing the selection of management techniques based on the capabilities of the Ogden Nature Center and the selected weedy species' characteristics, implementation of management techniques, monitoring of transects, and a conclusion proposing the most appropriate techniques for implementation at the Ogden Nature Center. Chapter 4 presents recommendations based on an evaluation of the information generated by this project and proposes tasks to be completed to assure long-term stability of plant communities on the site. The vegetation management plan drawing and the conceptual master plan drawing are included in this chapter. An outline of areas identified for further research appears in Appendix H.
CHAPTER 1
INTRODUCTION

Our urban centers can be viewed as bellwethers of our global environmental fate. Our success at meeting the challenges of protecting biological diversity in urban areas is a good measure of our commitment to protect functioning ecosystems worldwide (Murphy, 1988, 76).

Disturbed landscapes such as landfills, abandoned railroads, industrial, military, and mining waste sites, and other types of disturbed sites are posing new challenges to landscape architects. The site for the Ogden Nature Center is an example of a site that was disturbed to accommodate irrigation canal construction, agriculture, military activity and pond construction. Traditionally, landscape architects have approached restoration of disturbed landscapes with a bias for aesthetics. Despite some notable exceptions, such as Frederick Law Olmstead and Jens Jensen, landscape architects have historically been perceived as unconcerned about the ecological functions of landscapes (Krohe, 1993). This, however, is no longer the case. Many landscape architects are involved with large scale ecological restoration projects such as the reclamation of the Wesley D. Conda Mine in Boulder, Colorado, and the rehabilitation of industrial sites exemplified by The Wilds project in Ohio (Leccese, 1993 and Roberts, 1993). Smaller scale projects include the outdoor environmental learning center in Longmont, Colorado where a landscape architect is combining design skills with an ecologist's understanding of function and structure (Krohe, 1993). Plant ecologist, Deborah Keammerer, who collaborated with landscape architect Jim Fletemeyer to create the Longmont learning center notes: "It takes [sic.] both an eye for both design and natural environments ... Ecologists can do really ugly restorations and landscape architects can do really non-functional ones (Krohe, 1993, 76)." The purpose of this study is to apply both landscape architecture and ecological principles in the development of the Ogden Nature Center in Ogden, Utah.
As the Wasatch Front becomes more urbanized, opportunities for observing benchland plant and animal communities diminish along with the recreational enjoyment they provide for urban residents. "Ecological approaches are usually associated with wilderness, but our urban wilds need them most. Urban watersheds suffer from underground droughts and floods on the surface. Parks and lawns incur high maintenance costs and contamination from chemicals. Natural areas are invaded by exotic plants (Krohe, 1993, 76)." An opportunity exists at the Ogden Nature Center for the preservation of open space, plant communities and wildlife. The Ogden Nature Center can also provide recreational opportunities for urban residents, as well as the educational benefits of demonstrating ecological planning techniques, and the enhancement of a disturbed landscape.

The Ogden Nature Center is a non-profit organization designed to promote public understanding of the natural environment. It is located on a 130-acre site on 12th Street between highway I-15 and downtown Ogden (Johnson et al., 1984) (Figure 1). The mission statement for the Ogden Nature Center is: "To unite people with nature in enriching experiences and to nurture appreciation and concern for the environment (Cox, 1992)."

The Ogden Nature Center is envisioned as a member of a national network of nature centers. These centers are usually composed of a professionally trained staff and a protected, managed natural area. Mary Cox, executive director of the Ogden Nature Center, visualizes the Ogden Nature Center as a place which provides a haven for wildlife in an urban setting, and which offers an opportunity for human interaction with wildlife. She feels this type of interaction can instill in people a renewed sense of discovery each time they visit the Ogden Nature Center. According to the administrative master plan for the Ogden Nature Center, "Nature Centers are essentially living museums which
Figure 1. Ogden Nature Center Location Map. Johnson et al., 1984.
interpret the unique biota of the area (Cox, 1992).” In terms of design, it is desirable that "the physical design of the Nature Center should integrate the interpretive program into the site." (Cox, 1992). Cox believes that the interpretive experience could be enhanced at the Ogden Nature Center if plant community associations were more clearly defined. Enhancement of native plant communities at the Ogden Nature Center can provide the necessary food, cover, and shelter to attract new species of wildlife to the site and better provide for existing populations.

The Ogden Nature Center site has been disturbed numerous times in the past. Its landscape has been used for agricultural purposes, canal construction, storage and disposal of military wastes, and well-intentioned though poorly planned pond construction and tree planting. Care should be taken to be sure that any new proposed interpretive programs and master planning are in balance with the carrying capability of the resource.

SITE PLANNING HISTORY

Since the founding of the Ogden Nature Center in 1975 no formal planning occurred. From 1984 to the present, Ogden Nature Center Administrators have commissioned several site plans. A proposed master plan was prepared by the Utah State University Department of Landscape Architecture and Environmental Planning in 1984 (Figure 2). The plan was approved by the Board of Directors in the fall of that year (Johnson, Craig W., 1994). A conceptual master plan by Brent Morris Associates was accepted in April 1992 by the Ogden Nature Center Board of Directors (Figure 3). Neither plan has been fully implemented.

Master plans prepared by Utah State University (USU) and Brent Morris have addressed many of the needs of the Ogden Nature Center. USU’s master plan does an
Figure 2. Ogden Nature Center Proposed Master Plan, Johnson et al. 1984.
Figure 3. Brent Morris Associates Master Plan, 1992.
excellent job of analyzing the site, describing plant associations, wildlife habitat, and visitor program activities. The Brent Morris Associates master plan rendering shows possibilities for plant community enhancement, it includes a new interpretive/learning center and it addresses some of the program elements desired by the Ogden Nature Center. These master plans, along with the Ogden Nature Center administrative master plan and current program objectives are being evaluated by the Ogden Nature Center Board of Directors in order to develop a comprehensive master plan.

In all fairness, the site context has changed since the USU and Brent Morris Associates master plans were completed. The proposition of a new learning and visitors center complex and its corresponding detailed site design was not foreseen in the original Ogden Nature Center master plan proposed by Utah State University. The addition of the new program elements such as additional ponds, as proposed by Brent Morris Associates, without addressing the consequences of additional site disturbance, need to be reexamined. The importance of site planning is underscored by city planners such as Kevin Lynch's and Gary Hack's observations:

Site plans are seen as minor adjuncts to the dominant decisions of developers, engineers, architects and builders....This neglect is a dangerous error, since the site is a crucial aspect of environment. It has a biological, social, and psychological impact that goes far beyond its more obvious influence on cost and technical function... Its influence outlives that of most buildings, since site organization persists for generations. What we do to our habitat has an enduring effect (Lynch, and Hack, 1984, 2).

Additional site disturbance is perceived by the Ogden Nature Center Administrators as intrusive and should only occur where it is necessary.

Specific objectives of the Ogden Nature Center are described in the 1992 administrative plan. These include: 1) the development of an interpretive and demonstration area (water-conserving gardening, wildlife rehabilitation, recycling, etc.);
2) creation of a playground designed to facilitate children's appreciation and discovery of wildlife adaptations and behavior; 3) construction of a new learning and visitor's center complex; 4) design of an orientation area located adjacent to the proposed visitor's center and the interpretive/demonstration area; 5) planning for systematic control of exotic weeds; 6) development of a wildlife inventory and a plan to control wildlife pest species; 7) enhancement of pond and wetland areas (control of noxious weed invasion of disturbed areas); and 8) mapping of soil types.

The first priority of the Ogden Nature Center Board of directors has been the planning and construction of a new learning and visitor's center complex (Figure 4). The complex, designed by Bob Herman of Sanders and Herman Architects of Ogden, is to be a regional precedent-setting building constructed of recycled materials and systems which function in an environmentally sensitive manner. Recently, the Ogden Nature Center contracted with Landmark Design Inc. of Salt Lake City, to design the entry corridor, circulation, parking, and landscape adjacent to the proposed building. As of January 1994, the Ogden Nature Center had obtained 75% of its total building budget of $387,000.00. Due to this fund raising success, construction is proposed for spring of 1994.

The Ogden Nature Center Board of Directors has come to recognize the importance of long-term planning for the development of intensively used areas. The team of Herman and Sanders Architects and the landscape architects of Landmark Design Incorporated have been retained to synthesize previous master plans and prepare site specific designs. They are currently preparing plans and drawings for the learning and visitor's center complex, demonstration gardens, entry corridor, orientation area, circulation and parking. In cooperation and conjunction with these planning efforts, this
Figure 4. Sanders and Herman Architects, Proposed New Learning and Visitor’s Center, 1994.
thesis will address the problem of creating a conceptual master plan for the site and a vegetation management plan with a major focus on encroaching weedy vegetation.

A recent development which should also be included in the planning of the Ogden Nature Center is the proposed introduction of the June Sucker (*Chasmistes liorus*) into the ponds on the site. The June Sucker is an endangered fish of the Bonneville Basin. The interdisciplinary June Sucker Recovery Team is monitoring the ponds at the Ogden Nature Center to determine whether they can serve as June Sucker habitat. If the June Sucker is introduced, land and water use practices must be adapted to address the requirements of this endangered fish.

**BACKGROUND OF THE PROBLEM**

From 1984 to date several plans have been completed that respond to the changing context and program of the Ogden Nature Center. These include the master plans by Utah State University, 1984, Brent Morris Associates, 1992, the 1992 Ogden Nature Center administrative master plan, and site planning by the team of Herman and Sanders Architects and Landmark Design Inc., 1994.

The master plan by Utah State University recommended controlling exotic weedy species in upland, wetland, and riparian areas throughout the site. Efforts to reduce weedy populations have been made, but not on a systematic basis or at intensity levels required to significantly affect persistent weedy exotics (Horton, 1993). Therefore, the problem of exotic weedy vegetation continues to get worse.

The Brent Morris Associates master plan shows additional pond construction and the expansion of riparian areas; however, it does not address some of the site limitations and problems. These problems include: lack of a plan showing details of
proposed new facilities, failure to consider the consequences of additional site disturbance due to pond construction, and the lack of a management plan for invasive weedy species.

The Brent Morris Associates plan depicted at 1"=100' is appropriate for conceptual planning. However, enlargements showing the details of the new learning and visitor’s center complex, demonstration, entry, and orientation areas were not prepared. The Brent Morris plan shows numerous ponds in addition to those already in existence. Gaining access to groundwater on the site requires substantial disturbance, which may promote exotic weed growth and decrease soil stability; therefore it may not be feasible to construct new ponds as shown on the Brent Morris Associates plan without creating additional weedy vegetation problems.

The most recent site plan by Brent Morris Associates does not propose a plan to control weedy vegetation. However, many of the plant communities at the Ogden Nature Center are dominated by exotic species: wetlands by yellow starthistle (Centaurea solstitialis), teasel (Dipsacus sylvestris), and Canada thistle (Cirsium arvense); uplands by dyer’s woad (Isatis tinctoria) and puncturevine (Tribulus terrestris); the canal riparian corridor by burdock (Arctium minus) and houndstongue (Cynoglossum officinale); pond margins by tamarisk (Tamarix spp.).

The Ogden Nature Center exists to promote the preservation of native plant communities and wildlife habitat in an urban setting. However, with the exception of the riparian and wetland areas most of the plant communities on the site are non-native. Despite more than a decade of careful planning and the development of two master plans, several problems still exist including:
1) Lack of a synthesis of present program criteria with past master planning efforts such as:
   a) recognition of the difference between desirable and undesirable plant species, whether native or introduced, should be considered in management practices.
   b) the need to enhance native plant communities and reduce weedy species is recognized but no actions have been planned;
   c) the introduction of exotic tree species previously planted in the areas, such as the shelterbelt and Preservation Grove is no longer consistent with the goals of the Ogden Nature Center; and
   d) site inventory updates have not been made as man-made or natural disturbances occur.

2) The lack of a comprehensive vegetation management plan, which should include:
   a) a plan to determine appropriate methods of reducing weedy vegetation and enhance native plant communities;
   b) long-term monitoring of the vegetation on the site to provide baseline information;
   c) a precedent-setting opportunity for public education and interpretation of vegetation management techniques and enhancement of plant communities is desirable.

In addition, the proposal to introduce the June Sucker (*Chamistes liorus*), an endangered fish species, on the site further complicates the design and plan. Habitat requirements of the June Sucker may limit the use of certain vegetation manipulation techniques, such as the use of herbicides. Site disturbance resulting in sedimentation in the
ponds may also pose a threat to these endangered fish. Introduced fish populations such as the mosquitofish, *Gambusia spp.*, are predators of June Sucker fry and may need to be removed from the ponds.

Both USU and Morris master planning efforts are no longer up to date with the changes in site context due to unforeseen proposed new facilities, unfulfilled recommendations regarding weed control, and the desire for more limited site disturbance. The team of Sanders and Herman and Landmark Design Incorporated are designing detailed site plans for new facilities and their immediate surroundings.

The combination of overlooked details from previous master plans, with new proposed site development and possible introduction of endangered fish have created the need for further clarification and synthesis of both old and new ideas. Therefore a new master plan that ties all these elements together is necessary.

**THESIS OBJECTIVES**

This thesis has two objectives, one is to create a conceptual master plan for the Ogden Nature Center which will synthesize and update previous master planning efforts providing a focus for future planning decisions. The other objective and the focus of this thesis is to prepare a vegetation management plan as a component of the conceptual master plan for the Ogden Nature Center. Specifically, this thesis addresses appropriate management techniques for the control of encroaching weedy vegetation, and the enhancement of desired plant associations to improve wildlife habitat values.

Landscape architect, John Lyle (1985), recognized the importance of linkages between humans, animals and plants. He recommends the manipulation of the plant component of this trio as it is the most amenable to design and management.
For design purposes the linkage between human beings and animals is somewhat less critical than that between human beings and plants because human influence on animal populations is exerted mostly through the manipulation of plants and water (205).

METHODOLOGY

Conceptual Master Plan

As requested by the Ogden Nature Center, recommendations of tasks to be completed to assure long-term site stability will be included in the conceptual master plan based on the conclusions drawn from literature review, case studies, site inventory and analysis. Recommendations will also take into consideration the new building and the landscape elements proposed by Herman and Sanders Architects and Landmark Design Incorporated.

Methodology for the Conceptual Master Plan:

1) Problem statement.
2) Goals and objectives.
3) Determine design criteria in conjunction with Ogden Nature Center administration.
4) Review and evaluate existing master plans.
5) Literature and case study review.
6) Use design criteria and evaluation to develop the Conceptual Master Plan.
7) Evaluation of the Conceptual Master Plan in terms of success in meeting goals, objectives, and design criteria.
8) Complete Conceptual Master Plan.

Methodology for the Vegetation Management Plan:

1) Problem statement.
2) Goals and objectives.
3) Literature and case study review and evaluation.
4) Site inventory/resource assessment.
   a) Determine appropriate scale.
   b) Existing vegetation inventory.
   c) Existing vegetation analysis
   d) Identification of areas requiring vegetation manipulation.
5) Use site inventory, literature review, case studies and analysis to generate
   vegetation management plan.
6) Explore vegetation manipulation techniques.
7) Create preliminary drawing and a written draft of proposed vegetation
   management alternatives.
8) Comparative evaluation of alternatives in terms of success in meeting goals and
   objectives. Review preliminary drawing.
9) Determine phasing of implementation.
10) Delineate monitoring program.
11) Select preferred alternative(s).

Vegetation Management Plan

Four weedy species were selected for study based on their specific characteristics,
methods for their control, the site conditions and capabilities of the Ogden Nature Center,
and their compatibility with the priorities stated in the Intermountain Region Noxious
Weed and Poisonous Plant Control Program, Final Environmental Impact Statement, of
the USDA Forest Service, October 1986. The four species are: Cheatgrass (Bromus
tectorum), Dyer's woad (Isatis tinctoria), Teasel (Dipsacus sylvestris), and Tamarisk,
(Tamarix spp.). The priorities of the Intermountain noxious weed control program are:

Priority I: Potential New Invaders: Emphasis on education, awareness and prevention of noxious weed species that do not yet occur on National Forest System Lands.

Priority II: Eradication of New Invaders: The highest treatment priority will be given to new invading noxious weed species in a particular area. A key factor in treating Priority II weeds is to prevent conditions that allow them to become established. Eradication is the goal for weeds of this priority.

Priority III: Established Infestations: Weed species in this priority have become so established and spread to the extent that for all practical purposes, eradication would not be feasible. Emphasis will be given to
containing and preventing further spread of the infestation. Management practices will be used in conjunction with control activities (1986, Section 2, 5-6).

The priorities of the Intermountain Weed Control program are stated briefly here, for more detailed information, consult the Final Environmental Impact Statement described above.

Three vegetation management techniques will be considered in this thesis as they apply to weedy species in general and to the four species selected for study. These techniques were selected because they will offer the Ogden Nature Center administration several different management strategies to choose from in order to control weedy vegetation and match the Ogden Nature Center's site capabilities, funding, and human resources. They include 1) the natural competition technique, 2) the single method technique and 3) the integrated management technique. The techniques listed above will be explored as to their potential applicability on the Ogden Nature Center. The advantages and disadvantages of each alternative as applied to the Ogden Nature Center site in terms of long term-effectiveness, applicability, compatibility with the site and the ability to meet the objectives of the nature center will be evaluated.

Vegetation management strategies should be revised periodically to allow for opportunistic changes as new technologies develop. Since the ability to make site improvements is dependent on the fund raising efforts of the Ogden Nature Center, phasing of the master plan is a built-in consideration of this project. Therefore it is important to create a vegetation management plan which incorporates long-term objectives of the Ogden Nature Center while leaving room for flexibility.

The project design methodology discussed above was adapted from Lyle 1985, Scifres 1987, and Johnson 1993.
PRODUCTS

Conceptual Master Plan:

One plan drawing incorporating the following elements:

1) Recommendations to help assure long-term site stability.
2) Location of desired program elements.

Vegetation Management Plan:

1) Six site inventory drawings including a drawing which delineates the extent of weedy species.
2) A drawing of preferred locations for vegetation transects.
3) A written report identifying alternative methods of weed control, stabilization of the site, possible re-establishment of native plant communities, phasing of implementation, and monitoring. Description of alternative techniques as they relate to the site. Selection of preferred technique(s).

The combination of an updated conceptual master plan and the proposed vegetation management strategies will provide the Ogden Nature Center Administration with an overall master plan at a scale which identifies and addresses problems inherent in the site. The purpose of this project is to 1) integrate desired program elements into the site, 2) create a haven for fish and wildlife in an urban setting, 3) provide a program for vegetation enhancement, weed control and monitoring 4) harmonize the vegetation plan with existing and proposed architectural and site planning elements, 5) work within the budget constraints of a non-profit organization and 6) preserve the integrity of the mission of the Ogden Nature Center.
INTRODUCTION

Site inventory and analysis data were collected to provide an up-to-date understanding of the Ogden Nature Center’s landscape characteristics, and to assess site capabilities. Analysis of this information provides a basis for making appropriate recommendations in the conceptual master plan and the vegetation management plan. The data collected also permits comparisons with data collected in the past (For example, the 1984 USU proposed master plan) and the future allowing Ogden Nature Center administrators to monitor any changes which may occur on the site.

LAND USE HISTORY

The history of the land currently occupied by the Ogden Nature Center was compiled by Peters in 1978 (Johnson et. al, 1984). In 1841 a Spanish land grant allowed trapper Miles Goodyear to obtain original ownership of the land. This land was later sold to Mormon pioneer James Brown in 1848. The original farm house was built by William Hodson in 1872. It was renovated in 1912 and now serves as the Nature Center headquarters. Agriculture has been the primary land use on the site since 1850; pasture crops such as hay (crested wheatgrass, smooth brome, etc.) and alfalfa have been naturalized on the site and are still present today.

In 1940 the land was condemned by the Federal Government for use as a military storage depot known as the Defense Depot of Ogden, Utah (DDOU) (Johnson et al., 1984). While the land was owned by the Defense Depot it was used as a burning grounds for riot control materials, white smoke incendiary grenades, and a burial site for the
disposal of solvents and solid wastes (Slam, 1991). Burial and burning at the DDOU was usually done in unlined sites (Slam, 1991). In 1973 the federal government surplused the land to Ogden City with the stipulation that the land be used as a nature study area (Johnson et al., 1984). In 1975 a citizen’s committee was formed to promote the idea of a nature center (Dolph, 1994). A rent-free lease agreement was made between the city of Ogden and the Ogden Nature Center promoters later that year (Dolph, 1994). Since 1975, the Ogden Nature Center has functioned as a non-profit organization supported by memberships, donations, and user fees. The Ogden Nature Center is administered by a board of directors which currently includes an on-site executive administrative director (Cox 1994, Dolph 1994).

BASE MAP COMPILATION

The base map for this project showing topography, water features, vegetation patterns, and man-made site infrastructure was compiled from several different sources. These sources include: an aerial photograph, a topography map, and personal site observation.

For mapping purposes it is important to note that the Ogden Nature Center is located at the intersection of Section 18, Township 6 North, Range 1 West, and Section 13, Township 6 North, Range 2 West in Weber County (USDA, SCS, 1968). An aerial photograph taken by Aerographics Inc. in February, 1992, at 1” = 100’ scale shows the most current site detail (Figure 5). Unfortunately, the aerial photograph did not include site topography. A site survey was suggested; however, the Ogden Nature Center administration made the determination that a site survey was cost prohibitive for master planning purposes.
The best available topography map, which dates from 1977, was provided by the Defense Depot of Ogden (Figure 6). The topography map was at a scale of 1"=200'. This map was enlarged to a 1" = 100' scale and was laid over the aerial photograph. Unmapped topography, such as the ponds constructed after 1977, was interpolated from the overlay. The interpolated information was cross-checked with the elevation of Blackbird pond (existing in 1977) which was interpreted to be 4254'. The topography was also ground-truthed to determine rises and depressions not shown on the 1977 map.

It is to be noted that the resulting base map (Figure 7, 52 inches x 36 inches, actual size) is a reasonable representation of the existing topography as of 1994, and is suitable for master planning purposes. However, the mapped information is not accurate enough for construction purposes, and it is highly recommended that the site be surveyed prior to any extensive construction project or landscape modification.
Figure 5. Aerial Photograph Aerographics Inc., February, 1992.
Figure 6. DDOU. Topography Map, 1977.
Figure 7. Base Map, 1994.
TOPOGRAPHY AND CLIMATE

The topography of the Ogden Nature Center is flat to undulating, sloping down to the west. The elevations of the Ogden Nature Center vary only thirteen feet across the site ranging from a low elevation of 4252 feet to a high of 4265 feet. Few slopes exceed 5%, and those that do are located along the Plain City Canal, Mill Creek, and surrounding the ponds (Johnson, et al. 1984, and personal observation, 1994.). Pond slopes are rather steep and in some areas exceed 10%. In general, slopes under 10% are preferred as they are safer for people, allow access for wildlife, and permit establishment of vegetation (Adams and Dove, 1984).

The general climate of the site varies from extremely hot, dry summers to cold, wet winters. Summer temperatures vary from 80° F to 100° F during the daytime. Winter temperatures can reach lows from -10° F to -20° F, and average daytime highs in winter are between 20° F to 30° F (Johnson et al., 1984).

The Ogden Sugar Factory, elevation 4280 feet, was monitored by the Utah Climate Center and has the closest recorded climate characteristic to that of the Ogden Nature Center (Ashcroft, 1992). Record high and low temperatures vary from -26° F to 106° F. Normal annual precipitation is 16.84 inches. Climatic averages are standardized by the National Weather Service by averaging weather data over 30 year periods known as "normals". The 30 year "normal" period used in these data is the period from 1961-1990 (Ashcroft, 1992). Monthly precipitation, temperature, snowfall, and evapotranspiration patterns are described in Utah Climate (Ashcroft, 1992) and can be found in Appendix A. The last spring freeze (32° F or lower) dates range from: April 5th as the earliest, May 5th the average, and June 2nd the latest. The first fall freeze dates
range from: September 18th as the earliest, October 10th is the average, and November 9th as the latest. Frost-free days average 157 days annually (Ashcroft, 1992).

Winds at the Ogden Nature Center are usually mild, varying from 6.3 to 10.2 m.p.h. Winter winds are generally from the northeast and summer winds are usually from the southwest (Johnson et al., 1984). Occasionally the site is affected by strong diurnal east winds which flow from nearby canyons and are generated by changes in air temperature and pressure.

Open, exposed areas of the site are most affected by climatic extremes versus those areas which are sheltered by vegetation. The highest levels of precipitation occurs in the winter months and early spring and fall but not during the frost-free growing period from May through October. The combination of these types of extreme climatic conditions cause vegetative stress, making it difficult to raise crops or revegetate during the summer months. Plants which take advantage of early or late growing seasons when soil moisture is higher and temperatures are lower adapt better to these climatic conditions (USDA SCS, 1975).

VISUAL QUALITY

The Visual Resource Management System criteria was developed by the U.S. Forest Service in order to, "establish the visual landscape as an essential part of and equivalent to other land based resources (USDA USFS, 1974, 1)." According to these criteria: 1) all landscapes have a definable character and those with the greatest variety or diversity have the greatest potential for high scenic value; 2) landscapes with distinctive variety in form, line, color, and texture should be retained and perpetuated. (USDA USFS, 1974).
Due to its 130 acre expanse of open space, and its natural landscape features, the Ogden Nature Center is clearly distinguishable from the surrounding parking lots, commercial businesses, streets, and defense depot lands of the adjacent urban landscape. The topography of the site is gently undulating and provides little variation. However, other site features such as, the "naturalized" Blackbird pond and riparian zone along the Plain City Canal, starkly contrasting shady enclosed overhead tree canopies with wide-open pasture, and the potential for wildlife viewing, combine to create interest and the visual appeal which characterizes aesthetic landscapes.

The site is most often viewed by the public from 12th Street and 12th South. These views are partially obstructed by a forbidding 8 foot chain-link security fence, left over from Ogden Defense Depot property ownership (Johnson et al., 1984). This fence is no longer consistent with the present land use (Figure 8). Internal site views vary from intimate to expansive and are most often dictated by the varying vegetation. Linear overhead canopies are created by the riparian vegetation along the canal. A comfortable sense of enclosure is produced by the open meadow near Teal pond which is surrounded by a crescent of mature riparian vegetation (Figure 9). The dry grassland areas provide a sense of openness. Undulations in the terrain accentuate the different types of grasses and forbs (Figure 10).

Views from the site to the surrounding landscapes are for the most part unappealing. Adjacent land uses such as the large Internal Revenue Service parking lot to the west, busy traffic corridors along 12th Street and 12th South to the south and west, barren defense depot grounds and the security fenced Juvenile Detention Center to the east are harsh reminders of the urban landscape (Figure 11). Some efforts have been made to screen out these landscapes through berming and tree plantings but they are not articulated strongly enough to be as effective as they could be (Figure 12).
Views to the north riparian zone along the Mill Creek corridor on Ogden Defense Depot property are satisfactory, but could be improved. The irrigated plantings next to the road along the fenceline on Defense Depot property are healthy; however, the grass and tree plantings show little variation in the types of vegetation planted. Distant views of the Wasatch Range to the north and east of the site are superb (Figure 13).
Figure 8. 8 Foot Chain-link Security Fence.
Figure 9. Open Meadow and Mature Riparian Vegetation.
Figure 10. Grasses and Forbs.
Figure 11. Off-site Views to the East.
Figure 12. Existing Screen Plantings.
Figure 13. Views of the Wasatch Range to the East.
GEOLOGY AND SOILS

The Ogden Nature Center is located in the Weber Delta District of the Lake Bonneville Basin near the confluence of the Weber and the Ogden Rivers. Over time, the rivers have deposited alluvium and redistributed the clay, silt, gravel, and cobbles which comprise the soils of the site. In general, all the soils on the site are deep, and moderately alkaline, with the pH ranging from 7.5 to 9.3 (SCS, 1968). The depth to the water table for the soils on the site ranges from 20 to 40 inches or more depending on season and precipitation (USDA SCS, 1968). Steed and Sunset loam are the most prevalent soil types on this site. Soil permeability ranges from 0.63 inches per hour to greater than 6.3 inches per hour (USDA SCS, 1968).

The soil types shown on the Ogden Nature Center site inventory map (Figure 14) are as follows: IaA - Ironton, Kr Kirkham loam, SbA - Steed, SdA - Steed, SkA - Sunset loam, and SnA Sunset loam. The soil data and descriptions can be found in Appendix B and are discussed in greater detail in the Davis-Weber Area Soil Survey published in 1968 by the U.S. Department of Agriculture Soil Conservation Service in cooperation with the Utah Agricultural Experiment Station. The soils inventory map shows Ska, or Sunset loam to be the predominant soil type on the site, and it is described here.

**SkA or Sunset loam** occurs on 0 to 1 percent slopes on flood plains and low river terraces near the Weber river. The surface layer is composed of loam and reaches a depth of 15 to 24 inches. Subsurface layers are composed of stratified loam to sandy loam. Unless drained, this soil is usually saturated within 40 inches of the surface. It holds about 2 inches of water per foot. Runoff rates are slow and erosion hazards are low. The soil permeability rates vary from 0.63 to 2 inches per hour. This soil is used for irrigated crops and range (USDA SCS, 1968).
Because the 1968 Soil Conservation Service report was the most recent information gathered about the Ogden Nature Center's soil conditions topsoil samples were taken in October 1993. Some site disturbance such as ponding had occurred which also warranted the study. Twelve areas were sampled across the site in the locations shown on the soils map (Figure 14). Eight to ten representative samples were taken from each of the twelve areas. Samples were taken from the surface of the soil to 12 inches in depth as prescribed by the Utah State University Soil Testing Lab. The soils were tested under the Standard Fertility Test for pH, salinity, phosphorus, potassium, texture, and alkalinity. The test results showed that the soils have remained stable since the 1968 Soil Survey. pH ranged from 7.6 to 8.2 in the areas sampled. Overall soil texture is quite similar to that reported in the 1968 Soil Survey.

HYDRIC SOILS

A "hydric" soil is defined by the National Technical Committee for Hydric Soils as:

A hydric soil is a soil that is saturated, flooded, or ponded long enough* during the growing season to develop anaerobic conditions in the upper part (USDA SCS, 1991, 1).

* The duration of flooding is noted to be from one week to one month for a single event (USDA SCS, 1991, 1). This is important for planning purposes because a combination of hydric soils, hydrophytic vegetation, and hydrologic regime are used to delineate jurisdictional wetlands and some areas of the site may fall into this category (USDA SCS, 1991).

SdA, steed gravely fine sandy loam and SnA, Sunset loam gravelly substratum were identified in an unpublished 1990, Soil Conservation Service General Technical Guide as
Figure 14. Soils Map, 1994.
hydric soils for the Davis and Weber County area and are listed as such on the site inventory map (Figure 14). Further, Steed soils are officially listed/recognized by the National Technical Committee for Hydric Soils as "hydric."

The existence of a high water table and possibly hydric soils was also confirmed by the study of two aerial photographs taken by the Utah Aerial Photography Field Office (affiliated with the United States Department of Agriculture, Agricultural Stabilization and Conservation Service). The aerial photographs were taken in August 1984 (Figure 15) and in June 1988 (Figure 16). Interpretations of color infrared photographs cannot be used to identify soil types per se, but are helpful in identifying changes in land form, vegetation, and they can help to delineate soil boundaries (Lo, 1986).

Generally, drier soils will have a higher reflectance of radiant energy, and consequently will show up on an infrared photograph as a lighter gray-blue color. Soils having higher water and organic matter content will have a lower reflectance of radiant energy and will show on an infrared photograph as a darker blue color. (Lo, 1986). A limitation of infrared photography is that it does not account for layering, in terms of soils, and vegetation, (ground cover, understory and canopy). However, if vegetation occurs it can be inferred that the soil beneath it is wet enough to support plant life. Vegetation shows as red to pink in color (Lo, 1986). Although the aerial photographs of the Ogden Nature Center were taken in the early and late summer when water table levels usually drop, they do show a lot of deep red vegetation, and some darker blue soil coloration. Thus, this information from the infrared color aerial photographs reinforces evidence of high water table areas on the site.
Figure 15. USDA and ASCS, Utah Aerial Photography Field Office, August, 1984.
Figure 16. USDA and ASCS, Utah Aerial Photography Field Office, June 1988.
DEFENSE DEPOT OF OGDEN, UTAH: TOXIC WASTES DISPOSAL

From 1940 to 1973, a period of thirty three years, the Defense Depot of Ogden Utah owned the land which in 1973 was surplused to the City of Ogden and is now leased and administered by the Ogden Nature Center board of directors. While the Defense Depot of Ogden owned the Ogden Nature Center property it may have been used as, "a burial / burning grounds for riot control agent (o-Chlorobenzal Malonitrite), white smoke (possibly white phosphorous), and incendiary grenades (Slam, 1991, 1)."

Unknown quantities and concentrations of the following solvents, metals and inorganic compounds were also buried in unknown locations the site:

1. Arsenic
2. Chromium
3. Methylene chloride
4. 1,1-Dichloropropane
5. C-1, 2-Dichloroethane
6. Benzene
7. Tetrahydrofuran (Slam, 1991)

Sections of the property are described in reports from the DDOU as Burial Site 1, Burial Site 2, Burial Site 32 and Burial Site 34 (Slam, 1991). DDOU conducted burning and burial of wastes in unlined trenches, also evidence of buried metal drums were found during a magnetic survey of waste disposal areas (Slam, 1991).

Such vague documentation of hazardous waste disposal may be difficult to understand today, however, wastes were disposed by the DDOU on the site at a time prior to current environmental protection and hazardous waste disposal legislation. The Environmental Protection Agency, Resource Conservation and Recovery Act, the Toxic Substances and Control Act, and the Comprehensive Environmental Response Compensation and Liability Act (Superfund) were not created or passed by congress until the 1970s and early 1980 (Mazmanian and Morell, 1992). However, the DDOU owned this property during periods of war and military development and according to the Sierra
Club Legal Defense Fund, in *The Poisoned Well*, this problem was not limited to the DDOU, but was present throughout the military:

During times of fast-paced military development and war, records of disposal areas were either not kept at all, or were carelessly maintained. For many years afterwards, the veil of national security hid not only the locations where wastes were disposed, but also the kinds of wastes that were placed there.

To some extent, the shortcomings of the military's waste-management practices simply reflect the tension inherent in "the fox watching the chicken coop": until very recently, the production, use, handling, storage, disposal and cleanup of military toxics were entirely self-policed by military officers (SCLDF, Jorgensen Ed., 1989, 37).

On November 1, 1988, a Site Investigation (SI) was conducted at the Ogden Nature Center by the State of Utah Department of Environmental Quality, Division of Environmental Response and Remediation (Slam, 1991). A site investigation is one of the steps involved in the determination process for the designation of a site as a "superfund" site under the Comprehensive Environmental Response and Remediation Act (CERCLA) (Mazmanian and Morell, 1992). The steps of the CERCLA cleanup process, have been condensed from *Beyond Superfailure America's Toxics Policy for the 1990s*, (Mazmanian and Morell, 1992) and are located in Appendix C.

A magnetic survey during the site investigation determined the boundary areas of "Burial Site 32," the unlined burial site of toxic wastes shown on the soils inventory map (Figure 14) (Slam, 1991). Several types of samples were taken during the 1988 Site Investigation including: groundwater, soil, surface water, and sediment samples. Three groundwater and three soil samples were taken at monitoring wells drilled by the State. These sampling sites are shown as shaded circles on the soil inventory map. The monitoring wells were left uncapped, should the ground water need to be monitored in the future (Cox, 1994). Three sediment samples and two surface water samples were taken.
These sampling sites are shown as shaded triangles on the site inventory map. Surface water samples were taken at the two southern sampling sites in flowing water and not at the sampling site farthest north (no flowing water occurred at this sampling site) (Slam, 1991). The sampling sites farthest south are "control" sites used to measure background conditions of the water and soils, which should not be affected by contamination (Slam, 1991). The other sites were located downgradient of the contamination area. The groundwater flows north northwest across the site (Slam, 1991). Surface water in the canal flows north to Mill Creek, into Mill Creek and west to the Weber River (USDA SCS, 1968).

Results of the sampling tests showed that:

The hazardous substance concentrations in the soil are not significantly higher than the background levels for this area. The data also suggest that hazardous substances are not being released to the ground water or surface water pathways with the exception of arsenic, which was found (111 ppb) in one downgradient well. The air pathway was not evaluated during this site investigation because the waste is buried beneath the surface and release to air pathway seems unlikely (Slam, 1991, 7).

It is important to note that no drilling occurred in the actual waste disposal area designated as "Burial Site 32" (possibly to avoid contamination of the site due to disturbance) (Slam, 1991). The downgradient well containing the arsenic is the groundwater well nearest the waste disposal area. According to the 1993 Utah Administrative Code Water Quality Standards (U.A.C., R309-103-2, Table 103-1,1993, p.762), 50 ppb of arsenic is considered normal, the fact that the Ogden Nature Center ground water contained 111 ppb of arsenic when it was measured in 1988, is an indication that contamination of the ground water is occurring, and that ground water quality may deteriorate further in the future due to the hazardous wastes buried on the site. The surface water sample was taken south of the waste disposal site, not north of the disposal
Figure 17. Surface Water Inventory Map, 1994.
site which is the direction water flows in the canal. Due to the water control structure at the north end of the Plain City Canal (Figure 17), a lot of canal water is diverted into Blackbird pond. Water from the canal which passes by the waste disposal site may concentrate toxic chemicals suspended in the water or sediments of the pond. Water and sediment samples were not taken from the Blackbird pond. Wetland plants are also known to take up chemicals from water and sediments (Brodie et al., 1990). No vegetation was sampled to determine possible vegetative uptake of contaminants.

Since the Site Investigation of "Burial Site 32" concluded that no significant contamination has occurred, no further investigation of the site by the State of Utah or the Environmental Protection Agency is anticipated (Johnson, Brad, 1994). "Burial Site 1," has been located by the State of Utah and the DDOU during a Remedial Investigation/Feasibility Study of various areas on the DDOU (Slam, 1991). "Burial Site 1" contains white smoke grenades and is located at the northwestern corner of Ogden Nature Center property (Figure 18). It is under investigation by the State of Utah and is undergoing the CERCLA process. "Burial Sites 2" and "34", have not been identified. The "buried metal drums" remain buried and have not been removed from the site. No further monitoring has occurred at the Ogden Nature Center since 1988 when the Site Investigation was completed.

SURFACE AND SUBSURFACE WATER

All the surface water bodies on the Ogden Nature Center are due to human construction except for Mill Creek on the Northwest corner of the site. The Plain City Canal was constructed for irrigation purposes in sometime between 1920 and 1930 (Smith, 1994). The canal joins the Ogden River about a mile south of the Ogden Nature Center. The canal runs perennially, fluctuating with seasonal flows in the Ogden River.
Figure 18. "Burial Site 1" Slam, 1994.
In addition to water from the Ogden River, some urban runoff is present and can be seen as oil slicks on the surface of the water. The water in the canal flows from the southeast to the northwest following gently sloping topography. Adjacent to the footbridge at the south end of the site the canal is beginning to silt in and canal flows are beginning to be obstructed by cattails and other vegetation. At the north end of the site the water from the canal flows into Mill Creek. Mill Creek flows from east to west and its water is used both upstream and downstream for irrigation. A water control structure at the north end of the Ogden Nature Center allows for the canal flow to be regulated. Blackbird pond is connected to the canal via a PVC pipe, but there is currently no means to control water flow from the canal into Blackbird pond, therefore, the pond fluctuates according to the canal and groundwater levels. A capped well is located at the northern end of the Plain City Canal east of the riparian zone (Figure 17).

Three types of subsurface aquifers exist in the Weber River Basin. The first type of aquifer are the shallow unconfined aquifers, the second type are perched water body aquifers, and the third type are deep semi-confined aquifers (Slam, 1991). The pressures exerted by the geologic strata show that the shallow and deep aquifers are connected and that the upward pressure gradient allows water to rise from the deeper aquifer to the shallower ones (Slam, 1991).

The shallow unconfined aquifers are composed of a silty clay layer which starts approximately three feet below the soil surface and continues to approximately thirteen feet below the soil surface. Below this layer lie the perched water body aquifers in a water bearing layer composed of silt, sand and gravel. This layer varies in depth from 6 to 40+ feet (Slam, 1991). The bases of the shallow aquifers are composed of clay. Seasonal water table fluctuations vary from five to fifteen feet. The shallow aquifers are recharged
by upwelling from the deeper semi-confined aquifers and percolation from precipitation (Slam, 1991).

Although there is no record of the construction of Blackbird pond (approximately 48,000 sq. ft.) it was probably human made as a means to water livestock. The success of Blackbird pond as a bird habitat may in part be attributed to the nearby Bear River National Wildlife Refuge, which serves as a stop over for birds on their migratory flyway (Ryser, 1985). Blackbird pond's success may have influenced the decision to develop other water bodies to improve bird habitat at the Ogden Nature Center. Site features such as the availability of groundwater and gravel also provided incentives for development. Due to these influences, the Ogden Nature Center, in conjunction with the Utah Division of Wildlife Resources began construction of ponds on the site in 1984 (Cox, 1992).

Dragonfly pond (approximately 24,000 sq. ft.) and the potholes (approximately 2,500 sq. ft. avg.) adjacent to it were the first water features to be constructed in 1984. Teal pond (approximately 39,000 sq. ft.) was constructed in 1986. Small shallow "snake ponds," (approximately 11,500 sq ft.) were constructed south of Blackbird pond from 1987-1988. Arrowhead pond, (approximately 15,600 ft.) near the Ogden Nature Center headquarters was constructed in 1989. The proposed new pond (size undetermined) in the northeast corner of the site was begun in 1992 and is in the process of construction. All the ponds are approximately 5 to 6 feet deep and all are supplied by groundwater (Cox 1992, UDWR 1992). Blackbird pond and the snake ponds which connect to Blackbird pond are supplied seasonally with water from the Plain City Canal.

EXISTING VEGETATION

Several different plant communities exist on the site (Figure 19). They include natural or naturalized communities of riparian, riparian thicket, decadent riparian, dry
Figure 19. Existing Vegetation. 1994.
grassland, palustrine wetland, aquatics, and pasture, as well as patches of naturalized large trees and voluntary trees. Human plantings include: a shelterbelt, a wildlife food plot, a street screen, donation plantings, nature center plantings and cottonwood plantings.

The vegetation was inventoried during several site visits with the help of plant ecologist, Ed Horton. The existing vegetation site inventory map shows plant populations listed by plant community in order of abundance according to visual estimates:

D = Dominant, species which are becoming dominant or invasive in this plant community.
A = Abundant, species present in 75%-50% of this plant community.
P = Present, species present in 50% - 25% of this plant community.
S = Sparse, species present in 25%-10% of this plant community.
R = Rare, species present in 10% or less of this plant community.
I = Individual, notable individuals, usually native plants.
C = Cultivated, meaning cultivated intentionally, and recently by the Ogden Nature Center.

The dominant and abundant plant species which characterize each plant community will be discussed here, as well as those species which are significant due to their invasiveness, or that are present on the site and representative of native plant communities. For a comprehensive listing of the inventoried existing vegetation and weedy vegetation, see Appendix D.

The riparian zones along Mill Creek and along the Plain City Canal are comprised of large overstory trees, understory shrubs and understory grasses, forbs, and vines. The dominant overstory tree is Russian olive (*Eleagnus angustifolia*). Abundant trees include: green ash (*Fraxinus pennsylvanica*), box elder (*Acer negundo*), Siberian elm (*Ulmus pumila*), and black locust (*Robinia pseudoacacia*). Significant native trees which are sparse include: narrowleaf cottonwood (*Populus angustifolia*), and Fremont poplar (*Populus fremontii*). Peachleaf willow (*Salix amygdaloides*) is another native tree which
is present on the site, but rare. An individual river hawthorn (*Crataegus douglasii*) is growing in the riparian area adjacent to Blackbird pond. The sparse, rare, and individual riparian overstory tree species listed above are dominant overstory components of native riparian communities in Utah (Padgett, Youngblood, and Winward, 1989).

The understory of the riparian shrub community is composed of 1) Wood's rose (*Rosa woodsii*) which is dominant, and 2) coyote willow (*Salix exigua*) and golden currant (*Ribes aureum*) which are abundant. Understory grasses, forbs, and vines include: orchardgrass (*Dactylis glomerata*) which is present in areas where it receives adequate sunlight and is not overshadowed by overstory vegetation. Bryony (*Bryonia alba*), a vine, is the dominant understory vegetation and is a very aggressive climber. Understory forbs which are abundant include: burdock (*Arctium minus*) and deadly nightshade (*Solanum dulcamra*). False Solomon's seal (*Smilacina racemosa*), is a native riparian forb which is rare on the site.

Riparian thicket areas are present on the site where vegetation is very dense. An example of this type of dense vegetation growth exists on the northwest corner of Blackbird pond. The vegetation in the thickets is usually less varied, and is dominated by overstory trees and understory forbs with very few understory shrubs. The dominant overstory tree is Russian olive (*Eleagnus angustifolia*) and the dominant understory vine is bryony (*Bryonia alba*) with the abundant forb, burdock (*Arctium minus*).

Decadent riparian areas exist in several locations on the site. Decadent means that the dominant elements of this plant community are dead or decaying. Two decadent riparian stands are in topographical depressions running from east to west. The other stand runs from north to south adjacent to the canal. These decadent riparian areas, particularly the ones running from east to west may have been part of cottonwood groves created by flooding along the Weber river delta. The overstory of the decadent riparian
zones is an even mix of box elder (*Acer negundo*) and Siberian elm (*Ulmus pumila*). Fallen or dead narrowleaf cottonwood (*Populus angustifolia*) can be found in the decadent riparian zones. The understory shrub layer is composed of primarily of Wood's rose (*Rosa woodsii*) and occasional squawbush (*Rhus trilobata*) in drier areas. The understory herbaceous community is composed of duff, orchardgrass (*Dactylis glomerata*), and burdock (*Arctium minus*).

The largest area of the Ogden Nature Center landscape supports a herbaceous pasture plant community composed of grasses and forbs. The grasses listed as abundant include: cheatgrass (*Bromus tectorum*), quackgrass (*Elytriga repens*), crested wheatgrass (*Agropyron cristatum*), smooth brome (*Bromus inermis*), goatgrass (*Aegilops cylindrica*), and bulbous bluegrass (*Poa bulbosa*). Intermediate wheatgrass (*Agropyron intermedium*) is present. All are introduced plant species (Stubbendieck et al., 1992, Whitson et al., 1991).* Few native grass species are present on the site. Western wheatgrass (*Agropyron smithii*), is listed as present; Great Basin wild rye (*Elymus cinereus*), Indian ricegrass (*Ozyropsis hymenoides*), and bluebunch wheatgrass (*Agropyron spicatum*) are rare. The forbs are dominated by the weed teasel (*Dipsacus sylvestris*), which is found throughout the site and is listed as abundant (present in 50% to 75% of this plant community). Western yarrow (*Achillea lanulosa*), purple aster (*Machaeranthera canescens*), curly dock (*Rumex crispus*), filaree (*Erodium cicutarium*), alkali mallow (*Sida hederacea*), and common mallow (*Malva neglecta*) are present. Blue flax (*Linum lewisii*) and burnet (*Sanguisorba minor*) have been cultivated by the Ogden Nature Center as wildlife food sources.

Dry Grassland areas of the site, such as the northeast and northwest corners of the site have more gravely soils and support fewer varieties of grasses and forbs. Cheatgrass (*Bromus tectorum*) is the dominant grass. Quackgrass (*Elytriga repens*) is abundant. Goatgrass (*Aegilops cylindrica*) and smooth brome (*Bromus inermis*) are also present. Forbs are represented in the dry grassland by dyer's woad (*Isatis tinctoria*) and ragweed (*Ambrosia psilostachya*). The shrubs are represented by very few rabbitbrush (*Chrysothamnus nauseosus*). Sagebrush (*Artemisia tridentata*), commonly associated with rabbitbrush in dry grassland communities in the region are not found on the site.

The area south of Blackbird pond can be described as a palustrine wetland under the Cowardin classification of wetlands (Cowardin et al., 1979). Palustrine means "pond-associated." Although wetland definition has become controversial due to wetland conservation legislation, and the cyclic nature of wetland systems themselves, wetlands can be qualified by the following criteria as stated in *Wetlands of Utah*:

Any area fitting one or more of these categories is a wetland: (1) is temporarily or permanently inundated with water during a portion of the year (2) supports water-loving plants, or hydrophytes, such as cattails, rushes or sedges; and/or (3) contains undrained wet soil (hydric soil which is anaerobic or lacks oxygen in the upper region (Vice and Messmer, 1993, 1).

The shrub component of the wetland area consists of Wood's rose (*Rosa Woodsii*), and coyote willow (*Salix exigua*). Non-woody wetland plants found on the site are cattail (*Typha latifolia*), bulrush (*Scirpus acutus*), teasel (*Dipsacus sylvestris*), and horsetail (*Equisetum arvense*). Rushes (*Juncus spp.*) are present in low wet areas. Sparse populations of sedges (*Carex spp.*) and phragmites (*Phragmites australis*) occur around Blackbird pond margins.

Most of the human plantings on the site have some aspects of a monoculture. They include exotic evergreen or deciduous trees with a few shrubs and some natives.
interspersed. Examples of the human plantings include: the street screen, the shelterbelt, the nature center headquarters and the donation planting meadow, (a.k.a. as preservation grove). The shelterbelt is planted with Austrian pine (Pinus nigra) and golden willow, (Salix alba), in two or three rows with little or no variation in the southern portion of the shelterbelt. The northern portion of the shelterbelt contains a few additional species of fruitbearing trees. Few or no shrubs, or native vegetation have been planted along the shelterbelt. The shelterbelt is also very linear, providing little of the desirable characteristics of shelterbelts, such as variation in vegetation structure and edge (Johnson, et al. 1984). The plants growing in the shelterbelt are watered using drip irrigation (They are non-native species and have difficulty tolerating high summer temperatures and lack of moisture).

The wildlife food plot adjacent to Dragonfly pond is composed of Stephen’s Wheat, Hansel’s Wheat and Schuller Barley. This food plot may help feed wild ducks; however, the landscape was disturbed during plowing and some weedy species in the seedbank may reemerge as a result of tilling.

The cottonwood plantings on the site are composed of Fremont poplar, (Populus fremontii), narrowleaf cottonwood, (Populus angustifolia), and their hybrids. These trees are part of an experiment to study poplar physiology (Whitham, 1993).

Past human influences on the site such as grazing and pasture plantings have resulted in some species becoming naturalized to the site. For example, non-native, non-weedy species such as smooth brome, crested wheatgrass, and intermediate wheatgrass are relatively harmless and even beneficial elements because they are non-invasive, are preventing soil erosion, and do not currently require intensive management.
WEEDY VEGETATION

The invasive forb populations are grouped here according to their life cycles into the following categories: biennials, annuals, and perennials.

Biennial plants have a life cycle of two years. During the first year of their life cycle the weedy biennials develop a taproot underground and a leafy rosette above the ground. During the second year of growth biennials produce a flowering seed head. An example of a weedy biennial found on the site is Teasel (Dipsacus sylvestris). It appears in all the plant communities on the site and is listed as dominant on the weedy vegetation map (Figure 20). Other biennial forbs listed as present or sparse populations on the site include Scotch thistle (Onoporum acanathium), burdock (Arctium minus), and houndstongue (Cynoglossium officinale) (Whitson et al., 1991).

An annual is a plant that completes its life cycle in a year or less; sometimes as a winter annual which germinates in the fall and completes its growth the following spring (Arnow et al., 1980). Yellow starthistle (Centaurea solstitalis) is an aggressive weedy annual forb.

Perennials are non-woody plants which live longer than two years. Canada thistle (Cirsium arvense) and Whitetop (Cardaria sp.) are perennials shown on the weedy vegetation map as abundant and rare respectively. Canada thistle is particularly aggressive because of its ability to reproduce both sexually and asexually. It is a dioecious plant which has rhizomatous underground stems which allow it to form colonies. (Arnow et al., 1980).

Two other weedy forbs, Dyer's woad (Isatis tinctoria) and Prickly lettuce (Latuca serriole), are not easily classified according to their life cycles because they vary according
Figure 20. Weedy Vegetation, 1994.
to the temperature, moisture and seed viability. Dyer’s woad (*Isatis tinctoria*) is a winter
annual, biennial, or perennial forb corresponding with hot and cold temperatures and seed
viability (Farah et al., 1988). Prickly lettuce (*Lactuca serriola*) is biennial or winter annual
forb (Whitson et al., 1991).

Other weedy plants found on the site which do not fall into the forb category are
bryony (*Bryonia alba*), and tamarisk (*Tamarix spp.*). Bryony is a vine which occurs mainly
in riparian areas. It is a tree climber and shades out understory plants. Tamarisk is a non-
native aggressive deciduous or evergreen woody shrub which is highly competitive with
desirable native shrubs in riparian zones.

Some weedy plant species are currently found on the site, but do not threaten
desirable plant populations at this time. These weedy plant populations are invasive and
should be monitored and controlled. They include: the following introduced forbs:
bindweed (*Convolvulus arvensis*), marshelder (*Iva xanthifolia*), Russian thistle (*Salsola
iberica*), and kochia (*Kochia scoparia*); the native forb, western ragweed (*Ambrosia
psilostachya*); the native shrubs, Wood’s rose (*Rosa woodsii*) and poison ivy
(*Toxicodendron radicans*), and; the introduced tree, Russian olive (*Eleagnus angustifolia*).
Although no evidence of non-native purple loosestrife (*Lythrum salicaria*) has been found
on the site to date, Ogden Nature Center staff should watch wetlands to be sure that it
does not become established on the site. Purple loosestrife has been found in wetlands of
northern Utah. It can out-compete native vegetation and is of no value to wildlife
(Dewey, 1994) (See Appendix E for a description of purple loosestrife).

It is important to note that the weedy vegetation map shows major populations
only, or those likely to spread due to human activity. Due to their various requirements
and life cycles, weeds fluctuate on an annual basis (Horton, 1993). The weedy vegetation
inventory map is intended to provide baseline information concerning weed populations present on the site at this time. It should be updated annually if possible, in order to observe fluctuations in populations, and to determine persistent populations over time (Horton, 1993). This could be achieved by: 1) monitoring existing populations fluctuations; 2) mapping locations of any new populations, and; 3) recording efforts to control weedy species.

WILDLIFE

In *A Wildlife Conservation Manual for Urbanizing Areas in Utah*, critical habitats along the Wasatch Front are identified as water-related such as wetlands, ponds, stream corridors, as well as foothill grassland communities (Johnson et al., 1993). The Ogden Nature Center site features each of these critical habitat types. The Ogden Nature Center may also function as an urban "stepping stone" habitat between the wetland habitats of the Great Salt Lake and the upland oak/maple foothill habitat or deciduous forest habitat of the Wasatch Front due to: 1) its large scale regional context adjacent to the Great Salt Lake, making it a stopover for many migratory birds during their intercontinental migration, as well as, 2) its smaller scale context location along the Mill Creek drainage near the confluence of the Ogden and Weber rivers (Johnson et al., 1993).

The Ogden Nature Center has the potential to link the Plain City Canal in the Ogden Nature Center to the Mill Creek drainage. Such a connection would create an urban wildlife corridor extending to the east and west of the Ogden Nature Center. The connectivity between habitats allows for greater species mobility and the maintenance of species diversity (Adams and Dove, 1989). Mobility allows a species to find food, water, cover, or a mate upon which its own survival or the survival of that species in a given area depends (MacMahon, 1983). This idea was clearly articulated by Soulé and his
colleagues in a case study which documents the decline of bird species which inhabit chaparral habitats of southern California. The study concluded:

The most effective tool for the prevention of extinction of chaparral-requiring species in an urban landscape is the prevention of fragmentation in the first place by proper planning of urban and suburban development. Corridors of natural habitat, even quite narrow ones, are probably very effective in permitting dispersal between patches, thereby preventing or minimizing faunal collapse (Soule et al., 1988, 89).

The Wildlife inventory map (Figure 21) lists thirty seven bird species which frequent the Ogden Nature Center and an additional twenty bird species have been sighted once or occasionally. Twelve mammal species, three reptiles and four amphibians have also been observed. A detailed list of wildlife species is located in appendix E.

Due to the high mobility of bird species and the "island like" relative isolation of the Ogden Nature Center in its urban location, special attention has been devoted to the monitoring of bird species. However, it is urged that mammal, reptile, amphibian, and insect populations should be monitored and mapped in the future. During the past five summers the bird species at the Ogden Nature Center have been monitored and recorded by Nathan Welch. Therefore the bird population data may not account for other species which may be observable in the cooler months of year, or spring and fall migratory seasons. The map shows six habitats and the bird species sighted in those areas. The habitats are related to landscape features such as ponds, wetlands riparian areas and open meadows. They include: the riparian habitat of the Plain City Canal and Mill Creek, the palustrine wetland habitat of Blackbird pond, Dragonfly pond and adjacent potholes, Teal pond habitat, Arrowhead pond habitat, and open meadow habitat.

Bird species diversity, defined as the number of birds species present (Forman, and Godron, 1986), was highest in the riparian habitats along Plain City Canal and Mill Creek Canal. This is not surprising since research has shown that species diversity in Utah
Figure 21. Wildlife Inventory Map. 1994.
is highest in riparian habitats, when compared with other habitat types (Howe, 1994). A species diversity study conducted by the Utah Department of Wildlife Resources which focused on counts of neotropical migratory birds (those species which migrate from North America to Central America, South America, or the Caribbean), monitored the use of riparian habitat throughout Utah. These statewide measures of species diversity in riparian habitats produced counts of: "78 and 74 neotropical species in 1992 and 1993 respectively, and 108 and 116 for all birds combined (Howe, 1994, 60)." The importance of riparian zones is not simply limited to bird species. Howe's study also supports this view, he concludes that:

"Given the importance of riparian habitats to neotropical migratory birds, resident bird species and a host of amphibians, reptiles, mammals, fishes and invertebrates (Hubbard 1977, Brinson et al. 1981, Cross, 1985, Bury 1988), this habitat type and adjacent habitat types should be the primary focus of ecosystem management and preservation (Howe, 1994, 63)."

EXISTING CIRCULATION

Circulation at the Ogden Nature Center is achieved via roads or trails (Figure 22). The existing road system is linear. A gated road at the south end of the property adjacent to the nature center headquarters provides access from the busy 12th street arterial corridor to the site. For visitors the road access of 12th street terminates in a gravel parking lot. Visitors may leave their cars at the headquarters during orientation or for their entire visit should they prefer to explore the Nature Center's trail system. This road also gives access to the picnic area adjacent to Mill Creek at the north end of the Ogden Nature Center.
Figure 22. Existing Circulation Inventory. 1994.
The Ogden Nature Center trail network is based on the loop concept. Its major trailheads, from which trails leave and to which they return, are located at the nature center headquarters, at the south end of the site and at the picnic area at the north end of the site. The existing trail system causes some disorientation for users due to inconsistent or missing signage and site furnishings. Another problem with the trail system is that there is not a separation of uses between pedestrian and vehicular traffic. The trails cross the road in several places making it unclear whether the road system should be used as a trail or not.

Most of the slopes along the trail system would accommodate handicapped trail users, except near Arrowhead pond, where slopes are above 5%.

The trail system does provide visual variety, mystery, and a sense of the natural environment (Figure 23). Visual variety and mystery are experienced as the trail passes through the varying ecotones of the site. In some places the trails are simply mown, or marked by wood chips maintaining a sense of the natural environment for the visitor.

The existing trail system at the Ogden Nature Center seems mainly to have been designed for human use. Core habitat areas such as the Plain City canal riparian zone, Blackbird pond habitat and wetland areas are traversed by trails. This is not to say that humans should be excluded from these areas, but trail systems can designed to accommodate both human and wildlife needs. In a summary of site specific and construction recommendations to enhance wildlife habitat Johnson notes:

Site planning for wildlife conservation involves protection of all natural resources and systems. The resulting integrations of natural and built systems are more livable for humans and for wildlife (1993, Chapter 14, p.6).
Further observation and study of the wildlife specific to the site and their requirements is needed to help determine routes for the trails. For example, some species may benefit by trail closure during their breeding season. Could additional species be attracted to the site by moving trails out of core habitat areas?

Ed Horton, the resident plant ecologist at the Ogden Nature Center, has noted that some weedy vegetation species have spread across the site, not only due to seed dispersal by wind, water, and animals, but also because humans disperse weedy seed as they pass through trail sections near weed populations. This phenomenon may be casually observed by looking at one's socks after hiking across the site (Personal observation, 1993).
Figure 23. Ogden Nature Center Trail.
CHAPTER 3
WEEDY VEGETATION MANAGEMENT STRATEGIES

Introduction

The study of exotic invasive species or "biological pollution" is complex. As a result, there is not a lot of consensus of opinion regarding invasive species within the scientific community. The study of invasive species involves the intricacies of organism and population biology, evolution, and biogeography (Wagner, 1993). In his article, "Problems with Biotic Invasives: A Biologist's viewpoint," Warren Wagner provides a basic definition of a biotic invasive as: "a foreign taxon that enters an established ecosystem and contaminates it (1993, 1)." Wagner further clarifies the meaning of "contaminate" as follows:

The word "contaminate," however, has various connotations: it may mean that the introduction simply changes the "purity" of the ecosystem and merely adds a new alien species to the fauna or flora, which then becomes naturalized and settles in as a regular and well-behaved component. The word contaminate can also mean that the invasive organism seriously upsets the system. The alien becomes strongly undesirable in this case in that it competes with, and even smothers, its associates (1993, 1).

In most cases alien species behave as described above, however contaminate is a very subjective term. For example, if changes occur at the ecosystem level, even native species such as Juniper (Juniperus monosperma) of the Great Basin Pinyon-Juniper plant community become invasive.

The definition of "weed" is a very subjective one and is usually determined from humankind's point of view and human interpretations of appropriate land use(s) or land use objectives. In "What is a Noxious Weed?", a paper from the 1989 proceedings of the
National Noxious Range Weed Conference, Dewey and Torell describe their reasoning for a "universal" definition of weeds as follows:

A universal weed definition would have to be broad and flexible, allowing for differences in human perspectives as well as diversity and change in land (or water) use. The following definition fits those criteria, making it appropriate for nearly all situations:

A weed is any plant that interferes with the management objectives for a given area of land (or body of water) at a given point in time (1991, 3).

After defining "weeds" in a general sense Dewey and Torell further distinguish "weeds" from "noxious weeds." They explain that the terms "noxious weeds" have two different definitions—one which designates weeds as "noxious" by legislation, the other which designates weeds as "noxious" due to the harmful effects of weeds perceived by humans. Thus, a "noxious weed" defined in a regulatory sense is said to be as follows: "A plant species requiring management or control because of legislative action (Dewey and Torell, 1991, 3)." A "noxious weed," with regard to human perceptions of harmful effects can be defined broadly as: "A plant that is extremely prolific, invasive, competitive, harmful, destructive, or difficult to control (Dewey and Torell, 1991, 4)."

This is an important distinction because the competitive ability of the invasive species, or other characteristics such as toxicity, determine whether it will be targeted for control efforts. Teasel (Dipsacus sylvestris), and dyer's woad (Isatis tinctoria), are examples of highly competitive noxious exotic species which can out-compete and eventually suppress native populations. Other exotics such as smooth brome (Bromus inermis), crested wheatgrass (Agropyron cristatum), and intermediate wheatgrass (Agropyron intermedium), may grow in association with natives but do not overwhelm them (Rasmussen, 1994). This is illustrated clearly at the Ogden Nature Center by observing the differences in vegetation on the east and west sides of the canal. The east side of the canal (Figure 24) is dominated by cheatgrass (Bromus tectorum), and noxious
Figure 24. Vegetation East Side of Plain City Canal.
Figure 25. Vegetation, West Side of Plain City Canal.
weeds such as: yellow starthistle (*Centaurea solstitialis*), and Canada thistle (*Cirsium arvense*). On the west side of the canal introduced (exotic) pasture grasses were planted to revegetate the site for grazing. The vegetation on the west side of the canal is composed of introduced non-natives such as smooth brome, crested wheatgrass, etc. (See Figure 25). These non-natives have stabilized the soils on this portion of the site, preventing watershed damage by controlling sheet erosion. Although native grass species on the site have dwindled to a few small stands of individual plants such as: Western Wheatgrass (*Agropyron smithii*), Indian ricegrass (*Oryzopsis hymenoides*), and some bluebunch wheatgrass (*Agropyron spicatum*) still remain on the west side of the canal and have not been completely overwhelmed by the introduced exotic perennials.

The reason these native grass species have declined is that the non-native pasture grasses were selected to maximize forage production. Most grass varieties selected for forage are selected for their nutrient value, however they are also selected for their reliability. This means that they are hardy and usually competitive with other species. Varieties such as smooth brome, which is rhizomatous and sod-forming, fill in spaces around the native bunchgrasses, such as Indian ricegrass and bluebunch wheatgrass, thus competing with the native grasses for available resources. Smooth brome also has the advantage of reproducing through tillers, rhizomes and seeds, crested wheatgrass reproduces through seeds and tillers whereas the bunchgrasses usually reproduce primarily through seeds and rarely through tillers and rhizomes. Because the area was grazed in the past, the bunchgrass seeds were eaten by livestock causing a decline in the native species population. Thus grass varieties which reproduce underground via rhizomes, or above ground via tillers, and by seed, such as smooth brome have the competitive advantage. In
fact, the natives which still exist on the site do in some cases reproduce via tillers or rhizomes, and this may be the reason that they persist.

Many biological processes are involved in the competitive success of invasive plants, such as their environmental requirements, adaptability, mobility, physiology, reproductive systems and interspecies associations; thus, contingency creates different problems for each situation (Wagner, 1993). Also, most noxious weedy species are invaders far from their country of origin, therefore they usually have no natural diseases or predators to control their population growth (Lacey and Olsen, 1991). Therefore they can gain a competitive advantage over native species. Each species, and techniques for its control need to be considered on a case-by-case basis.

In her article, "Noxious Weed Management Strategies", Celestine Lacey explains that the management of extensive weed populations includes a three step overall planning process. This includes: "1) weed inventory and site assessment 2) selection and application of control techniques, and 3) follow-up management (1991, 75-83)."

Traditionally, vegetation management has been accomplished by using one or more techniques. These techniques include: biological, mechanical, and chemical methods; prescribed burning; revegetation; and fertilization (Vallentine, 1989). These techniques will be explored as to their potential applicability at the Ogden Nature Center. The advantages and disadvantages of each alternative as applied to the Ogden Nature Center site in terms of long term-effectiveness, applicability, compatibility with the site and the ability to meet the objectives of the nature center will be evaluated. Three alternative vegetation management techniques will be considered in this thesis. They include 1) the natural competition technique (succession) 2) and the single method technique 3) the integrated management technique.
The Natural Competition Technique

The natural competition technique would allow the vegetation on the site to proceed through several serial stages to some a stable "climax" condition. This model of plant community dynamics assumes that "...all possible states of vegetation can be arrayed on a single near linear continuum...and all changes occur continuously and reversibly along this continuum (Laycock, 1991, 427)."

Traditionally this has been the accepted model of rangeland plant community dynamics, however natural competition does not adequately describe plant community dynamics in some cases and has been determined to be too limited. In his article, "Stable states and thresholds of range condition on North American rangelands: A viewpoint," Laycock discusses various alternative models that may better describe the rangeland plant community dynamics. He combines the ideas of "stable states" and "thresholds of change" to create a more accurate depiction of rangeland plant community dynamics.

A stable state is described as a state which resists change imposed upon it by external forces, and returns to its original condition after disturbance (Laycock, 1991). Unstable states do not return to their original condition after disturbance but cross a threshold to reach a different state or remain in flux (Laycock, 1991). Wesotby et al. (1989) may have provided the basis for these ideas, he describes rangeland dynamics using a state and transition model. Westoby et al. (1989) define a state as a stable group of species which occupy an area, and transition between states as a disturbance caused either by natural events or management actions or a combination of both.
Laycock suggests the following reasons why stable states and threshold conditions may occur:

The reasons for suspended stages of or different trajectories of succession may include dominance by a highly competitive species or life form, long generation times of the dominant species, lack of seed or seed source, specific physiological requirements that limit seedling establishment except at infrequent intervals, climatic changes, restrictions of natural fires or others (1991, 427).

Natural Competition Technique General Advantages and Disadvantages

The problem with applying the natural competition technique on the Ogden Nature Center site is that the site's plant dynamics at this point more closely resemble the stable state and threshold dynamics described above. First, the site has been disturbed numerous times in the past by toxic waste burial and burning, grazing, agricultural practices, and pond and canal construction, thus making it difficult to ascertain whether any of the original natural edaphic conditions remain. Second, native vegetation was not reintroduced following disturbances, and few individual plants of native species remain at the Ogden Nature Center. Third, noxious exotic species such as, teasel (Dipsacus sylvestris), dyer's woad (Isatis tinctoria), and tamarisk (Tamarix spp.) have invaded which may, if not controlled, lead to stable state communities of noxious exotics. Finally, cheatgrass, Bromus tectorum has been identified as a stable state/threshold community (Laycock, 1991).

If plant community dynamics are allowed to continue along the present trajectory, the vegetation on the site such as desirable introduced species and the few remaining native species may be outcompeted by noxious weedy exotics. This may result in a stable state community and a loss of plant species diversity. Since the function of the Ogden Nature Center is to provide a sanctuary for wildlife in an urban setting, and the
encroaching noxious weedy vegetation is of little value to wildlife species, then dominance of the site by noxious weeds would run contrary to the Nature Center's objectives.

Thus, the question arises, is it desirable to allow the existing stable state/threshold process to continue, or should an area of the site be manipulated to approximate a preexisting "natural" successional process, and if so which preexisting condition?

An advantage of manipulating the site to approximate a preexisting condition is that once an area of the site is "restored," the succession process should theoretically proceed with relatively little human management (Bradshaw, 1989). The disadvantage of manipulating the site to approximate a preexisting condition is that the site may already be in a stable state and the human resources required to manipulate the vegetation to cross a threshold may be cost prohibitive and unobtainable.

MacMahon, points out that management to favor or oppose natural competition may not be possible because so little is known about successional processes in urban environments:

Urban perturbations are completely new, representing selective forces not encountered previously by the biota. We know so little about urban ecology, that it is difficult to know what is possible or even desirable with regard to management (1983, 19).

Sprugel notes the difficulties in defining "natural" communities, in his article, "Disturbance, Equilibrium, and Environmental Variability: What is "Natural" Vegetation in a Changing Environment?" He states:

In some areas an equilibrium may exist in which patchy disturbance is balanced by regrowth, but in others equilibrium may be impossible because (1) individual disturbances are too large or infrequent; (2) ephemeral events have long-lasting disruptive effects; and/or (3) climate changes interrupt any movement toward equilibrium that does occur (1991, 1).
Therefore the determination of "benchmark" or "natural" communities needs to be reconsidered. Sprugel points out that what we consider to be the long-lived (in human terms) old growth forests of the Pacific Northwest, have not established an equilibrium. Old growth forests are dominated by fire-following Douglas Fir (*Pseudotsuga menziesii*), which live from 1000 to 1200 years, and pollen records for Douglas fir begin 6000 years ago. Therefore the old-growth vegetation community has only existed for five to ten Douglas Fir life-spans (Sprugel, 1991). Based on his studies of variations in natural competition between species and the differing succession regimes of several plant communities, Sprugel makes the following observations:

(1) Many types of natural vegetation are far less stable than they appear to be.  
(2) Small or transient environmental changes can cause large and long-lasting vegetation changes.  
(3) Every point in time is special.  
(4) Because of vegetational instability, it may be impossible to define the natural vegetation or the natural disturbance regime in many areas (1991, 12-14)

Sprugel recommends that management for natural ecosystem processes should be revised to include a larger spectrum of vegetation to be considered "natural" within a landscape (1991). The Ogden Nature Center administration may not be able to restore a "native" grassland, but it can attempt to preserve the "naturalized" grassland community and control the further spread of undesirable noxious weeds.

**Single Method Technique**

Traditionally, vegetation management has been accomplished by using one or more techniques. These techniques would alter the competitive balance between species and thus influence the natural ecosystem processes. These techniques include: biological,
mechanical, chemical methods; prescribed burning; revegetation; and fertilization (Vallentine, 1989).

The single method technique is fairly self-explanatory. One method, from those listed above, would be used to manage undesirable vegetation. For instance, in areas where herbicide spraying may adversely affect wildlife, hand weeding may be the only feasible method for weed control. When considering a vegetation management method the following factors should be involved in helping select the best method:

1. Management Objectives
2. Characteristics of the target species
3. Characteristics of the secondary species
4. Topography and terrain
5. Kind of soil
6. Site potential
7. Follow-up required (Vallentine, 1989, 88-89)

The single method techniques to be considered for application at the Ogden Nature Center include: mechanical control, herbicides, biological control, revegetation, and the integrated management technique. (For more in-depth information and analyses of these techniques refer to L.F. James et al. 1991, Vallentine 1989, or Scifres 1980, and/or the most current articles in the appropriate journals).

**Mechanical Control.**

Mechanical control methods are means of controlling vegetation using muscle power and tools or mechanical equipment. Mechanical control may be selective, allowing for control or removal of an individual plant species, or non-selective meaning that both undesirable and desirable plants are controlled or removed. Mechanical control methods that are selective include, hand cutting, girdling, top pruning, hand grubbing, power grubbing, and bulldozing. Non-selective methods which are more effective on non-resprouting vegetation include blading, chaining, crushing, shredding, mowing, pipe harrowing, diskimg and plowing. (Vallentine, 1989).
Vallentine (1989) notes the importance of determining first, whether individual plant removal or multiple plant removal is to be accomplished, and second whether it is necessary to remove the entire plant or only the top growth of the plant. The individual plant removal techniques are cost effective on low density populations. As populations increase the broadcast and less selective techniques become more advantageous. Due to the management objectives, availability of equipment, the types of vegetation to be controlled, and site characteristics the methods which would be considered most applicable at the Ogden Nature Center are hand cutting, hand grubbing, and mowing to be applied where appropriate to dyer’s woad (*Isatis tinctoria*), teasel (*Dipsacus sylvestris*), and tamarisk (*Tamarix spp.*).

**Hand Grubbing.**

Hand grubbing is a treatment applied to remove entire individual plants. It is human muscle powered and may be done in combination with equipment such as: shovels, hoes, axes and chain saws (Vallentine, 1989).

**Hand Grubbing: General Advantages**

1. For low density populations, hand grubbing is less expensive than other techniques.
3. Best adapted to widely scattered sparse stands of vegetation (Vallentine, 1989).

**Hand Grubbing: General Disadvantages**

1. As population densities increase hand grubbing becomes very labor intensive.
2. Hand grubbing without follow-up revegetation will allow invasive species to establish easily in disturbed areas.
3. Hand grubbing is not well adapted to resprouting root systems (Vallentine, 1989).
4. Hand grubbing causes more physical soil disturbance than herbicide application.
5. Hand grubbing may require follow-up treatments.
Hand Cutting.

Hand cutting is applied to individual plants to remove plant growth above ground level. It is human muscle powered and may be done in combination with equipment such as scythes, shovels, brush hooks, machetes, axes or chain saws (Vallentine, 1989).

Hand Cutting: General Advantages

1. Hand cutting allows for selectivity.
2. Hand cutting is less expensive than other techniques.
3. Hand cutting is less labor intensive than hand grubbing.
4. Hand cutting is best adapted for cutting non-resprouting plants at ground level.

Hand Cutting: General Disadvantages

1. Hand cutting is labor intensive.
2. Hand cutting without follow-up revegetation will allow invasive species to establish easily in disturbed areas.
3. Hand cutting will not kill resprouting plants.
4. Hand cutting may require follow-up treatments.

Mowing.

Mowing is based on the same principles as hand cutting, the objective is to remove the top growth of multiple plants above ground level (Vallentine 1989). This method is non-selective for individual plant removal such as hand grubbing or hand cutting. This method requires a mower.

Mowing: General Advantages

1. Mowing is less labor intensive than hand cutting or hand grubbing.
2. When mowing herbaceous plants, mowing may be done when flower stalks are bolting, if plants are not removed or controlled in the rosette stage.
3. Mowing may increase or decrease the competitive ability of some herbaceous species.
4. Mowing involves little soil disturbance so perennial herbaceous plants are not disturbed.
Mowing: General Disadvantages

1. Mowing is less selective than hand cutting, and thus disturbs both desirable and undesirable vegetation.
2. Mowing without follow-up revegetation will allow invasive species to establish easily in disturbed areas.
3. Mowing doesn't kill resprouting species although it may suppress them.
4. Mowing often requires follow-up treatments.

Herbicides

Scifres defines herbicides as "...chemicals that kill plants or retard the rate and extent of their normal growth (1980, 140)." The use of herbicides will be examined for the different types of vegetation selected for control in this study. In his article, "Principles of Chemical Control," Rodney Bovey notes:

It is essential that the user understand the properties and the effects of herbicides to use them safely and effectively (1991, 103).

It is always important to select the correct herbicide. One way to avoid some confusion is to understand herbicide nomenclature; herbicides are referred to by their chemical name, their trademark names and their common names. The chemical name is the actual unabridged name of the chemical compound (Scifres, 1980). The trademark names are the names under which the herbicide products are sold. There are numerous trademark names because each herbicide company uses a different name for the same basic chemical compound (Scifres, 1980). The common name is a short name which is used consistently to facilitate the referencing of herbicidal compounds and is set by the Weed Science Society of America (WSSA), since the numerous trademark names and chemical compound names are often extremely long (Scifres, 1980). For clarity, this report will refer to the compounds by their common names, using the trademark name only if it has some distinguishing characteristic. The consumer should also always consult the herbicide label for safety measures to take, correct proportioning and correct application procedures (Vallentine 1989, Scifres 1980).
Most herbicides can be applied in a variety of ways depending on the type of vegetation, density of the weeds, and the size of the area to be covered (Bovey, 1991). In the case of the Ogden Nature Center, the types of herbicide application to be considered will be: broadcast, and individual plant treatment such as the cut-stump method.

Most herbicides are highly selective and designed to interfere with the plant's physiological processes (Scifres, 1980). Different types of herbicides and methods of their application are important depending on the plant's environment and the way the control is designed to affect the plant's physiology. Therefore, climate factors (temperature, wind, humidity and moisture) and season of herbicide application and type and amounts of herbicide applied are very important when using this technique for vegetation control (Bovey, 1991, Scifres, 1980).

Herbicides may be applied using many different methods. Two categories of spray application are individual plant treatment, and broadcast treatment. Individual plant treatments are usually applied to smaller stands of vegetation. Broadcast spraying is usually applied to larger stands of vegetation and to those plant species which are susceptible to absorption of herbicides through their foliage. The methods appropriate for application at the Ogden Nature Center include: 1) individual plant application (cut-stump method) via a backpack sprayer, to be applied to tamarisk (Tamarix spp.) and; 2) broadcast spraying using a backpack sprayer to be applied to dyer's woad (Isatis tinctoria) and broadcast spraying using a boom sprayer to be applied to teasel, (Dipsacus sylvestris).

**Herbicide Individual Plant Application (i.e. backpack sprayer):**

**General Advantages**

1. This technique is less labor intensive than other techniques for low density populations.
2. This technique allows for selective control of noxious weeds while leaving surrounding vegetation unharmed.
3. Backpack sprayers are easy to maneuver in comparison to other herbicide applicators, such as boom sprayers.
Herbicide Individual Plant Application (i.e. backpack sprayer):
General Disadvantages

1. This technique may be more expensive than other techniques as population densities increase.
2. This technique may require follow-up treatments until seedbank is reduced.
3. If vegetation is not present which is non-resistant to the herbicide applied, this technique does not consider possible soil erosion, or reinvasion of the site following herbicide application.

Herbicide Broadcast Application (i.e. backpack or boom sprayer):
General Advantages

1. This technique is less labor intensive than other techniques.
2. Boom spray application of herbicide allows for an even distribution of herbicide and reduces drift (Vallentine, 1989).

Herbicide Broadcast Application (i.e. backpack or boom sprayer):
General Disadvantages

1. This technique may be more expensive than other techniques.
2. This technique may require follow-up treatments until seedbank is reduced.
3. This technique does not consider possible soil erosion, or reinvasion of the site following herbicide application.
4. This technique is non-selective and may harm desirable vegetation.
5. Boom spray equipment is at times difficult to maneuver.

Biological Control

Broadly defined, biological control is: "the planned use of living organisms to reduce the vigor, reproductive capacity, density, or effect of weeds (Quimby et al., 1991, 85)." Agents of biological control include various organisms such as livestock, wildlife, insects, fungi, pathogens, and other competitive vegetation (interspecific competition) (Quimby et al., 1991). Four types of biological control agents will be discussed in relation to the vegetation at the Ogden Nature Center. They include a discussion of the use of a rust pathogen in relation to dyer's woad, and the possible application of bacteria in the
case of cheatgrass, as well as a general discussion of interspecific competition, (also classed under revegetation) and grazing possibilities where applicable.

**Biological control: general advantages**

1. Most biological controls are selected to attack only the target species; biological control is in most cases less disturbing to the ecosystem than other forms of control.
2. Less expensive than other methods such as herbicide application, if available.
3. Offers an interesting educational opportunity.

**Biological control: general disadvantages**

1. In some cases biological control is labor intensive, and more expensive than other techniques.
2. Knowledge of the pathogen and life cycle of plant is necessary.
3. This method of control may require follow-up treatments until plant populations or seed banks are reduced.
4. The risks associated with the implementation of the particular biological control must be assessed.
5. Biological controls are often unavailable.

**Revegetation**

Revegetation can be defined as: "The reestablishment or improvement of vegetation through either natural or mechanical means; that is natural or artificial revegetation (Scifres, 1980, 325)." This definition encompasses both intentional revegetation by humans and unintentional natural revegetation and natural competition. Natural revegetation can be considered the same technique as the natural competition technique discussed previously. The broad definition of "revegetation", however, includes artificial revegetation.

Vallentine's definition of natural revegetation is made from the standpoint of range improvement. According to Vallentine (1989, 215), "Natural revegetation is based on checking the current cause or causes of depletion and allowing secondary succession to
raise range condition to satisfactory levels." Natural revegetation/natural competition may be appropriate in some areas of the site to study the successional characteristics of the undesirable species where it is not possible to control them. Vallentine considers artificial revegetation as it relates to forage production, he states: "when insufficient desirable forage plants remain, consideration must then be given to artificial revegetation,- usually involving preparation of a seedbed followed by drilling or broadcasting harvested seed (1989, 215)." However the decision to revegetate an area should be based not only on range improvement for forage production, or forage production alone but, as in the case of the Ogden Nature Center, on other site management objectives such as site stabilization, possible reintroduction of native species, enhancement of wildlife habitat, etc. Vallentine (1989) proposes some useful general guidelines for artificial revegetation; he suggests a site inventory of the types and amounts of plants remaining, consideration of alternative approaches (including costs), the requirements of seedling establishment, expected rates of establishment, climate, soil conditions, and the possible necessity of supplementary reseeding (or other treatments). Artificial revegetation at the Ogden Nature Center may be considered as a follow-up treatment in combination with other treatments, or as an educational opportunity such as the study of the effects of interspecies competition, as in the case of cheatgrass and other perennials.

The types of plants selected for reseeding should include both natives and introduced species, depending on management objectives (Vallentine, 1989). Non-native introduced species should not be overlooked simply because they are "exotics" (Vallentine, 1989). Important characteristics to consider when selecting species are their adaptability to site conditions, and the anticipated use and management of the stands (Vallentine, 1989).
Revegetation: General Advantages

1. Seeding may cause less site disturbance than other methods.
2. Revegetation helps to reduce soil erosion following site disturbance.

Revegetation: general disadvantages

1. The cost of seed can be expensive.
2. Risk of failure is high which may require follow-up treatments.

Alternative Control Methods.

Other methods of control such as prescribed burning and fertilization are not included in this study. The urban location of the Ogden Nature Center inhibits the use of fire due to safety issues and permitting requirements (Rasmussen, 1994). Fertilization of the vegetation on the site may lead to unintentional encouragement of undesirable vegetation (i.e. cheatgrass) and possible nutrient loading in the watershed and are not compatible with Ogden Nature Center objectives at this time. However these management tools should not be completely disregarded, and should they be determined to be applicable in some instance, they should be reconsidered at that time.

General advantages and disadvantages of the single method technique

An advantage of the single method approach is that it is inexpensive in the short term. Another advantage of the single method approach is that reasons for success or failure of a particular method are more easily identified. The disadvantages of this approach are that single methods are not always effective enough on their own, and over time, costs both economic and environmental of applying single methods repeatedly (such as spraying) can accrue. As an example, economic and environmental damage could occur when herbicide-resistant weed species develop. The cost is environmental because once a weedy species becomes herbicide resistant there may be no other means to control it and it will continue to spread. The cost is economic because after investing a lot of money in
herbicide development to control a species: 1) it can become resistant to that type of herbicide and continue to spread, and 2) it will also cost more money to do additional research to develop new alternative methods of control once methods previously relied upon fail. Single treatment methods traditionally applied as stand alone controls have been found to be costly and ineffective in the long term (Scifres, 1987). However, it is important to study single methods since they can be synergistic when combined, and their efficiency can be increased. This is a different technique known as integrated brush management systems or (IBMS). IBMS simply combines single method techniques to enhance manage specific plants using appropriate timing and planning to take advantage of the strengths and weaknesses of the associated individual techniques effectiveness (Scifres, 1987).

**Integrated Management Technique**

The integrated management technique combines complimentary vegetation manipulation techniques in a logical sequence which should produce predictable results (Scifres, 1987). The integrated management technique is based on the idea of Integrated Brush Management Systems (IBMS) (Scifres, 1987). Scifres defines the way a brush management system can be developed as follows:

The word system has more than fifteen definitions and a multitude of uses. Meanings which may apply directly to brush management systems include (1) a coordinated body of methods or a complex scheme or plan of procedure; (2) any formulated, regular, or special method or plan of procedure; and (3) due method or orderly manner of arrangement or procedure. A brush management system, then may be considered a plan of procedure in which the application of the individual methods is coordinated by the manger in an orderly manner. Thus, the resource manager must become familiar with the applicability of all available methods and their specific place in a sequential arrangement for maximum results (1980, 277).
Scifres further mentions that the development of a brush management system requires long-term planning on the part of the manager, and that flexibility in timing of the methods to be applied and possible alternative methods should be evaluated (Scifres, 1980). Ongoing monitoring of each technique's effectiveness as it is applied allows for possible innovations in techniques. Monitoring also offers an opportunity for an evaluation of the process as each step occurs so that a technique may be repeated if necessary or additional unnecessary techniques are not applied. Thus, integrated management is in some cases dynamic and iterative, which permits flexibility (Figure 26).

"Critical considerations," for the development of an integrated management system are explained by Scifres et al. (1983, 2-3):

1. Development of management objectives for effective land use.
2. Estimate of the natural resource potential.
3. If grazing is to be implemented, consider grazing objectives (Rasmussen, 1994).
5. Proportion of management unit to be treated.
6. Economics.

These critical considerations provide guidelines necessary for developing an integrated management system. Most often, integrated management has been applied on rangelands where grazing management is a factor for consideration. Since the Ogden Nature Center does not currently plan to accommodate livestock grazing, it is not a necessary consideration. However, should grazing become an appropriate tool for the management of some type of vegetation, or some other purpose that would serve Ogden Nature Center management objectives, it should be considered. The coordinated efforts necessary for the success of integrated management require a spirit of cooperation and commitment to be successful.
Figure 26. IBMS Model from Scifres, C. J. et al. 1983, p.2.
Integrated Management Technique General Advantages and Disadvantages

Since the application of Integrated Management Techniques are generally more species specific they are discussed on a case by case basis later in this chapter. An example of an integrated approach which combines a variety of single methods which may prove successful at the Ogden Nature Center would be to apply hand cutting or mowing, biological control, and revegetation to the case of dyer's woad (*Isatis tinctoria*).

Integrated Management Technique: General Advantages

1. Synergistic effect of combining vegetation manipulation techniques allows more effective control of noxious weeds.
2. Possible realization of the site's ecological potential in the long-term.
3. Educational benefits.
4. Improved site management.
5. Flexibility in terms of accommodating management objectives.

Integrated Management Technique: General Disadvantages

1. Because the integrated method combines single method techniques it may be more expensive in the short term than other methods.
2. The integrated method may be as labor intensive as other methods.
3. It will require intensive management and monitoring to be successful.

Post Project Management and Monitoring

Important aspects of any vegetation control program are post project management and monitoring; in fact, they are crucial to the success of the control measures taken. Celestine Lacey notes:

Follow-up management determines the longevity of control obtained with chemical, biological, or cultural weed control methods. Because most noxious weeds have persistent and tenacious growth characteristics and seeds that remain viable for years, long-term control programs must be implemented. These include retreatment with herbicides or continued cultural control practices to maintain low levels of weed populations (1991, 82).
However, only the integrated management technique builds these concepts of monitoring and post project management into a vegetation management plan. It is very important to keep records of the manner in which techniques are implemented in order to track their effectiveness and to recreate similar results if desired. In their article, "Integrated Brush Management Systems Concepts and Potential Technologies for Running Mesquite and Whitbrush," Scifres et al. (1983) show an excellent example of a schedule for recording techniques and their implementation (Appendix G).

**Weedy Species Selection Criteria**

Four weedy species were selected for study based on their specific characteristics, methods for their control, the site conditions and capabilities of the Ogden Nature Center, and their compatibility with the priorities stated in the *Intermountain Region Noxious Weed and Poisonous Plant Control Program, Final Environmental Impact Statement*, of the USDA Forest Service, October 1986 (for a listing of the priorities refer to Chapter 1, p. 14).
Weedy Species Selected for Control

The weedy species selected for control are: cheatgrass, or downy brome (*Bromus tectorum*), dyer's woad (*Isatis tinctoria*), teasel (*Dipsacus sylvestris*) and tamarisk or saltcedar (*Tamarix spp.*) (Figures 27-30). Each of these species was selected because they are or have the potential to become major infestations at the Ogden Nature Center. They have different physiology and life cycle characteristics which distinguish them: cheatgrass is an annual grass, tamarisk is a woody shrub, dyer's woad is a biennial forb which functions as a perennial if its capacity to reproduce is controlled and teasel is a biennial forb.

Cheatgrass is ubiquitous and easily identifiable at the Ogden Nature Center (Figure 20, Weedy Vegetation map). Besides its invasive nature, cheatgrass was selected due to the interesting interpretive and educational opportunities provided by the study of its physiology in comparison with other grass species and its case history.

Cheatgrass provides an opportunity to study competition between solitary or bunching annuals (cheatgrass), and perennial native bunchgrasses, and non-native bunchgrasses and rhizomatous grasses. The case history of cheatgrass also poses some instructive and perplexing issues. Its dual roles as an aggressive invasive exotic and as a valuable spring forage for livestock has made it difficult to determine appropriate management objectives (Morrow and Stahlman, 1984, Thill et al., 1984). It is interesting to note that there is a biological control for cheatgrass (Kennedy, et al., 1989).
Figure 27. Cheatgrass (*Bromus tectorum*).
Figure 28. Dyer’s Woad (*Isatis tinctoria*).
Figure 29. Teasel (*Dipsacus sylvestris*).
Figure 30. Tamarisk (*Tamarix* spp.).
However, it maybe infeasible to use it over the large areas that cheatgrass now dominates [approximately 5.7 million hectares in the west (Kennedy, et al., 1989)] due to economic costs of revegetation, and the possibility of watershed damage prior to re-establishment of the revegetated areas (Rasmussen, 1994). The biological control may be feasible to use in a small area such as the Ogden Nature Center. Cheatgrass is classed as a Priority III weed by the Intermountain Noxious Weed Program. It is not on the Utah state noxious weed list. The selection of cheatgrass allows for the study and possible comparison of the following controls should the Ogden Nature Center chose to implement several of the control techniques presented. these control methods could be implemented at the Ogden Nature Center on the northeast corner of the site:

Natural Competition Technique/Single Method Technique:

I. Natural Revegetation

Single Method Technique

I. Artificial Revegetation

Integrated Management Technique

I. Fall Mowing, Spring Boom Sprayer Broadcast Herbicide Application, Artificial Revegetation and Monitoring

A future possibility- Biological Control.

Dyer's woad is a priority III established invader. It is present in dry grassland areas at the Ogden Nature Center. The largest population occurs adjacent to Dragonfly pond. Dyer's woad is listed on the Utah state noxious weed list. It could be targeted for biological control as one of several management strategies to help manage and possibly reduce the dyer's woad since it is already under seige, and the implementation and study of the results of such a control method would be very educational. When done correctly,
biological control can be one of the most environmentally sensitive, and effective methods of control. However, successes of biological control have been under-publicized. In his article, "Classical Biological Control- An Endangered Discipline?," John Drea notes: "Classical biological control has never been a widely known or well-supported science (1993, 217)."

In 1992 the biological control, Puccinia thlaspeos (a rust pathogen), was observed on dyer's woad plants at the Ogden Nature Center. Since then the pathogen has spread naturally to other plants of the same species on the site. Since the pathogen is already present on the plants at the Ogden Nature Center, it provides an ideal situation for use as a tool for control and an opportunity to further public understanding of biological control. The selection of dyer's woad allows for the study and possible comparison of the following techniques should Ogden Nature Center administrators decide to implement several of the techniques presented:

**Single Method Techniques**

I. Hand grubbing  
II. Hand cutting  
III. Mowing  
IV. Biological Control  
V. Backpack Sprayer Broadcast Herbicide Application

**Integrated Management Techniques**

I. Backpack Sprayer Broadcast Herbicide Application followed by Monitoring and Artificial Revegetation as necessary  
II. Mowing or Hand Cutting, Biological Control, followed by Monitoring  
III. Backpack sprayer Herbicide Application Biological Control, followed by Artificial Revegetation followed by Monitoring  
IV. Study of Grazing as a possible Biological Control followed by Monitoring
Teasel is a priority III established invader. It is most dominant in wetland areas and is present in most other plant communities represented on the site. Because of its ubiquitous nature, control of the teasel population provides an opportunity for comparison of vegetation control techniques based not only on the plant's physiological response, but on microclimate as well. Teasel is undesirable at the Ogden Nature Center because it is most prevalent in the mesic areas (in or adjacent to riparian zones, ponds and wetlands) which offer visual variety, prime habitat, diverse vegetation, and which are important "outdoor classroom," showcase areas for visitors. Therefore, Ogden Nature Center administrators have requested that this study examine methods to help control the teasel infestation. Teasel was targeted for control not only because it is beginning to dominate the plant communities on the site but its control has also become a management objective of the Ogden Nature Center. Teasel population control allows for the study and possible comparison of the following control techniques should the Ogden Nature Center administrators decide to implement several of the techniques presented:

**Single Method Techniques**

I. Hand Grubbing  
II. Hand Cutting  
III. Mowing

**Integrated Management Techniques**

I. Fall Mowing, Spring Boom Sprayer Broadcast Herbicide Application and Artificial Revegetation followed by Monitoring

II. Study of Grazing as a possible Biological Control followed by Monitoring.

Tamarisk is a relatively recent invader at the Ogden Nature Center. According to Ed Horton, Ogden Nature Center plant ecologist, it was introduced to the Ogden Nature
Center by pond construction equipment during the construction of Teal and Dragonfly ponds (Horton, 1993). It occurs around the margins of these two ponds (Horton, 1993).

At this point tamarisk is still possible to control since it has not yet established itself in sufficient numbers as to be ineradicable (Horton, 1993). From the standpoint of the Ogden Nature Center this species should be considered a "priority II, new invader" and methods for its control should be explored and implemented as soon as possible to prevent its permanent establishment on the site. This type of proactive management prevents the need for more intensive time-consuming and costly efforts later. Due to its ubiquitous presence in wet areas associated with riparian corridors, wetlands, and ponds in the region, and its reproductive capabilities, it is possible that tamarisk could be reintroduced onto the site by wind, water, or animal transport. Tamarisk is not included on the Utah state list of noxious weeds, but control of tamarisk should not be overlooked. The selection of tamarisk will allow for the study and possible comparison of the following techniques should the Ogden Nature Center administrators decide to implement several of the techniques presented:

**Single Method Technique**

**I. Hand Grubbing**

**Integrated Management Technique**

**I. Individual Plant (Cut-Stump Method) Backpack Sprayer Herbicide Application followed by Artificial Revegetation and Monitoring**

A priority I potential new invader species which should be watched for is purple loosestrife (*Lythrum salicaria*). Purple loosestrife has been found in wetlands of northern Utah. It can out-compete native vegetation and is of no value to wildlife (Dewey, 1994). This species was mentioned in Chapter 2, however due to the importance of identifying it when it appears, and keeping it from becoming established at the Ogden Nature Center it
is mentioned again here (For further information about the physical characteristics of purple loosestrife see Appendix E). Management strategies should also be studied for other invasive species on the site such as: Canada Thistle (Cirsium arvense), Yellow starthistle, (Centaurea solstitialis) (both species listed on the Utah state noxious weed list) Burdock, (Arctium minus), and Bryonia (Bryonia alba).

Cheatgrass or Downy Brome (Bromus tectorum)

Introduction

Cheatgrass probably originates in Central and Southwestern Asia (Young, 1991.) It was first introduced into the Great Basin around 1900, possibly due to contaminated seed, introduction of livestock into the region, and/or seed transfer from threshing combines (Young, 1991). It was first observed in Utah around 1890 (Welsh et al., 1991). The railroad not only provided a mode of transportation which contributed to the spread of cheatgrass, but steam locomotives provided a repetitive source of wildfire ignition which damaged native perennials and further helped to establish cheatgrass along railway corridors (Young, 1991). The range sheep industry also contributed to the spread of cheatgrass. Nomadic sheep covered long distances between their seasonal ranges, and dispersed cheatgrass seed in their wool (Young, 1991). Overgrazing of the rangelands has also allowed cheatgrass to compete successfully against native bunchgrass perennials. Wildfires are a natural part of the sagebrush bunchgrass ecosystem; however with the degradation of rangelands and the advent of cheatgrass, the natural wildfire frequency has been altered to favor cheatgrass. Cheatgrass matures in July, earlier than the native herbaceous species which usually mature in August (Young, 1991). Because cheatgrass matures early, the wildfire season is prolonged and the timing of wildfires is changed causing much more physiological damage to native herbaceous species, which in the past were adapted to burning later in the season (Young, 1991). Cheatgrass produces a fine
thatch which burns easily and at very high temperatures. After a fire a lot of cheatgrass seed may be killed; however, the growth season following the fire surviving cheatgrass seeds germinate early and outcompete perennials for available resources (Young, 1991). Cheatgrass is also adapted to take advantage of nutrients released in the environment following wildfire events (Young, 1991).

In their discussion of the history of cheatgrass introduction into the entire United States, Morrow and Stahlman attribute the successful spread of cheatgrass to timing of appropriate conditions when,

...preadaptation, habitat alteration simultaneous with entry, conformation of agricultural practices to the plant’s ecology, and susceptibility of the native flora to invasion are all in phase. Seldom has the vegetation of such a large area been changed so fast and possibly so permanently (1984, 3).

Cheatgrass is not designated as a noxious weed in the legal system, nor does it appear on any state lists of noxious species (Young, 1991). This is probably due to the importance cheatgrass has gained as a forage species for livestock over the years and cheatgrass populations have become so pervasive that control is not possible. Therefore, cheatgrass continues to compete with native herbaceous perennials (Young, 1991) and in some cases overwhelms them.

**Description**

Cheatgrass is a spring germinating annual, or a fall germinating winter annual. It is a reproductive by seed production. It may produce tillers (additional shoots) from its root crown, therefore it is either solitary or grows in clumps like bunchgrass (Thill, et al., 1984). However, it is not a sod forming grass like rhizomatous or stoloniferous grasses. It can vary in height from 4 inches to 30 inches (Whitson et al., 1991). Cheatgrass has a finely divided root system, averaging seven main roots per plant (Thill et al., 1984). Cheatgrass root systems are usually shallow allowing the plants to take advantage of
surface soil moisture. The roots of fall germinating plants may continue their growth during winter months (Thill et al., 1984). Leaf blades and sheaths are covered with soft hair. The inflorescence is a panicle approximately 2 inches to 6 inches long slender, one-sided and bends softly (Whitson et al., 1991). Spikelets have 5-8 flowers approximately 3/8 inch to 3/4 inch in length and may be hairy or smooth. Awns extending from the spikelets are 3/8 inch to 5/8 inch and may be straight or bent. Awns change from a pale green to purple at maturity or in drought conditions.

**Life history**

Cheatgrass is found in a variety of soil types and spreads across vegetation zones from salt desert vegetation zones through the sagebrush zone and into higher elevation zones which support Ponderosa pine and Douglas Fir (Morrow and Stahlman, 1984). It is most prevalent in the sagebrush zone.

Cheatgrass most often follows the life cycle of a winter annual. It usually self-pollinates (however some cross-pollination has been observed [Thill et al., 1984]). Fall germinating cheatgrass requires repeated late summer or fall rain for germination and growth to occur. In winter, the young plants become partially dormant, although their roots may continue to grow if temperatures remain warm (Thill, et al., 1984). Warm spring temperatures cause the plants to resume growing rapidly and vigorously. Should fall-germination be inhibited, some seeds will remain viable and germinate the following spring. One of the successful attributes of cheatgrass is that it can germinate under a wide range of conditions.

Once downy brome caryopses have overcome the initial post harvest dormancy, they will germinate of a wide range of constant or alternating temperature regimes (Thill et al., 1984, 9).

Seed viability has been reported to reach 90% even before the caryopsis (single-celled seed fused to its seed coat) has changed to its mature purple coloration (Thill, et al,
The length of time a seed remains viable is inconclusive; however, it is generally agreed that most seed retain their viability for 2 years (Morrow and Stahlman, 1984). Flower head production for both fall and spring germinating cheatgrass usually occurs from mid-May until late June depending on the time of germination and field conditions (Thill et al., 1984). Cheatgrass plants will produce from one to five seeds regardless of site conditions (Mack and Pyke, 1983).

Roots of cheatgrass do not penetrate the soil very deeply; they may only reach a depth of 4 feet. The root systems are very efficient and the fine root hairs enable the plants to extract nearly all of the available water in the upper layers of the soil (Morrow and Stahlman, 1984). The majority of root production occurs in the spring and maximum root growth is simultaneous with flowering (Hironaka, 1961).

Several desirable characteristics of cheatgrass are: 1) due to its early establishment it produces early spring forage for livestock and wildlife 2) stands of cheatgrass add organic matter to the soil and 3) dense root growth helps to control soil erosion (Morrow and Stahlman, 1984). However, cheatgrass is also considered undesirable because 1) large stands of cheatgrass are susceptible to fire and may burn completely, posing an erosion hazard to the landscape 2) early establishment and soil moisture depletion by cheatgrass allow it to repress the growth of desirable perennial grasses (Morrow and Stahlman, 1984), and 3) during drought years sufficient germination and growth may not occur to protect the soil resources (Rasmussen, 1994).

**Characteristics that make cheatgrass a successful weed**

1. Ease of establishment (Morrow and Stahlman, 1984)
2. Rapid growth (Morrow and Stahlman, 1984)
4. High rate of seed production.
5. Excellent seed viability and germination rates.
6. Ability of seed to germinate either in spring or fall to insure species perpetuation (Morrow and Stahlman 1984, and Thill et al. 1984).
9. Ability to alter fire frequencies to fit its growth characteristics
10. Other presently undetermined characteristics?

Control Possibilities

Due to large populations of cheatgrass on the site several of these techniques may be applied in various locations to study and compare the effectiveness of the different techniques.

Natural competition technique/ single method

1. Natural revegetation

Cheatgrass occupies the same environmental potential at the same moments in time as the seedlings of the native perennials. When two or more biologic organisms occupy the same time and space, interference occurs. The species with the most biologically effective inherent physiologic systems are successful in these cases of interference, and in the case of sagebrush ecosystems, the winner is cheatgrass (Young, 1991, 415).

Although cheatgrass excludes most native perennials some non native species have been observed to compete with cheatgrass such as 1) medusahead (Taeniatherum asperum) because it is more competitive in fine textured soils when climate conditions are favorable 2) bur buttercup (Ranunculus testicualtus) because it does not occupy the environmental potential window simultaneously with cheatgrass and 3) kochia (Kochia prostrata) (Young, 1991). It has also been suggested that dominance of cheatgrass in the intermountain region is transitory and that cheatgrass will be supplanted by perennials. However many perennials that can replace cheatgrass are undesirable perennials such as leafy spurge (Euphorbia escula) and knapweeds (Centauria spp.) (Young, 1991). Thus natural competition may be a tradeoff between noxious weedy species. Observation of cheatgrass communities can teach us more about the stable state/threshold theory of plant...
community dynamics. What is the threshold that must be passed to move cheatgrass from its position of dominance?

Because cheatgrass is so difficult to control, the natural competition technique will be observed in this case mostly by default. In order to determine whether the techniques suggested here are effective in comparison to an undisturbed population, a "control" plot may be designated. The drawback of designating a control plot in this case is that the population of cheatgrass will continue to expand if, after evaluating the effects of the other techniques, the "control" plot continues to reproduce.

**Single method**

1. **Artificial revegetation.**

   Mountain rye (*Secale montanum*) and the hybrid "Hycrest" crested wheatgrass, (*Agropyron cristatum* × *desertorum* "Hycrest"), have been suggested as competitors for cheatgrass (Buman et al. 1988). Buman et al. (1988), mention that these species take advantage of the concept of using a hardy perennial which would establish simultaneously and compete with cheatgrass as a method of control. Further research conducted under field conditions by Andersen et al. has shown that mountain rye is:

   "...capable of rapid, vigorous establishment and significant reduction of downy and Japanese bromes through the duration of its dominance on a brome-infested minesite. However we must conclude that use of mountain rye as a companion crop was not effective for sustained control of annual bromes and enhancement of permanent revegetation because of its short persistence on the site and negative to neutral effects on other seeded perennial grasses. The effectiveness of rye for short-term brome reduction however, should encourage further research on different rye seeding strategies for longer-term brome control (1992, 351)."

Although mountain rye is only capable of short-term brome reduction, research may lead to the development of a variety or method which could be applicable in the future.

cheatgrass only dominates a site if a disturbance removes the existing perennial vegetation.
If a disturbance occurs cheatgrass usually gerninates prior to perennials and quickly establishes itself before perennials can reestablish.

Evidence of competition between cheatgrass, bunchgrasses such as bluebunch wheatgrass and rhizomatous perennial grasses such as Western wheatgrass, can be found at the Ogden Nature Center alongside the trail which crosses the large meadow west of Teal pond. An interpretive trail marker in this area would provide patrons an opportunity to study competition between introduced perennials such as smooth brome, Bromus inermis, crested wheatgrass, Agropyron cristatum and introduced annuals such as cheatgrass, Bromus tectorum, and perennial native bunchgrasses and sod-forming (rhizomatous) grasses, as well as the comparison of the effects of competition between different perennial growth habits, that is, rhizomatous growth versus bunchgrass growth.

Plots of grasses and forbs could be planted in the northeast corner of the site to allow Ogden Nature Center patrons to study their various competitive abilities versus cheatgrass. Various grasses and forbs to include may be Western wheatgrass, (Agropyron smithii), a native rhizomatous perennial, intermediate wheatgrass, (Agropyron intermedium), an introduced perennial bunchgrass with rhizomes, bluebunch wheatgrass (Agropyron spicatum), a native bunchgrass perennial, red fescue (Festuca rubra), an introduced rhizomatous grass, Indian ricegrass (Oryzopsis hymenoides), a native bunchgrass perennial, globemallow, (Sphaeralcea coccinea), a native highly adaptable forb, evening primrose, (Oenothera caespitosana) a native adaptable forb, Western yarrow, (Achillea millefolium) a native adaptable rhizomatous forb. Although some species listed here such as intermediate wheatgrass (Agropyron intermedium) and red fescue (Festuca rubra) are introduced, they are adapted to extreme conditions, are sod-formers (red fescue) and may be competitive with cheatgrass.

Another option would be to plant representatives of the sagebrush/benchland community which would include the native grasses and forbs listed above, as well as
shrubs such as: rabbitbrush (Chrysothamnus nauseosus), big sagebrush (Artemisia tridentata), and squawbush (Rhus trilobata).

**Advantages**

1. Planting competitive grasses, forbs, and shrubs to compete with cheatgrass may be ineffective in some cases however can be valuable for education purposes.
2. If some perennial species establish the monoculture effect of cheatgrass will be reduced.

**Disadvantages**

1. Cheatgrass generally out competes natives, therefore this method will probably prove ineffective.

**Integrated management technique**

1. **Fall Mowing, Spring Boom Sprayer Broadcast Herbicide Application, and Artificial Revegetation followed by Monitoring**

This integrated management technique could be applied to a plot of the cheatgrass population located in the northeast corner of the Ogden Nature Center. In the late fall mow the cheatgrass. The following spring when cheatgrass is emerging, usually in March, spray the plot with glyphosate (Round-up) which will kill the emerging cheatgrass and most perennials. After glyphosate residue has leached form the soil (glyphosate half-life is 30 days) revegetate the site, using perennial sod forming grasses to prevent soil erosion and prevent reinvasion of undesirable plant species. Grass species should also be selected which are competitive with cheatgrass. Possible grass species to include are: Western wheatgrass, (Agropyron smithii), a native rhizomatous perennial, intermediate wheatgrass, (Agropyron intermedium), an introduced perennial bunchgrass with rhizomes, bluebunch wheatgrass (Agropyron spicatum), a native bunchgrass perennial, red fescue (Festuca rubra), an introduced rhizomatous grass, Indian ricegrass (Oryzopsis hymenoides), a native bunchgrass perennial, cheatgrass competitors to include are:
Mountain rye (*Secale montanum*) and the hybrid "Hycrest" crested wheatgrass, (*Agropyron cristatum x desertorum"Hycrest"*). After grasses have established and Broadleaf weeds are controlled consider planting nitrogen fixing forbs to improve soil conditions. Forbs to consider are: globemallow, (*Sphaeralcea coccinea*), a native highly adaptable forb, evening primrose, (*Oenothera caespitosa*) a native adaptable forb, Western yarrow, (*Achillea millefolium*) a native adaptable rhizomatous forb. Nitrogen fixing forbs to consider are: Locoweed, (*Astragalus spp.*) a drought tolerant native, Wild licorice, (*Glycyrriza lepidota*), a native already present at the Ogden Nature Center, and short-stemmed lupine, *Lupinus brevicaulis*, a native tolerant of open sandy sites. In order to determine which plants are most tolerant of glyphosate (Round-up) consult a weed extension specialist and the herbicide label. Spring herbicide application should emerging cheatgrass seedlings providing perennials the maximum amount of time from early April until the end of September to grow and establish without competition from cheatgrass which remains in the site seedbank. Broadleaf weeds may emerge once cheatgrass is removed, if this occurs application of metsulfuron (Escort) will control broadleaf weeds while allowing perennials to grow. Since application of metsulfuron will kill nitrogen fixing forbs, they should be planted later after it has been determined whether broadleaf weeds need to be controlled. Any thatch left over from mowing or herbicide application should be left on the ground to prevent erosion, help retain existing soil moisture and add nutrients to the soil (Dewey, 1994).

**Monitoring**

This integrated management technique should be followed by monitoring to evaluate the process and evaluate and determine how management needs are being met. Records should be kept of the manner in which the techniques are implemented for comparison of their results. This can be done by setting up consistently sized test plots, measuring original vegetation densities in the plots and any changes in vegetation densities
during and after the implementation of the techniques. Keep records of the management objectives, types of control techniques implemented, and any special notations concerning: timing, any particular variations in the manner in which techniques are applied, expected results, and actual results (Scifres et al., 1983).

Advantages

1. If applied properly this technique may control cheatgrass.
2. Educational opportunity re: integrated method.

Disadvantages

1. Broadleaf weeds may emerge, creating another weed control problem.
2. Immediate revegetation is necessary to stabilize the site.
3. This method will help to control cheatgrass, however in situ seedbank remains.

A future possibility: Biological Control

A soil bacteria that specifically inhibits the root growth of cheatgrass has been studied and recommended by Kennedy et al. (1989) as a biological control for cheatgrass. However, this control method is controversial because should the bacteria escape the treatment area and infect large cheatgrass populations the effect could be devastating. Cheatgrass is currently so widespread that much of the western landscape is dominated by it (Kennedy et al., 1989). In many cases cheatgrass is the only plant present preventing soil erosion. Therefore the both the economic and environmental costs of implementing this biological control are prohibitive. The infection of large cheatgrass populations using this bacteria could cause a large die-off of cheatgrass resulting in erosion and creating a watershed hazard if nothing is available to replace the cheatgrass (Rasmussen, 1994). Although this method of biological control may be infeasible to apply at the present time, it should be reconsidered should any discoveries or developments occur which would make it a more feasible control option.
Dyer's woad (*Isatis tinctoria*)

**Introduction**

Dyer's woad originates in southeast Russia. Long used in Europe due to its popularity as a dye, colonists intentionally imported it from Europe to North America where it was cultivated. Dyer's woad was later transported to the western United States via California in contaminated alfalfa seed imported from Ireland and also via pioneers as a dye (Roché, 1992, Welsh, 1991). Dyer's woad is now invading rangeland in Utah, Idaho, Wyoming, Montana, California and Oregon (Roché, 1992). Dyer's woad is considered a noxious range weed because it spreads rapidly throughout rangelands and competes with desirable forage plants (Evans 1991, Farah et al. 1988). Farah et al. explain why it is difficult to control the spread of dyer's woad in rangeland areas:

Chemical and mechanical controls exist for croplands. However, due to damage of non-target desirable forage plants, steepness and rockiness of most range sites and questionable economic feasibility, these methods are unsuitable for most rangelands (Farah et al., 1988, 186).

Geographically, dyer's woad appears to be spreading to the north and east across the western United States (Evans, 1991). According to Evans, dyer's woad has particularly adapted to the western region: "Dyer's woad appears to be especially adapted to the physical and environmental conditions of the intermountain states since it currently does not exist as a threatening weed in the eastern United States where it was initially introduced... (1991, 387)." Dyer's woad was first observed in Box Elder County (Evans, 1991), Utah around 1910 (Welsh et al., 1991). To date, Box Elder county is the area most densely populated by dyer's woad, suggesting favorable conditions for its life cycle (Evans, 1991). Dyer's woad is classified as a noxious weed in Utah (Roché, 1992).
Description

Dyer’s woad is a member of the mustard family. The plant grows from a long taproot. When the plant is in rosette form it has stalked oblong basal leaves. The leaves are bluish green with cream colored midribs; their margins are entire. When dyer’s woad is flowering, it may reach one to three feet in height. The flowering stalk leaves are alternate, and similar in appearance to rosette leaves except they are not fuzzy. Dyer's woad flowers grow in racemes on the upper parts of stems which branch from the main flower stalk. It has small yellow flowers approximately 1/4 inch in diameter; each flower has four petals and four sepals. Flowering stands are bright yellow and easily identifiable. Each flower produces seed pods that are approximately 3/4 inch long by 1/4 inch wide and they contain 1 or 2 seeds. The seed pods are teardrop shaped and are attached to the plant by a small stalk. These pods change from a light green to black, or purplish brown at maturity.

Life history

John Evans articulately describes the growth process of dyer's woad as follows:

In the intermountain region, dyer's woad germinates in the fall or early spring. The seedlings develop rosettes which produce large taproots during the first growing season. Seedlings arising in the spring will bolt and flower the following spring whereas the fall germinating seedlings overwinter as small rosettes and usually require the following growing season to develop sufficient below-ground support and reserves to sustain the flowering plants (1991, 388).

The life span of dyer's woad is contingent upon whether it is disturbed. Undisturbed dyer's woad plants act as annuals or biennials and usually die after seed production (Evans, 1991, Roché, 1992). Plants which are disturbed by mowing, hand weeding or breaking bolting stalks become perennials since seed production is not completed (Evans, 1991). Bolting plants will produce as many as 20 bolting stalks and
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will bolt more than once in a season. Even if plants are damaged they may resprout from buds at the crown of the taproot or from the roots (Roché, 1992). Dyer's woad also reproduces vegetatively from its taproot (Evans, 1991). A study of the autecology and population biology of dyer's woad by Farah et al. (1988) determined that dyer's woad plants produce an average of 496 fruits per plant.

According to Evans (1991) seeds are not dormant, but are enclosed in the fruits which exude a water soluble germination inhibitor which prevents germination of dyer's woad and other plant species. The inhibitor also leaches into the surrounding soil and curbs root growth of competitors (Evans, 1991). Seeds are generally dispersed by wind and rain; long distance dispersal may be caused by humans, animals, vehicles, flowing water, and crop seed distribution (Roché, 1992).

Farah et al. (1988) determined two areas of vulnerability in the life cycle of dyer's woad. They are the transition from seed to seedling (establishment) and transition from immature to mature rosettes. Only 3% of seeds matured to seedlings (establishment). However they determined that this did not accurately account for population growth because it did not include vegetative propagation, or continued seed bank build-up of the preexisting dyer's woad in the field. Only 23% of immature rosettes reach maturity, and this is considered the most vulnerable stage of growth for dyer's woad (Farah et al., 1988).

Farah et al. concluded:

If seed production could be prevented for a few years, dyer's woad populations would probably be reduced substantially as soil seed reserves are exhausted. However this would require a method to control vegetative individuals.... This mode of reproduction is likely to be intensified when individual plants are damaged. It is therefore, difficult to decimate the vegetative portion of the population, especially those in mature stages of growth (1988, 191-192).
Farah et al. (1988) recommend targeting dyer’s woad for control in its most vulnerable stage in the immature rosette form. Research should also be conducted to discover a method to curb its ability to reproduce vegetatively as well.

**Characteristics that make dyer's woad a successful weed**

1. Each plant produces an average of 496 fruit (Farah et al., 1988).
2. Dyer’s woad can reproduce sexually or asexually (Evans, 1991).
3. Seed pods produce and inhibit growth of dyer’s woad and other seeds as well as the root growth of competing plants. Thus, after the inhibitor breaks down, surviving dyer's woad seedlings may gain some advantage over competitors' seedlings (Roche 1992, Evans 1988).
4. Dyer's woad has the ability to invade and reproduce on healthy well-vegetated sites which have not been disturbed for several decades. This discredits the perception that weedy species are incapable of invading undisturbed areas (Farah et al., 1988).
6. Ability to rebolt and reproduce more than once a season should seedling stalks be removed (Roche 1992, Evans 1988).
7. Other presently undetermined characteristics?

**Control Possibilities**

Due to large populations of dyer’s woad on the site several of the techniques noted below may be applied in various locations to study and compare the effectiveness of the different techniques. Some techniques may be more applicable in some locations due to accessibility, landscape features, and dyer’s woad population size.

The rust pathogen, *Puccinia thlaspeos*, a native biological control has been observed on the site since 1992. Before applying the techniques listed below it will be useful to determine the rate of infection of dyer’s woad by this pathogen. By determining the rate of infection the effectiveness of the techniques applied can be more accurately evaluated as well as help to determine which techniques would be most useful to apply.

Since dyer’s woad is a priority III established infestation at the Ogden Nature Center and the goal of that priority is to control or prevent spread of the infestation. Since dyer’s woad is capable of out competing native species, the natural competition technique should only be observed in those areas where other forms of control cannot be applied. In order to determine which of the other techniques are most effective in
comparison to an undisturbed population, a "control" plot may be designated. The
drawback of designating a control plot in this case is that the population of dyer's woad
will continue to expand if, after evaluating the effects of the other techniques, the
"control" plot continues to reproduce.

Single Method Techniques

I. Hand grubbing

Hand grubbing can be done for small patches of dyer's woad still in the rosette
stage. As much of the root as possible should be removed to prevent resprouting. Hand
grubbing should be done as early in the growing season as possible before the taproot has
a chance to elongate, thus making entire plant removal difficult.

Advantages

1. Hand grubbing allows for selective removal of the entire plant, thus preventing
dyer's woad establishment.

Disadvantages

1. If hand grubbing is not done while dyer's woad is in the rosette stage, the dyer's
woad taproot will elongate making entire plant removal difficult. Dyer's woad
behaves as a perennial if only the top of the plant is removed.

II. Hand cutting

An alternative to hand grubbing is hand cutting. Bolting stalks should be cut back
to the ground when flowering begins. Some plants may reflower again if the stalk is cut
before the flower heads appear and/or if the stalks are not cut to the ground. Therefore
cutting may need to be done more than once during the growing season, as well as from
year to year until seedbanks are depleted.
Advantages

1. Hand cutting allows for selectivity in areas where dyer's woad populations are small other plant materials are not cut.
2. Hand cutting maybe done when flower stalks are bolting, if plants are not removed or controlled in the rosette stage.

Disadvantages

1. Dyer's woad behaves as a perennial and rebolts if only the top of the plant is removed.
2. Hand cutting may require follow-up treatments.

III. Mowing

Another alternative is mowing. Mowing is based on the same principles as hand cutting (see discussion in previous section) however a mower is used. This affects the advantages and disadvantages of this method in the following manner:

Advantages

1. Mowing is non-selective and can both disrupt and enhance the competitive capabilities of other herbaceous plants competing with dyer's woad.
2. Mowing may be done when flower stalks are bolting, if plants are not removed or controlled in the rosette stage.

Disadvantages

1. Mowing is non-selective and can both disrupt and enhance the competitive capabilities of other herbaceous plants competing with dyer's woad.
2. Dyer's woad behaves as a perennial if only the top portion of the plant is removed.

IV. Biological control

Dyer's woad can be controlled with the rust pathogen *Puccinia thlaspeos*. This method may be ideally suited to the Ogden Nature Center since the pathogen has already been observed in the dyer's woad at the Ogden Nature Center. According to Cox, (1994) the rust was first observed on the plants in 1992, and presumably spread naturally from other areas. In order to determine the effectiveness of this method and accurately study its
effects, it will be necessary to determine the current rates of infection of dyer's woad by *Puccinia thlaspeos* already occurring at the Ogden Nature Center. This can be done by calculating the density of infected dyer's woad vs. uninfected dyer's woad in a transect or a quadrat in the area where the rust was first observed on the site (For specialized information on calculating vegetation densities see Bonham, 1989. *Measurements for Terrestrial Vegetation*).

*Puccinia thlaspeos* is a good biological control because: 1) it is a systemic pathogen, it moves through the entire plant and once the plant is infected with the rust it remains infected 2) the rust prevents seed production in dyer's woad 3) the rust is native to cruciferous plants in the region, but affects only dyer's woad (Flint, 1994).

Inoculation of dyer's woad with *Puccinia thlaspeos* is only effective when the dyer's woad is in the rosette stage. The most effective method for dyer's woad inoculation in the field is to grind infected dyer's woad plants up and dust the rosettes with the ground material (Flint, 1994). The best time for inoculation is late spring to early summer, late April through the beginning of June (Flint et al., 1993). Rust spore viability is not good at high temperatures which occur later in the summer. The best weather conditions for inoculation are when it is humid or about to rain. Apparently cool summers are best for infection. It is important to note that this method of control does not kill the plant, it prevents seed production from occurring. This method of control is also ineffective if the dyer's woad is past the rosette stage in its life cycle (Flint, 1994).

**Advantages**

1. *Puccinia thlaspeos* is available on the site, and would be relatively easy to translocate to uninfected individuals.
2. Most dyer's woad plants exhibit easily identifiable symptoms of infection.
3. Offers an interesting educational opportunity re: biological control.
Disadvantages

1. Natural inoculation rate is slow, so reapplication of treatment is necessary to help speed the process.
2. Most plants do not show symptoms of infection from 3-9 months following infection.
3. This method of control is not effective if the dyer's woad has past the rosette stage in its life cycle.

V. Backpack sprayer broadcast herbicide application

Recent field experiments have shown that applications of metsulfuron methyl affects pollen viability, seed formation and seed viability (Ashgari and Evans, 1992a and 1992b). Herbicide treatments occurred when the plants were in mid-blossom stage (probably around mid-May). The herbicides were broadcast using a backpack sprayer. The results of Ashgari and Evans' experiment showed that increased rates of herbicide application caused a decrease in the numbers of fruits and seed production as well as a reduction in pollen viability.

This technique could be applied at the Ogden Nature Center to reduce the seed production of bolting plants which are past the rosette stage. In order to determine the appropriate rate of herbicide application an extension weed specialist should be consulted. Since experimentation using this herbicide is recent, it would be advisable to contact Evans or Ashgari (See Appendix H).

Advantages

1. This herbicide reduces seed production in dyer's woad plants which have passed the rosette stage in the dyer's woad life cycle.

Disadvantages

1. This herbicide may not be appropriate in areas with shallow water tables consult the herbicide label.
2. This technique does not consider possible soil erosion, or reinvasion of the site following herbicide application.
Integrated Management Techniques

I. Backpack Sprayer Broadcast Herbicide Application followed by Monitoring and Artificial Revegetation as necessary

Herbicide (metsulfuron methyl) should be broadcast using a backpack sprayer. After herbicide application the site should be monitored to determine the effectiveness of the technique. Depending on the density and plant species affected herbicide application should be followed-up with revegetation. Consult an extension weed specialist, the herbicide label, and evaluate site conditions to determine which types of seed to plant. Artificial revegetation following herbicide application helps to stabilize the site to prevent further erosion and decrease reinvasion by weedy species.

The control methods discussed above will need to be reapplied until the viable seedbank is reduced. After populations are reduced the site will need to be monitored continually for reintroduction of dyer's woad plants due to the ease of dyer's woad establishment and large populations in the region.

Advantages

1. This herbicide reduces seed production in dyer's woad plants which have passed the rosette stage in the dyer's woad life cycle.
2. This technique provides for site stabilization through artificial revegetation of the site following herbicide treatment.

Disadvantages

1. Must determine appropriate rate of herbicide application for methyl metsulfuron treatment consult an extension weed specialist.

II. Mowing or Hand Cutting, Biological Control, and Monitoring

In the area where this technique is to be applied, first determine the rate of infection of dyer's woad by the rust Puccinia thlaspeos. This may be done by measuring
densities of the infected vegetation versus uninfected vegetation using quadrats or transects.

Second apply the rust pathogen, *Puccinia thlaspeos* all dyer's woad plants in the rosette stage. This works best if it is done in the spring while the rosettes are still small and spring precipitation is to follow. The rust will inhibit flowering of the dyer's woad.

Next determine areas to be cut using hand cutting or mowing. Cutting or mowing should be done when the dyer's woad starts to send up bolting stalks. Hand cutting is more effective in less densely populated areas. It allows the vegetation to be cut selectively. Selectivity is desirable because other plants in the community are not harmed. However possible drawbacks associated with hand cutting are: knowledge and identification of infected plants is necessary, and intensive labor is involved. Mechanical cutting is effective in more densely populated areas because higher number of exotics make it more difficult and too labor intensive to cut selectively. Mowing of herbaceous vegetation may increase competitive ability of some plant species. After being cut the dyer's woad may rebolt several times during the season. It is important to remove all bolting stalks so cutting or mowing will have to be done more than once during the season.

**Monitoring**

The control methods discussed above will need to be reapplied until the viable seedbank is reduced. After populations are reduced the site will need to be monitored continually for reintroduction of dyer's woad plants due to the ease of dyer's woad establishment and large populations in the region.
Advantages

1. This technique will control dyer's woad in both the rosette stage and the bolting stage
2. The biological control pathogen is available on the site.
3. This technique offers an interesting educational opportunity re: integrated method techniques.
4. No herbicides are used, thus the problem of herbicide resistance is avoided.

Disadvantages

1. Knowledge of the life cycles of dyer's woad and the pathogen are necessary in order to determine the proper timing and conditions for pathogen inoculation.
2. This technique will require follow-up treatments until the seedbank is reduced.

III. Backpack Sprayer Broadcast Herbicide Application, Biological Control and Artificial Revegetation followed by Monitoring

This technique is similar to the technique described above. However, herbicide application is applied before the biological control. The herbicide reduces the dyer's woad rosette population, then the rust pathogen keeps the established dyer's woad population from reproducing. The type of herbicides to be applied is the same as previously discussed: metsulfuron methyl. Artificial revegetation is contingent on those species which will tolerate the herbicide residues in the soil.

Monitoring

The control methods discussed above will need to be reapplied until the viable seedbank is reduced. After populations are reduced the site will need to be monitored continually for reintroduction of dyer's woad plants due to the ease of dyer's woad establishment and large populations in the region.

Advantages

1. This technique will control dyer's woad in both the rosette stage and the bolting stage
2. The biological control pathogen is available on the site.
3. This technique offers an interesting educational opportunity re: integrated method techniques.
Disadvantages

1. The rate of herbicide application must be determined
2. This method may require follow-up treatments until the seedbank is reduced.
3. Knowledge of the life cycles of dyer's woad and the pathogen is necessary in order to determine the proper timing and conditions for pathogen inoculation.

IV. Study of Grazing as a possible Biological Control followed by Monitoring

Although West and Farah (1989) have determined that sheep prefer other types of forage than dyer's woad, perhaps other exotic grazers such as llamas or goats could help control dyer's woad in the rosette stage. No harmful effects from the rust pathogen have been observed in animals such as deer which sometimes browse dyer's woad (Flint, 1994), however this has not been studied extensively. Further research could be conducted to determine whether any harm would come to grazers if they ingest the plants which contain the pathogen, and small test plots could be created for grazing and monitored to determine whether this would be an effective alternative biological control.
Teasel (Dipsacus sylvestris)

Introduction

Teasel originated in Eurasia and Northern Africa. They were most likely introduced as ornamentals, or accidentally through decorations or other plant seed imported from Europe (Solecki, 1993). Teasel is distributed throughout most of the United States. It was introduced into Utah sometime before 1900 (Welsh et al., 1991). Solecki notes that use of teasel as an ornamental has fostered its spread throughout North America: "Horticultural use of common teasel has aided in expansion of its North American range. For example, teasel used in floral decorations at gravesites has resulted in dispersal in and around cemeteries (1993, 86)." Teasel is considered a noxious weed because it invades open wet meadow areas, rapidly colonizing them and excluding native vegetation.

Description

Teasel grows from a basal rosette to reach 6 feet in height. The basal rosette usually dies in the second season when the plant sends up the flower head stem. The stem is striated and angled with small spines along the ribs of the stem. The main stem branches out and flower heads are produced at the ends of the stalk. Stem leaves are opposite and lanceolate. They may reach up to 10 inches long (Whitson et al., 1991). Leaves have light green veins and the midrib on the under side of the leaf is prickly. Flower heads are approximately 2 inches long and covered with tiny purple flowers. At the base of each flower are tiny spiny bractlets. At the base of the flower head where it attaches to the stem are involucral bracts which are generally longer than the flower head.

Life history

Teasel produce seed from July to August (Whitson et al., 1991). The seeds fall from the parent plant and most establish themselves within several feet of that plant (Werner, 1979). Sometimes seeds are dispersed by humans, animals and birds. Long
distance dispersal usually occurs when teasel are near water, since teasel seeds are able to float for long periods of time and then subsequently germinate. After germination the plant forms a rosette which may become established after one year or in some cases even longer (Solecki, 1993). The plant also grows a taproot, which may reach up to 2.5 feet long (Werner, 1979). After the rosette and taproot have supplied the teasel with enough energy reserves the teasel sends up a flowering stalk. The flowering stalk may branch and include one or more flower heads. Flower heads are composed of many tiny purple flowers and each flower is capable of producing a small fruit which bears a single seed. One plant may generate over three thousand seeds (Werner, 1979). Teasel have a germination rate which varies from 28 to 86% in field conditions (Werner, 1979). Teasel are monocarpic perennials, which means that they may grow for several seasons; however, they only flower and bloom once before dying (Solecki, 1993). Unlike other aggressive weedy plants, teasel does not reproduce vegetatively (Solecki, 1993). Plentiful seed production and successful germination rates allow it to compete with other plants.

Characteristics that make teasel a successful weed

1. Seed production of over 3,000 seeds per plant (Werner, 1979).
3. Seed remain viable up to six years if stored in a dry place (Werner, 1979).
4. Spines on stalks leaves flowers and flower heads make it unpalatable to grazers (Solecki, 1993).
5. Long taproots provide storage for carbohydrates and water which nourish the plants (Solecki, 1993).
6. Ability to disperse seeds both long and short distances (Solecki, 1979).
7. Ability of teasel seeds to float in water and subsequently germinate (Werner 1979).
8. Parent plants provide "optimal" nursery conditions for seedlings after they die (Solecki, 1993).
9. Capable of remaining photosynthetically active longer during the growing season than competing native species (Solecki, 1993).
10. Other presently undetermined characteristics?
Control Possibilities

Due to large populations of teasel on the site several of these technique may be applied in several different locations, to study not only the effectiveness of the different techniques, but also to compare the effects of the different techniques in different microclimates.

Since teasel is a priority III established infestation at the Ogden Nature Center and the goal of that priority is to control or prevent spread of the infestation and since teasel is capable of outcompeting native species, the natural competition technique should be observed only in those areas where no other form of control can be applied. However, in order to determine which of the other techniques are most effective in comparison to an undisturbed population, a "control" plot may be designated. The drawback of designating a control plot in this case is that the population of teasel will continue to expand if, after evaluating the effects of the other techniques, the "control" plot continues to reproduce.

Single Method Techniques

I. Hand grubbing

Hand grubbing can be done for small patches of teasel still in the rosette stage. As much of the root as possible should be removed to prevent resprouting. Hand grubbing should be done as early in the growing season as possible before the taproot has a chance to elongate thus, making entire plant removal difficult.

Advantages

2. Hand grubbing is most effective while teasel is still in the rosette stage.
Disadvantages

1. If teasel has passed the rosette stage hand grubbing is more difficult and the taproot may break allowing resprouting.
2. Due to the possibility of resprouting hand grubbing may require follow-up treatments.
3. Teasel has a high population density in many areas.

II. Hand cutting

An alternative to hand grubbing is hand cutting. Flowering stalks should be cut back to the ground when flowering begins. Some plants may reflower again if the stalk is cut before the flower heads appear and/or if the stalks are not cut to the ground. Therefore cutting may need to be done more than once during the growing season, as well as from year to year until seedbanks are depleted. After the stalks are cut from the plants, most plants will not usually reflower and will die at the end of the growing season. According to Glass, in his article, "Vegetation Management Guidelines: "Cut-leaved teasel (Dipsacus laciniatus L.) and Common Teasel (Dipsacus sylvestris Huds.),": "Cut flowering stalks should be removed from the natural area, because immature seedheads can produce viable seed on the stem even after cutting (1991, 213)." Stalks may be disposed of by burning (Dewey, 1994).

Advantages

1. Hand cutting allows for selectivity in areas where teasel populations are small other plant materials are not cut.
2. Hand cutting maybe done when flower stalks are bolting, if plants are not removed or controlled in the rosette stage.

Disadvantages

1. Hand cutting allows teasel to rebolt from the root crown.
III. Mowing

Another alternative is mowing. Mowing is based on the same principles as hand cutting (see discussion in previous section), however a mower is used.

Advantages

1. Mowing may be done when flower stalks are bolting, if plants are not removed or controlled in the rosette stage.
2. Mowing is non-selective and may increase the competitive ability of some herbaceous species.

Disadvantages

1. Mowing is less selective than hand cutting, and thus disturbs both desirable and undesirable vegetation.
2. Mowing allows teasel to rebolt from the root crown.

Integrated Management Technique

I. Fall Mowing, Spring Boom Sprayer Broadcast Herbicide Application, Artificial Revegetation and Monitoring

The following integrated management technique is recommended for large stands of teasel (Dewey, 1994). In the fall, mow teasel canes produced that season and remove them from the treatment area. This keeps canes from intercepting herbicides to be applied in the following season. It also reduces the seedbank. Herbicide should be applied in April or May while the plants are in the rosette stage. The plants should be treated before flowering to avoid additional seed production (Glass, 1991). According to Dr. Steven Dewey, USU Weed Extension Specialist, a combination of Metsulfuron (Escort) and 2,4-D are very effective (approximately 98-100%) in reducing teasel populations. In order to determine the appropriate mixture of herbicides consult an extension weed specialist such as Dr. Dewey, a county extension service agent, or the herbicide manufacturer (See Appendix H for local contacts). Dr. Dewey suggests that the herbicides be applied using a 12' boom sprayer attached to a truck or an ATV. It is important to note that this information is changeable, since herbicide registration changes often, and new research
may show additional herbicide combinations to be effective. Therefore, it is advisable to keep up to date with current herbicide application practices.

The herbicides recommended above are mild and allow reseeding of grasses after application. Monitor the area after herbicides are applied to determine whether management objectives are being met. Artificial revegetation should be done depending on the density and species of plants affected by the herbicide application. Herbicide applications may need to be done several times, or as individual plant treatments depending on the monitoring information. In order to determine which grasses and other herbaceous species should be seeded, a weed specialist and the herbicide label should be consulted.

**Monitoring**

The control methods discussed above will need to be reapplied until the viable seedbank is reduced. After populations are reduced the site will need to be monitored continually for reintroduction of teasel plants due to the ease of teasel establishment and large populations in the region.

**Advantages**

1. Overall this integrated method has the potential to be 98% effective if all the methods are conducted properly and in the correct sequence.
2. Artificial revegetation as a follow-up treatment will help to stabilize the site and prevent reinvansion of the site.

**Disadvantages**

1. Due to Teasel seed longevity and the large teasel populations on the site follow-up treatment may be necessary.

**Biological control**

At this time there is no known method of biological control for teasel.
II. Study of Grazing as a possible Biological Control followed by monitoring

Based on the literature review conducted for this thesis little research has been done to determine whether grazing animals find teasel palatable in the rosette stage. Perhaps sheep or exotic grazers such as llamas or goats could help control teasel in the rosette stage. Small test plots could be created for grazing and monitored to determine whether this would be an effective alternative biological control.

Saltcedar or Tamarisk (Tamarix spp.)

Introduction

Tamarisk originated in Europe, the Middle East, and Asia (Frasier and Johnsen Jr. 1991). They were introduced into North America some time in the mid-1800s as ornamental shrubs (Brotherson and Field, 1987, Frasier and Johnsen Jr., 1991). Brotherson and Field note that tamarisk's escape from cultivation and subsequent rapid spread went virtually unnoticed:

... it apparently did not escape cultivation until the 1870s. The only accurate information concerning its escape is found in herbarium collections. Little attention was paid to the increasing spread of saltcedar for the next several decades, and there is no record that anyone was aware that a problem was in the making. For example, in the early 1900s farmers were using this plant for erosion control (Everitt, 1980). However, it became clear by the 1920s that saltcedar was becoming a serious problem for it was spreading rapidly from one watershed to another (1987, 110).

Tamarisk was first observed in Utah around 1920 (Welsh et al., 1991). The spread of tamarisk was concurrent with the influx of pioneer populations and their impacts on western riparian zones in some cases may have contributed to its spread (Brotherson and Field, 1987).
Tamarisk is considered noxious because: 1) mature stands of tamarisk can congest river channels, changing their hydrology and creating potential risks of flooding in adjacent areas (Frasier and Johnsen Jr., 1991). 2) tamarisks may evapotranspire more ground water than original native vegetation, as well as affect river flow (Frasier and Johnsen Jr., 1991). 3) tamarisk easily displaces native vegetation "Large stands of salt cedar may rapidly become monocultures with almost no undergrowth able to survive the dense canopy and deposited saline crust (Sudbrock, 1993, 32)." 4) Monocultures of tamarisk reduce wildlife habitat. Comparisons of native vegetation versus tamarisk show significant reductions in bird species. A study by Anderson and Ohmart found that one hundred acre stands of native vegetation along the Colorado River supported 154 bird species versus 4 bird species of birds in a one hundred acre area overrun with tamarisk (Sudbrock, 1993). 5) Tamarisk is very persistent and is not easily controlled via chemical or mechanical means (Frasier and Johnsen Jr., 1991).

Description

Tamarisk are deciduous members of the genus Tamarix of the tamaraceae family. There are seven species of deciduous tamarix, but only three species common in North America, these are T. ramosissima, T. chinensis, and T. parviflora. T. ramosissima and T. chinensis are virtually indistinguishable and may also hybridize (Sudbrock, 1993). Due to the difficulties in distinguishing these species some scientists group all deciduous tamarisk into one species T. pentandra (Sudbrock, 1993). "...they [Tamarix spp.] are similar in their ecology and their response to treatment ...(Sudbrock, 1993, 31)."

Therefore, in this report they will be grouped collectively as tamarisk or Tamarisk spp.

Tamarisk is a phreatophytic shrub or small tree. In some areas it may reach heights of 30 feet. It is usually upright in form with a tendency to spread and droop in the upper branches forming a feathery rounded crown. Tamarisk has slender wiry sienna
colored branches and gray green scaly leaves which are deciduous (Elmore, 1976). Tamarisk bloom in spring and summer. The tiny pink blossoms are located at the ends of branchlets in raceme-like clusters which vary in length from 1/2 inch to 2 inches long. Seed pods contain 3-5 tiny hairy seeds (Frasier and Johnsen, 1991). "One mature tamarisk can produce approximately 500,000 seeds per season (Brotherson and Field, 1987, 110)."

**Life history**

Tamarisk produce hundreds of thousands of seeds from April to October. The tiny seeds are dispersed easily by wind and water. Most often, establishment occurs in areas where soils have been saturated due to flooding or where water levels recede from seasonally high levels (Brotherson and Field, 1987). Sudbrock notes several reasons that tamarisk are able to compete favorably with native vegetation:

> Not only are the pollen-sized seed dispersed widely by wind and water, but the prolonged seed-production and dispersal season gives saltcedar a competitive advantage over native trees such as cottonwood and willow, which have shorter seeding and dispersal seasons (1993, 31).

Once established, tamarisk grow a long taproot into the soil which may not branch until meeting the water table (Brotherson and Field, 1987). While the tap root is growing little growth occurs at the top of the plant. After the taproot reaches water the tamarisk grows upward rapidly. "Seedlings may grow up to one foot (30 cm) per month in early spring, with growth leveling off in midsummer (Sudbrock, 1993, 32)." Tamarisk are able to reproduce through seed, vegetatively from their roots and even by sprouting from a branch or a stem buried in a wet stream bank. Tamarisk create undesirable conditions for competitors by concentrating salt beneath their canopies thus restricting undergrowth. Undergrowth is further restricted by tamarisks' thirst for water. Not only is tamarisk able to restrict competition by creating harsh environmental conditions for its competitors but it is able to withstand harsh environmental conditions itself. "A mature salt cedar can drop
its leaves to withstand drought and can survive complete submergence for 70 days (Sudbrock, 1993, 32)." It is also able to vegetatively resprout following a fire, flooding or herbicide treatment (Brotherson and Field, 1987). Therefore tamarisk is quite persistent and deserving of the dubious distinction of being listed as one of the ten most noxious weeds in North America (Frasier and Johnsen, Jr., 1991). In their article Brotherson and Field note the following Characteristics that make tamarisk a successful weed:

1. Continuous seed production for as long as the growing season permits.
2. Cross-pollination by the wind.
3. Self-compatible when cross pollination unavailable
4. High seed output in favorable environmental circumstances
5. Ability to produce seed under a wide range of environmental conditions.
6. Adapted for long or short range dispersal.
7. Vigorous asexual (vegetative) reproduction capability.
8. Britleness in stems and not easily removed from the ground.
9. Competes interspecifically by allelochemics due to presence of salt-glands.
10. Capability for tolerating extreme range of environmental conditions.
11. "Facultative phreatophyte" due to its ability to live totally inundated or in total absence of saturated soils.
12. Difficult to control with foliar chemicals (Brotherson and Field, 1987, 110).
13. Other presently undetermined characteristics?

Control Possibilities

First, determine the current size of the population of tamarisk at the Ogden Nature Center. This is possible using visual observation and judgment, or measuring the vegetation with transects or plots. Many tamarisk may have died due to the long period of high water levels which inundated their pond margin habitat in the spring and summer of 1993.

Since tamarisk is a priority II, new invader species at the Ogden Nature Center and the goal of that priority is to prevent establishment of new invaders on the site and possibly eradicate them, and since tamarisk is capable of outcompeting native species, the
natural competition technique will not be applied in this case. It is also undesirable to
designate a "control" plot in this case since the goal of priority II is to remove noxious
weed populations before they become established.

Single Method Technique

1. Hand grubbing

Hand grubbing can be done at any time during the growing season. To help keep
population numbers down it should be done before tamarisk flowers in April. Tamarisk
debris should be removed to a weed disposal area and burned or buried, or piled to create
some cover for birds.

Advantages

1. Hand grubbing allows for selective removal of the entire plant and is effective in
early stages of tamarisk growth (1-6 inches).
2. Where population densities of tamarisk are low this technique may be the most
economical.

Disadvantages

1. If the entire tamarisk plant is not removed in early growth stages (1-6 inches),
tamarisk will resprout from its roots.
2. Hand grubbing is only applicable if population densities of tamarisk are low.

Integrated Management Technique

1. Individual Plant (cut-stump method) Backpack Sprayer Herbicide Application
followed by Artificial Revegetation and Monitoring

The cut-stump method is a method of herbicide application where the plant is cut
down to the surface of the ground and herbicide is applied to the stump immediately.
This method was employed very successfully at a 10 hectare wetland at the Coachella Valley Preserve in Riverside California (Barrows, 1993). In his technical report Barrows clearly describes the timing and method of herbicide application:

November through January proved to be the most effective time to achieve full time kills of the tamarisk; apparently because the plants are entering dormancy at that time and translocating resources into their roots. The herbicide was more likely to be pulled into the root system at this time, thus killing the below-ground portion of the plant. The herbicide we used was also most effective when applied to the surface of the stump immediately following cutting: waiting more than just a few minutes seemed to increase the likelihood of subsequent resprouts (1993, 36).

Barrows also notes that backpack sprayers were easiest to use as they facilitated herbicide application, and did not require refilling as often as hand sprayers (1993). The herbicide Barrows and his crews used was Trichlopyr (Garlon 3A and 4, Dow Chemical). Due to the expense of the herbicide it was diluted in water at a ratio of one part herbicide to two to three parts water. Using this herbicide over half the tamarisk resprouted. Barrows attributes this to protocol for treatment not always being followed and the persistence of tamarisk.  This case study is important to consider since, the management objectives and resources at the Coachella Valley Preserve are similar to those of the Ogden Nature Center. Barrows employed volunteers to apply the herbicides, tried to keep costs economical, as well as be sensitive to the environment and the safety of the volunteers (1993). After tamarisk removal the site was revegetated as well. Monitoring is an ongoing process while the site continues its recovery. Contact information for Cameron Barrows is provided in appendix H.

Two other types of herbicides should be considered for application as they may better suit the specific needs of the Ogden Nature Center. These herbicides may be
applied using the cut-stump method as well. They are Glyphosate [specifically Rodeo formulation (trade name)] and Imazapyr.

If tamarisk populations continue to exist around Teal pond the specific use of the Rodeo (trade name) formulation of Glyphosate should be used in that area since Teal pond was stocked in the summer of 1993 with June Sucker, an endangered fish. Rodeo has a very small soil leaching potential, is non-toxic to aquatic organisms and in some instances may require an additional nonionic surfactant (Barrows, 1993, Whitson et al. 1993). Due to the risks involved for the endangered fish, a fish biologist, a weed extension specialist and the manufacturer of the product should be consulted in order to determine whether this herbicide should be administered.

If tamarisk populations continue to exist around Dragonfly pond the use of imazapyr should be considered. Aerial application of imazapyr (including surfactants) was applied to tamarisk in 1989 at Artesia, New Mexico. In a Western Society of Weed Science research progress report by K.W. Duncan, the mortality rate in 1992 for tamarisk was 95.1%. [Interestingly, the water table rose from 5.5 meters to the surface 34 months after application, (Duncan, 1993)]. According to Bovey (1991) imazapyr is available in an oil-based formulation for use in the cut-stump method for application. Currently imazapyr is registered for non-crop areas such as rights-of-way and industrial sites. It has a higher leaching potential than glyphosate and trichlopyr, but may be more effective at reducing tamarisk than either of the other two herbicides. A weed control specialist should be consulted as to the possibility of the use of this herbicide at the Ogden Nature Center.

Depending on the current size of the tamarisk population and costs it would be informative to do a comparison of the effectiveness of the different herbicides. Tamarisk debris should be removed to a designated weed disposal area, and be burned or buried, or they may be left in piles for bird cover. Herbicide control efforts should be followed by revegetation. If the tamarisk population is high, then the soil may have to be redressed or
saline tolerant plants should be planted, due to salts exuded by large populations of tamarisk.

Since the site was disturbed due to pond construction, relatively few native seed remain at the pond margins. Cottonwood pole plantings have been made. Carex and sedges which are usually found surrounding pond margins are absent. Artificial revegetation should occur after the herbicide selected breaks down in the soil so that herbicide residue does not harm seedlings. Refer to the herbicide label or the most current state weed control manual for information regarding herbicide decomposition. Utah pond habitats and palustrine wetland sites should be studied to determine the types of plants to establish. If possible seed sources on the site should be used. The use of seed from the site will cut costs and possibly establish faster. If necessary, revegetation may be supplemented using off-site seeds or plants. Possible seed sources are listed in Appendix J.

**Monitoring**

Due to large populations within the region perpetual maintenance is associated with the goal of controlling tamarisk (Barrows, 1993). The possibility of tamarisk seed blowing onto the site or arriving via the canal is quite high. Once the existing tamarisk population is controlled, it will be necessary to check wet areas regularly for emerging seedlings. These areas include pond margins, canal banks and wetland margins. If seedlings are pulled before they become established annual control efforts can be minimized.

**Advantages**

1. The cut-stump method of herbicide application allows for selective treatment of individual tamarisk plants.
2. If herbicide application is followed by revegetation, the site should recover, reinvasion or new invaders would not be able to establish easily following revegetation.

3. This method may be more cost effective in terms of labor involved in sites with higher populations of tamarisk than other methods.

Disadvantages

1. Because tamarisks may aggressively resprout, herbicide application and revegetation may require follow-up treatments.

Biological control

At this time there is no known biological control for tamarisk.

Conclusion

The choice of weed management strategies to be implemented at the Ogden Nature Center is for the Ogden Nature Center administrators to decide upon based on site capabilities, funding, and human resources. Considering the management objectives of the Ogden Nature Center, and the extent of noxious weed populations on the site, it is my opinion based on the research above that the integrated management techniques discussed in this chapter would be the most effective weed management strategies to implement. Integrated management techniques also allow for flexibility as management objectives change over time. This recommendation is made from a biological perspective and does not consider economic factors.
The original design theme of landscape stewardship, discussed by Johnson et. al. in the 1984 USU master plan, continues to complement the planning objectives and educational programs of the Ogden Nature Center today. In fact time has shown that natural landscapes in urban settings in which landscape stewardship can be practiced and observed are becoming rarer due to urban growth pressures. Thus the need for planning for them has become more imperative, especially if we consider the following observations made by Gary Paul Nabhan and Stephen Trimble in *The Geography of Childhood*:

By the year 2000, 38 percent of the world population will be urbanized in such metropolitan areas where wildness has been severely impoverished. Of course, urban parks, backyards and even abandoned railroad yards still offer some children the chance to romp and rummage, to seek out crawl spaces, hideaways, treehouses and shrubby shelters. Nevertheless, an increasingly large proportion of inner-city children will never gain adequate access to unpeopled places, neither food-producing fields nor wildlands. They will grow up in a world where asphalt, concrete, and plaster cover more ground than shade-providing shrubs and their resident songbirds (Nabhan, 1994, 11).

Consider a PBS interview conducted in the wake of the Los Angeles riots of 1992. One adolescent in south-central L.A. listed a half-dozen different automatic weapons used on the streets, and he was able to identify each by its sound. He did not see this as an unusual piece of discriminatory knowledge for someone his age. These were the sounds he heard, learned and sensed to be vital to his own existence. In another place and time, he would have spoken as matter-of-factly about the calls of six common species of hawks and owls (Nabhan, Trimble, 1994, xv).

Therefore, urban wilds such as the Ogden Nature Center provide sanctuary not only for urban wildlife, but a haven for humans to learn of their interconnectedness with the landscape and its inhabitants. This conceptual master plan was designed to be consistent with landscape features and demonstrate landscape stewardship (See conceptual master plan and vegetation management plan drawings, Figures 31 and 32).
Figure 31. Ogden Nature Center Conceptual Master Plan, 1994.
Figure 32. Ogden Nature Center Vegetation Management Plan. 1994.
Conceptual master plan recommendations are in a suggested order of priority organized with regard to: 1) resource management, 2) community context and visitor accommodations and, 3) educational and interpretive opportunities. Recommendations for vegetation management can be found under the resource management section of the conceptual master plan recommendations. See also the Appendix I which outlines subjects for further research. Appendix J furnishes information regarding local, regional and national agencies to contact for further information.

CONCEPTUAL MASTER PLAN

RESOURCE MANAGEMENT RECOMMENDATIONS:

I. Resource planning and site stability

1. Obtain an accurate up-to-date topographic survey of the entire Nature Center for continuing planning purposes!

2. It is highly recommended that the Ogden Nature Center administration work with state and Ogden City officials to propose site clean-up and rehabilitation, or groundwater and surface water monitoring on an annual basis. There is the possible presence of unlined toxic waste burial sites of unknown quantities and concentrations in several areas on the site. In order to assure long-term site stability, protect substantial economic investments and protect the environment from damage caused by potential leaching of hazardous materials into the soil, surface water, or groundwater this recommendation should be considered a priority.
3. Maintain the existing water control structure which regulates water flow in Plain City Canal at the north end of the site.

4. Install a water control structure to protect Blackbird pond from upstream contaminants and to provide some control of water levels in the pond.

5. Install a water control structure at the south end of the site on the Plain City Canal to be used in an emergency situation (such as a highway chemical spill) to protect the Ogden Nature Center riparian corridors and the water table. Consult hydrologists for the appropriate type and location of the structure.

6. Consider installing water control structures in the Mill Creek stream corridor to protect Ogden Nature Center riparian corridors from upstream contaminants.

II. Vegetation management recommendations

1. Consider the management of encroaching invasive weedy vegetation a priority. Weed management strategies for the following species are discussed in detail in chapter 3.

CHEATGRASS / Bromus tectorum

Control possibilities:

Natural Competition Technique/Single Method Technique:

I. Natural Revegetation

Single Method Technique

I. Artificial Revegetation
Integrated Management Technique

I. Fall Mowing, Spring Boom Sprayer Broadcast Herbicide Application, and Artificial Revegetation

A future possibility- biological control.

DYER'S WOAD / *Isatis tinctoria*

Control possibilities:

Natural Competition Technique/Single Method Technique:

I. Natural Revegetation

Single Method Techniques

I. Hand grubbing
II. Hand cutting
III. Mowing
VI. Biological Control
V. Backpack Sprayer Broadcast Herbicide Application

Integrated Management Techniques

I. Hand Cutting or Mowing, Biological Control, and Artificial Revegetation
II. Backpack Sprayer Broadcast Herbicide Application followed by Artificial Revegetation
III. Biological Control, Backpack Sprayer Herbicide Application followed by Artificial Revegetation

TEASEL / *Dipsacus sylvestris*

Control possibilities:

Natural Competition Technique/Single Method Technique

I. Natural Revegetation
Single Method Techniques

I. Hand Grubbing
II. Hand Cutting
III. Mowing

Integrated Management Technique

I. Fall Mowing, Spring Boom Sprayer Broadcast Herbicide Application and Artificial Revegetation

TAMARISK / Tamarix spp.

Control possibilities:

Single Method Technique

I. Hand Grubbing

Integrated Management Techniques

I. Hand Grubbing followed by Artificial Revegetation
II. Individual Plant (Cut-Stump Method) Backpack Sprayer Herbicide Application followed by Artificial Revegetation.

The choice of weed management strategies to be implemented at the Ogden Nature Center is for the Ogden Nature Center administrators to decide upon according to site capabilities, funding, and human resources. In my opinion, considering the management objectives of the Ogden Nature Center, and the extent of noxious weed populations on the site, the integrated management techniques discussed in this chapter would be the most effective weed management strategies to implement. Integrated management techniques also allow for flexibility as management objectives change over time. This recommendation is made with the realization that economic factors are not included.
2. Maintain access to existing weed disposal area.

3. After controlling encroaching weedy vegetation, review vegetation restoration techniques that have been employed in the region. Determine why they have failed or have been successful. Develop test plot sites. Implement revegetation using those techniques that prove successful in the test plots.

4. Transplant or remove exotic plant materials in Preservation Grove. Redesign Preservation Grove as a xeriscape demonstration garden area or a wildflower meadow.

5. Proposed Berm and Sagebrush Benchland plant community.

Discontinue construction of the proposed pond on the northeast corner of the site. Repeated disturbance of this area is allowing weedy species of vegetation to encroach on the site. Consider berming the eastern side of this corner to screen barren areas of the defense depot. Due to limited water availability and harsh microclimate conditions, revegetating to benchland sagebrush plant community would adapt best to this location (Additional research required).

Other suggestions:

1) Construction of an ephemeral playa-type wetland may be possible in this location. Achieving a natural effect of a shallow depression will require meticulous grading (Additional research required).

2) Drastically decrease the size of the proposed pond and plant drought tolerant vegetation surrounding the pond to provide a more hospitable microclimate; screen undesirable views of the defense depot and provide cover for wildlife.
6. Enhance shelterbelt  
Turn off existing drip irrigation in the shelterbelt to determine which vegetation has established. Widen the existing shelterbelt, using a variety of plant materials to avoid monoculture effect. Select vegetation with regard to microclimate soil conditions, plant community associations, and water availability. Create progression in the height of vegetation for example: grassland, shrub, deciduous tree, evergreen, deciduous tree, shrub, grassland (See Johnson et. al. 1984, Master Plan Shelterbelt discussion). This type of variety will increase the function of the shelterbelt as an effective wind screen, visual screen, and wildlife shelter.

7. Create an east-west shelterbelt connection south of Dragonfly pond between existing north-south shelterbelts.

8. Remove the surviving existing cottonwoods, currently planted in a ring shape in the northeast corner of the site, and transplant them adjacent to the Plain City Canal riparian corridor where the watertable is more easily accessible, and microclimate conditions are more favorable to their long-term survival.

9. Redesign existing berms along the south fenceline of the Ogden Nature Center, and plant trees and shrubs to screen 12th street and buffer traffic sounds.

10. Where possible, thin existing cottonwood plantings (ie. remove dead saplings); plant understory vegetation.
11. Removal of undesirable vegetation along trails or rerouting of trails should be considered in order to prevent the further spread of weedy vegetation.

12. Avoid harming June Sucker endangered fish populations in Arrowhead and Teal ponds. Regrade and redress topsoil and revegetate the west bank of Arrowhead pond. The current slope is too steep to accommodate nesting birds and the visual effect is unnatural. Utilize silt fencing to avoid siltation of the pond.

Consider an experiment in cooperation with the June Sucker Recovery Team to study the different types of aquatic vegetation and how it fulfills habitat requirements for juvenile June Sucker, endangered fish populations.

13. Consider regrading and redressing the topsoil and revegetating the banks of Dragonfly pond and where necessary revegetate the banks of the pothole ponds. Provide shrubby cover for wildlife adjacent to Dragonfly pond. Utilize silt fencing to avoid siltation of the ponds.

14. Remove existing parking lot and road which provide access to the picnic area at the north end of the site. After removing the road and parking area revegetate these areas. Note: road berm arrests east-west surface water flow, keeping pothole area surface soils moist.

15. Should the Mill Creek riparian corridor currently owned by the Defense Depot of Ogden be acquired by the Ogden Nature Center:
   1) Remove existing irrigated vegetation and revegetate the stream corridor using appropriate riparian vegetation.
   2) Remove the existing road and revegetate.
3) At the confluence of the Plain City Canal and Mill Creek plant vegetation to connect these riparian zones and create habitat continuity.

III. Wildlife

1. Carefully observe and record wildlife activity during all seasons of the year to determine habitat requirements and thus make appropriate provisions to enhance habitat and diversify wildlife communities at the Ogden Nature Center.

2. Due to the high mobility of bird species and the "island like" relative isolation of the Ogden Nature Center in its urban location, special attention has been devoted to the monitoring of bird species. However, it is urged that mammal, reptile, amphibian, and insect populations should be monitored and mapped in the future.

3. Some species may be habituated to the existing site conditions, and the potential to attract additional species to the site may also exist. Therefore it is important that any proposed changes take into account the habitat requirements of as diverse an array of species as possible, so that species diversity on the site increases rather than declines (Rasmussen, 1994). Frank Howe, avian program coordinator at the Utah Division of Wildlife Resources suggests the following conservation strategies for riparian areas, which could be applicable to all habitat types across the board:

   Conservation strategies should consist of a combination of acquisition, enhancement, restoration and ecologically sound management. Inventory, monitoring and research projects are required to provide managers with information such as species lists, species/habitat associations, life history characteristics and limiting factors needed to develop effective riparian conservation strategies. Education programs are
needed to increase public awareness and inform land owners and managers of successful strategies (Howe, 1993, 63).

4. Observe habitat management suggestions made in the 1984 Ogden Nature Center Proposed Master plan by USU.

5. Should a species of wildlife become a pest at the Ogden Nature Center, consult with the Utah department of Natural Resource's Division of Wildlife resources about humane predator control practices. One such method is to use live traps and then release the animal in a natural setting which fulfills its habitat requirements. A good resource book which addresses this issue is Being Kind To Animal Pests, by Steve Meyer, 1991, P.O. Box 247, Garrison IA, 52229.

6. After meeting program and land management objectives of the Ogden Nature Center at its current size, consider expansion of the Ogden Nature Center through the acquisition of Defense Depot of Ogden land along the Mill Creek riparian corridor to increase habitat area and connectivity.

7. In the interest of wildlife conservation in the long-term, suggest to Ogden City and/or Weber County planning commission that they consider the possibility of purchasing and buffering upstream and/or downstream greenway linkages along the Mill Creek stream corridor. Perhaps a city or county-wide wildlife conservation plan could be developed using the Salt Lake County Wildlife Conservation plan as an example, as well as the techniques described in A Wildlife Conservation Manual for Urbanizing Areas In Utah. A plan such as this should be developed as soon as possible due to the rapid urban growth in Weber County.
COMMUNITY CONTEXT AND VISITOR ACCOMMODATIONS

RECOMMENDATIONS:

I. Community context

1. Maintain contact with businesses and community groups already involved with Ogden Nature Center activities and development. Wherever possible develop additional new relationships within the community.

2. Include representatives of the Defense Depot of Ogden in Ogden Nature Center planning activities. Invite Defense Depot of Ogden employees to attend Ogden Nature Center events and projects.

3. Enhance community support of the Ogden Nature Center. Build rapport with the Internal Revenue Service. Invite the Internal Revenue Service, community representatives to review Ogden Nature Center Planning efforts. Suggest compatible land management opportunities. Invite Internal Revenue Service staff to join in Ogden Nature Center events and projects.

4. Explore the possibility of creating a program to train youth at the juvenile detention center or community service workers to help the Ogden Nature Center achieve land management objectives, a successful local example in the region is the Utah state prison work crew known as the Flame-N-Goes.

5. Explore the possibility of inviting Ogden Nature Center Members and members of the community at large to participate in future planning or program development efforts.
at the Ogden Nature Center. An example of a successful community workshop in planning was conducted for the development of the Red Butte Gardens and the State Arboretum of Utah in Salt Lake City.

6. Do not overlook the possibility of greenway development upstream or downstream along Mill Creek or Plain City canal corridors with linkage to the Ogden River.

II. Visitor accommodations

1. Reduce height and redesign the fence at the south end of the property to create a sense of entry and invitation to visitors as they view the Ogden Nature Center from 12th street. Another method of enclosure, such as a lower fence composed of natural materials, a berm, or hedges would provide a more inviting atmosphere for visitors and be more consistent with the Ogden Nature Center's program of education and land stewardship (Figure 33).

2. Site furnishings such as signs, bridges, blinds, benches, picnic tables, etc. should be constructed of materials which compliment one another and blend in with the environment, thus providing visual unity throughout the site and a sense of identity specific to the Ogden Nature Center.

3. Update restroom facilities at the north end of the site so that they complement the current design standards and image the Ogden Nature Center wishes to project.
4. Provide opportunities for picnics adjacent to the wildlife rehabilitation center and the new learning center. Accommodate informal picnics at the north end of the site, but encourage large picnics at the south end of the site to separate human use areas from wildlife sanctuary areas.

5. Maintain desirable pedestrian circulation routes from the new learning and visitor's center to the demonstration garden and wildlife rehabilitation enclosures and farm house. In order to achieve this it is advised that directional signs and maps be placed at trailheads, and changes in pavers should be considered at road crossings.

6. Handicapped trail users could be better accommodated on the site by 1) changing trail grades to between 1-5%, 2) widening the trails in some areas to permit wheelchair passage, and 3) creating accessible rest stops along the trail system.

7. Consider seasonal closure of trails passing through the riparian corridor and wetland areas if nesting opportunities would be improved by doing so. Consider introducing an additional section of trail which circumvents the Riparian Corridor (possible optional route during nesting season.) and provides access to the northeast corner of the site.

8. Construct wildlife observation blinds and site them adjacent to Teal pond, Blackbird pond, and in other locations as funding allows. Blinds provide wildlife viewing opportunities while minimizing wildlife disturbance.
Figure 33. Example of an Alternative Method of Enclosure.
EDUCATIONAL AND INTERPRETIVE OPPORTUNITIES:

1. Compile ideas for community out-reach projects for all ages and levels of education.

2. Consider projects to be conducted by the Ogden Nature Center teaching staff or local public school teachers that last through several seasons, or years which provide long-term benefits for the Ogden Nature Center (such as weed control or shelterbelt enhancement).

3. Develop a network of contacts with state, federal, and national agencies to acquire up-to-date information relevant to the programs, and land management strategies which may benefit at the Ogden Nature Center. Consider developing a network with other Nature Centers across the United States to learn from others' successes and failures and to share new ideas with such entities as: Bear River Migratory Bird Refuge, Utah; Red Butte Gardens and the State Arboretum of Utah, Salt Lake City, Utah; Great Basin Nature Conservancy Field Office, Salt Lake City, Utah, Carson Nature Center, Littleton, Colorado; San Pedro National Riparian Conservation Area, Arizona Bureau of Land Management; The National Institute of Urban Wildlife, Colombia, Maryland.
4. Provide signs and brochures which interpret wildlife, vegetation, and ecosystem interactions along Ogden Nature Center trails. For example, an opportunity exists to interpret herbaceous plant competition, cheatgrass vs. rhizomatous and cespitose grasses along the trail which crosses the open meadow east of Teal pond.

5. Gather seeds from both desirable and undesirable plant communities found at the Ogden Nature Center and create experiments to determine seed viability, and longevity. As an offshoot of this idea, create an Ogden Nature Center seedbank.

6. Create test plots to see if periodic grazing by sheep, goats or exotic grazers such as llamas will help to control weedy vegetation in various stages of growth.

CONCLUSION

The Ogden Nature Center offers many wonderful experiences: from the simple pleasures of childhood, playing in the mud, chasing dragonflies, exploring for a glimpse of lizards, birds, frogs or skunks!... to discovering what pond life looks like under the microscope or capturing a glimpse of Saturn's rings through a telescope...to the awe inspired by being the sole witness of a great blue heron's takeoff ...to the community celebrations of spring thaw, summer solstice, autumn harvest, and winter dormancy. The recommendations made in this conceptual master plan and vegetation management plan are intended as guidelines to assist the Ogden Nature Center to fulfill its management objectives as it continues to develop its potential as an invaluable community resource. Priorities which are essential to preserving the long term stability of the site, such as monitoring or removal of toxic wastes, and controlling the invasive noxious weeds to enhance habitat value and preserve desirable plant communities on the site should be
addressed as soon as possible by the Ogden Nature Center Administration. Guidance by Ogden Nature Center Administrators and active community participation in creating a sense of place are what landscape stewardship is all about. Carpe diem!
REFERENCES


Asghari, J.B. and J.O. Evans.


Dolph, Joan. 1994. Personal interview. Citizen Founder and Teacher Naturalist for the Ogden Nature Center. Ogden, UT.


Furhiman, Jerry, 1993. 1994. Personal communication on several occasions regarding the Ogden Nature Center. Professor and Thesis committee member. Utah State University. Department of Landscape Architecture and Environmental Planning. Logan, UT.


Academic Press Inc. San Diego, CA.

Vice, Daniel and Messmer, Terry. 1993. Wetlands of Utah. Published in cooperation
with Utah State University Cooperative Extension Service, U. S. Fish and Wildlife
Service, Environmental Protection Agency, and Utah Division of Wildlife
Resources.

In: Biological Pollution: The Control and Impact of Invasive Exotic Species.
1-8. Proceedings of a Symposium held at the University Place Conference Center,
Indiana University-Purdue University at Indianapolis on October 25 and 26, 1991.
Ed. Bill N. McKnight. Indiana Academy of Science, Indianapolis, IN.

Utah-1842 to present. 17-29. In: Noxious Range Weeds. Eds. Lynn F. James,
Boulder, CO.


West, Neil E., and Kassim O. Farah. Effects of clipping and sheep grazing on dyer's

Vol. 42: 4 (July), 266-274.

Whitham, Tom. 1993. Personal communication regarding cottonwood plantings at the
Ogden Nature Center. Professor of Biology, Northern Arizona University.
Flagstaff, AZ.

University, Utah State University, and University of Wyoming.

APPENDICES
Appendix A

Climatic conditions

Monthly precipitation, temperature, snowfall, and evapotranspiration patterns in the Ogden Nature Center's vicinity are described in *Utah Climate* (Ashcroft, 1992) as follows:

**MONTHLY PRECIPITATION IN INCHES**

<table>
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<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
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<tr>
<td>N*</td>
<td>1.31</td>
<td>1.29</td>
<td>1.65</td>
<td>1.96</td>
<td>1.92</td>
<td>1.32</td>
<td>0.60</td>
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<td>3.61</td>
<td>4.45</td>
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<td>5.51</td>
<td>4.21</td>
<td>3.61</td>
<td>5.62</td>
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N= Normal, R= Record

**NORMAL* MONTHLY FAHRENHEIT TEMPERATURES**

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<td>H*</td>
<td>35.9</td>
<td>42.7</td>
<td>51.7</td>
<td>61.8</td>
<td>72.0</td>
<td>82.7</td>
<td>92.1</td>
<td>89.7</td>
<td>79.0</td>
<td>66.1</td>
<td>49.9</td>
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<tr>
<td>M*</td>
<td>26.6</td>
<td>32.5</td>
<td>40.7</td>
<td>49.3</td>
<td>58.4</td>
<td>67.8</td>
<td>76.0</td>
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<td>52.0</td>
<td>39.4</td>
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<tr>
<td>L*</td>
<td>17.3</td>
<td>22.3</td>
<td>29.7</td>
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<td>37.8</td>
<td>28.8</td>
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</table>

H= High, M= Mean, L= Low

**MONTHLY SNOWFALL IN INCHES**

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</table>

N= Normal, R= Record

**MONTHLY EVAPOTRANSPIRATION IN INCHES**

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<td>4.79</td>
<td>2.85</td>
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* Climatic averages are standardized by the National Weather Service by averaging weather data over 30 year periods known as "normals". The 30 year "normal" period used in these tables is the period from 1961-1990 (Ashcroft, 1992).
Appendix B

The soil data and descriptions are discussed in greater detail in the Davis-Weber Area Soil Survey, published in 1968 by the U.S. Department of Agriculture Soil Conservation Service in cooperation with the Utah Agricultural Experiment Station.

Soils

**IaA or Ironton silt loam** occurs on 0 to 1 percent slopes on lake terraces or flood plains. The soil is described as a silty loam soil at the surface with underlying loam or silty loam containing accumulations of lime. This soil is moderately alkaline, drains slowly, and is rated as having little or no erosion hazards. It can hold approximately 2 inches of water per foot. Depth to the water table ranges from 24-40 inches. Soil permeability rates vary from 0.63 to 2.0 inches per hour. This soil is used for crops and pasture.

**Kr or Kirkham loam** occurs on slopes ranging from 0 to 1 percent along the flood plains of the Weber River. The surface layer is loam and reaches depths from 8 to 18 inches. This soil is considered moderately well drained, runoff is slow, and erosion hazards are low. It can hold approximately 2 inches of water per foot. Depth to the water table fluctuates seasonally. Soil permeability rates vary from 2.0 to 6.3 inches per hour. This soil is used for pasture and crop growth.

**SbA or Steed fine sandy loam** occurs on 0 to 1 percent slopes along the Weber River flood plain. The surface layer is a sandy loam ranging from 6 to 10 inches. Subsoils are usually loamy sand, and mottled in places. This soil is considered well drained, moderately permeable and somewhat susceptible to erosion by wind. This soil can hold approximately 1.5 inches of water in the surface layer, dropping to about .5 inch in subsurface layers. Soil permeability rates are greater than 6.3 inches per hour. This soil is usually used as range.
SdA or Steed gravely fine sandy loam occurs on 0 to 2 percent slopes along the Ogden and Weber Rivers. The soil profile is very similar to Steed Fine Sandy loam, however the soil is gravely throughout. The soil surface layer ranges from 5-8 inches deep. It can hold 3-3.5 inches of water per foot to a depth of 5 feet. Soil permeability rates are greater than 6.3 inches per hour. This soil is used for range irrigated crops and industrial purposes.

SkA or Sunset loam occurs on 0 to 1 percent slopes on flood plains and low river terraces near the Weber river. The surface layer is composed of loam and reaches a depth of 15 to 24 inches. Subsurface layers are composed of stratified loam to sandy loam. Unless drained, this soil is usually saturated within 40 inches of the surface. It holds about 2 inches of water per foot. Runoff rates are slow and erosion hazards are low. The soil permeability rates vary from 0.63 to 2 inches per hour. It is used for irrigated crops and range.

SnA or Sunset loam, gravely substratum, occurs on slopes of 0 to 1 percent on nearly flood plains adjacent to the Weber River. This soil profile is similar to Sunset loam but has a gravely sandy loam sub layer at a depth ranging from 25 to 36 inches. It holds approximately 5.5 inches to 6 inches of water per foot to a depth of about 5 feet, however, the sub layer containing gravel can only hold about .5 inch per foot. Runoff rates are slow and erosion is low. This soil is used to grow irrigated crops.
Appendix C

The steps of the CERCLA cleanup process, outlined below, have been condensed from *Beyond Superfailure America's Toxics Policy for the 1990s*, (Mazmanian and Morell, 1992, 32):

Step 1 Determine the degree of threat to health and environment due to the presence of contaminants, and necessity for their control or removal.

Step 2 Estimate the danger posed by the contaminated site as a result of the preparation of a Preliminary Assessment.

Step 3 After preparing the Preliminary Assessment, determine the necessity either to stop the investigation or proceed to analyze the site, through a Site Investigation. A Site Investigation determines whether the site should be included on the National Priority List of superfund sites; this is determined by the site's score based on the Hazard Ranking System. If the site is not placed on the National Priority List the site investigation may stop at this point in the process.

Step 4 Determine all the parties responsible for cleanup.

Step 5 Prepare a Remedial Investigation and Feasibility Study (RI/FS stage) to determine alternative methods for site cleanup. Identify the preferred alternative.

Step 6 Set aside two months for public input and review of the preferred cleanup alternative.

Step 7 The EPA prepares a record of decision which explains the reasons for the selection, and the procedures to be followed during the cleanup.

Step 8 Design the cleanup process ("Remedial Design Stage").

Step 9 Fulfill the requirements of the Remedial Action Plan (RAP); this may include follow-up monitoring.

Step 10 Finalize approval of site cleanup and removal of the site from the National Priority List.
Appendix D

OGDEN NATURE CENTER
EXISTING VEGETATION INVENTORY

RIPARIAN

OVERSTORY TREES
Russian Olive / Eleagnus angustifolia
Green Ash / Fraxinus pennsylvanica
Box Elder / Acer negundo
Siberian Elm / Ulmus pumila
Black Locust / Robinia pseudoacacia
Narrowleaf Cottonwood / Populus angustifolia
Wild Plum / Prunus sp.
Wild Pear / Pyrus sp.
Fremont Cottonwood / Populus fremontii
Honey Locust / Gleditsia triacanthos
Peachleaf Willow / Salix amygdaloides
River Hawthorn / Crategus douglasii

UNDERSTORY SHRUBS
Wood's Rose / Rosa woodsii
Coyote Willow / Salix exigua
Golden Currant / Ribes aureum
Chokecherry / Prunus virginiana
Red Osier Dogwood / Cornus stolonifera

UNDERSTORY GRASSES / FORBS / VINES
Bryony / Bryonia alba
Burdock / Arctium minus
Deadly Nightshade / Solanum dulcamara
Orchardgrass / Dactylis glomerata
Virginia Creeper / Parthenocissus quinquefolia
False Solomon's Seal / Smilacina racemosa
RIPARIAN THICKET

OVERSTORY TREES
Russian Olive / *Eleagnus angustifolia*
Siberian Elm / *Ulmus pumila*
Box Elder / *Acer negundo*
Green Ash / *Fraxinus pennsylvanica*

UNDERSTORY GRASSES / FORBS / VINES
Bryony / *Bryonia alba*
Burdock / *Arctium minus*
Orchardgrass / *Dactylis glomerata*
False Solomon’s Seal / *Smilacina racemosa*

DECADENT RIPARIAN

OVERSTORY TREES
Box Elder / *Acer negundo*
Siberian Elm / *Ulmus pumila*
Russian Olive / *Eleagnus angustifolia*
Golden Willow / *Salix sp.*
Narrowleaf Cottonwood / *Populus angustifolia* *
*Fallen or Dead

UNDERSTORY SHRUBS
Wood’s Rose / *Rosa woodsii*
Squawbush / *Rhus trilobata*

UNDERSTORY GRASSES / FORBS
Burdock / *Arctium minus*
Orchardgrass / *Dactylis glomerata*
PALUSTRINE WETLAND

TREES
Russian Olive / *Eleagnus angustifolia*

SHRUBS
Wood’s Rose / *Rosa woodsii*
Coyote Willow / *Salix exigua*

WETLAND PLANTS
Cattail / *Typha latifolia*
Bulrush / *Scirpus acutus*
Teasel / *Dipsacus sylvestris*
Horsetail / *Equisetum arvense*
Rush / *Juncus spp.*
Sedges / *Carex spp.*
Phragmites / *Phragmites australius*

AQUATICS
Pondweed / *Potamogeton sp.*
Late summer algal bloom

DRY GRASSLAND

GRASSES
Cheatgrass / *Bromus tectorum*
Quackgrass / *Elytrigia repens*
Goatgrass / *Aegilops cylindrica*
Smooth Brome / *Bromus inermis*

SHRUBS / FORBS
Dyer’s Woad / *Verbascum thapsis*
Ragweed / *Ambrosia psilostachya*
Tansy Mustard / *Desvrania pinnata*
Rabbitbrush / *Chrysothamnus nauseosus*
PASTURE

GRASSES
Cheatgrass / Bromus tectorum
Quackgrass / Elytrigia repens
Crested Wheatgrass / Agropyron cristatum
Smooth Brome / Bromus inermis
Goatgrass / Aegilops cylindrica
Bulbous Bluegrass / Poa bulbosa
Foxtail Barley / Hordeum jubatum
Western Wheatgrass / Agropyron smithii
Orchardgrass / Dactylis glomerata
Witchgrass / Panicum capillare
Intermediate Wheatgrass / Agropyron elongatum
Great Basin Wild Rye / Elymus cinereus
Indian Ricegrass / Ozyropsis hymenoides
Bluebunch Wheatgrass / Agropyron spicatum

FORBS
Teasel / Dipsacus sylvestris
Western Yarrow / Achillea lanulosa
Wild Licorice / Glycyrrhiza lepidota
Dogbane Hemp / Apocynum cannabinum
Catnip / Nepeta cataria
Purple Aster / Machaeranthera canescens
Milkweed / Asclepias labriformis
Curly Dock / Rumex crispus
Filaree / Erodium cicutarium
Alfalfa / Medicago sativa
Curlycup Gumweed / Grindelia squarrosa
Sunflower / Helianthus annus
alkali Mallow / Sida hederacea
Common Mallow / Malva neglecta
Wild Asparagus / Asparagus officianlis
Goldenrod / Solidago decumbens
Prairie Goldenrod / Solidago missoriensis
Western Salsify / Tragopogon dubius
Yellow Sweetclover / Medicago officianlis
Blue Flax / Linum lewisii = C*
*Cultivated by the Ogden Nature Center
Burnet / Sanguisorba minor = C*
*Cultivated by the Ogden Nature Center
COTTONWOOD PLANTINGS

Fremont Cottonwood / *Populus fremontii*
Narrowleaf Cottonwood / *Populus angustifolia*
Cottonwood Hybrids

SHELTERBELT

Austrian Pine / *Pinus nigra* *
Golden Willow / *Salix alba* *
*Monocultured in Southern portion of shelterbelt.
Northern portion of shelterbelt includes various fruitbearing trees.

STREET SCREEN

Red Cedar / *Juniperus virginiana*
Honey Locust / *Gleditsia triacanthos*

WATER HARVESTING

Siberian Elm / *Ulmus pumila*

DONATION PLANTING

Random planting of exotic evergreen and deciduous trees
and shrubs, some natives interspersed.

NATURE CENTER PLANTING

Irrigated trees, shrubs, grass and perennial plantings
adjacent to the Ogden Nature Center Headquarters.

WILDLIFE FOOD PLOT

Stephen's Wheat
Hansel's Wheat
Schuller Barley
OGDEN NATURE CENTER
INVASIVE PLANT POPULATIONS 1993

FORBS
Teasel / *Dipsacus sylvestris*
Yellow Star Thistle / *Centaurea solstitialis*
Dyer's Woad / *Isatis tinctoria*
Prickly Lettuce / *Lactuca serriola*
Canada Thistle / *Cirsium arvense*
Puncture Vine / *Tribulus terriblis*
Burdock / *Arctium minus*
Houndstongue / *Cynoglossum officinale*
Scotch Thistle / *Onoporum acanthium*
Whitetop / *Cardaria sp.*

VINES
Bryony / *Bryonia alba*

TREE / SHRUB
Tamarisk / *Tamarix Spp.*

POPULATIONS TO MONITOR:

FORBS
Bindweed / *Convolvulus arvensis* = P
Western Ragweed / *Ambrosia psiliostachya*
Marshelder / *Iva xanthifolia*
Russian Thistle / *Salsola iberica*
Kochia / *Kochia scoparia*
Poison Ivy / *Toxicodendron radicans*

SHRUBS
Wood's Rose / *Rosa woodsii*

TREES
Russian Olive / *Eleagnus angustifolia*
Appendix E

Purple Loosestrife/ *Lythrum salicaria* Description

Purple loosestrife is a tall stalky plant three to six feet in height. It has simple lanceolate leaves which attach directly to the stalk and long spike shaped light purple flowers (Dewey, 1994). Populations of loosestrife are being monitored by Utah State University's Cooperative Extension Service. Should loosestrife ever be found on the site, it should be documented and reported to extension service agents (Dewey, 1994).
Purple loosestrife (*Lythrum salicaria*).
Appendix F

OGDEN NATURE CENTER
WILDLIFE INVENTORY 1993

Birds sighted more than once on the site during the summer season are recorded on the wildlife inventory map according to location are as follows:

DRAGONFLY POND / POTHOLE HABITAT

Barn Swallow / *Hirundo rustica*
Canada Goose / *Branta candensis*
Great Blue Heron / *Ardea herodicas*
Killdeer / *Charadrius vociferus*
Mourning Dove / *Zenaida macroura*
Red-winged Blackbird / *Agelaius phoeniceus*
Ring-necked Pheasant / *Phasianus colchicus*
Spotted Sandpiper / *Actitius macularia*
White- Faced Ibis / *Plegadis chihi*

BLACKBIRD POND HABITAT

American Coot / *Fulica americana*
Black-billed Magpie / *Pica pica*
Black-capped Chickadee / *Parus atricapillus*
Cinnamon Teal / *Anas cyanoptera*
Great Blue Heron / *Ardea herodicas*
House Finch / *Carpodacus mexicanus*
Mallard / *Anas playrhynchos*
Mourning Dove / *Zenaida macroura*
Red-winged Blackbird / *Agelaius phoeniceus*
Snowy Egret / *Egretta thula*
Western Tanager / *Piranga ludoviciana*
Yellow Warbler / *Dendroica petechia*
PLAIN CITY CANAL / MILL CREEK HABITAT

American Goldfinch / Carduelis tristis
American Kestrel / Falco sparverius
American Robin / Turdus migratorius
Black-capped Chickadee / Parus atricapillus
Black-headed Grosbeak / Pheucticus melanocephalus
California Quail / Callipepla californica
Great Horned Owl / Bubo virginianus
House Wren / Troglodytes aedon
Lazuli Bunting / Passerina amoena
Mourning Dove / Zenaida macroura
Northern Flicker / Colaptes auratus
Northern Oriole / Icterus glabula
Ring-necked Pheasant / Phasianus colchicus
Western Tanager / Piranga ludoviciana

TEAL POND HABITAT

American Coot / Fulica americana
Black-billed Magpie / Pica pica
Canada Goose / Branta candensis
Cinnamon Teal / Anas cyanoptera
Forster's Tern / Sterna forsteri
Great Blue Heron / Ardea herodias
Killdeer / Charadrius vociferus
Mallard / Anas playrhythchos
Mourning Dove / Zenaida macroura
Red-winged Blackbird / Agelaius phoeniceus
Ruddy Duck / Oxyura jamaicensis
Snowy Egret / Egretta thula
ARROWHEAD POND HABITAT

American Coot / *Fulica americana*
Barn Swallow / *Hirundo rustica*
Belted Kingfisher / *Ceryle alcyon*
Canada Goose / *Branta candensis*
Forster's Tern / *Sterna forsteri*
Killdeer / *Charadrius vociferus*
Snowy Egret / *Egretta thula*
Western Kingbird / *Tyrannus verticalis*

OPEN MEADOW HABITAT

American Kestrel / *Falco sparverius*
California Quail / *Callipepla californica*
Killdeer / *Charadrius vociferus*
Northern Oriole / *Icterus glabula*
Ring-necked Pheasant / *Phasianus colchicus*
Western Kingbird / *Tyrannus verticalis*
Western Meadowlark / *Strunella neglecta*
BIRDS SIGHTED ONCE OR RARELY ON THE SITE DURING THE SUMMER SEASON ARE AS FOLLOWS:

Black-crowned Night Heron / *Nycticorax nycticorax*
Blue Grosbeak / *Guiraca caerulea*
Blue-winged Teal / *Anas discors*
Brewer’s Blackbird / *Euphagus cyanocephalus*
Broad-tailed Hummingbird / *Selasphorus platycercus*
Cattle Egret / *Bubulcus ibis*
Cliff swallow / *Hirundo pyrrhonota*
Dark-eyed Junco / *Junco hyemalis*
Downy Woodpecker / *Picoides pubescens*
Evening Grosbeak / *Coccothraustes vesperitinus*
Franklin’s Gull / *Larus pipixcan*
Green-winged Teal / *Anas crecca*
Marsh Wren / *Cistothrus palustris*
Redhead / *Aythya americana*
Rock Dove / *Columba livia*
Sharp-shinned Hawk / *Accipter striatus*
Turkey Vulture / *Cathartes aura*
White-crowned Sparrow / *Zonotrichia leucophrys*
Willet / *Catoptrophorus semipalmatus*
Wood Duck / *Aix sponsa*

MAMMALS

Chipmunk species / *Eutamias sp.*
Deer Mouse / *Peromuscus maniculatus*
Ground Squirrel species / *Spermophilus sp.*
House Mouse / *Mus musculus*
Mule Deer / *Odocoileus hemionus*
Muskrat / *Ondatra zibethicus*
Nuttall’s (Mountain) Cottontail / *Sylvilagus nuttallii*
Raccoon / *Procyon lotor*
Rat species / *Rattus sp.*
Red Fox / *Vulpes vulpes*
Striped Skunk / *Mephitis mephitis*
Vole species / *Microtus sp.*
REPTILES AND AMPHIBIANS

Garter Snake species / *Thamnophis sp.*
Great Basin Gopher Snake / *Pituophis melanoleucus*
Western yellow-bellied Racer / *Coluber constrictor*
Green Frog / *Rana clamitans*
Northern Leopard Frog / *Rana pipiens*
Great Plains Toad / *Bufo cognatus*
Tiger Salamander / *Ambystoma tigrinum*
Appendix G


<table>
<thead>
<tr>
<th>PHASE I</th>
<th>PHASE II</th>
<th>PHASE III</th>
<th>PHASE IV</th>
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<tr>
<td>HERBICIDE APPLICATION</td>
<td>IMPROVE HERBACEOUS STANDS</td>
<td>FINE FUEL DEVELOPMENT/ BURN PREPARATION</td>
<td>PRESCRIBED BURNING</td>
<td>MAINTENANCE OF RANGE IMPROVEMENT</td>
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<tr>
<td><strong>OBJECTIVES</strong></td>
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<tr>
<td>Reduce canopy cover and density of running mesquite and associated brush to release forage.</td>
<td>Use grazier rest periods to allow increase in proportion of desirable perennial herbs in stand.</td>
<td>Build continuous load of fine fuel adequate to ensure hot, uniform fire.</td>
<td>Maintain brush suppression expedite increased proportion of desirable grasses and forbs.</td>
<td>Perpetuate desired level of productivity with minimal financial input.</td>
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<td><strong>ACTIVITY</strong></td>
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<td>Aerially apply 3.1 kg/ha of 2,4-D+ picloram (1:1) or equivalent in the spring.</td>
<td>Defer from grazing for 60-90 days to allow for grass release; increase stocking rate in accordance with response of key species.</td>
<td>Defer grazing for 90-120 days in fall to build fuel; prepare fire plan and install fire guards.</td>
<td>Install prescribed burn according to sound fire plan; defer grazing to allow recovery of key species; then allow removal of no more than 60-65% of topgrowth before next deferral.</td>
<td>Schedule prescribed burns as needed (approximately 3- to 5-year intervals).</td>
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<td><strong>CONSIDERATION(S)</strong></td>
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<tr>
<td>Apply in appropriate patterns for game management; usually treat no more than 80% of management unit; treatments will likely be extremely damaging to several prefer- ferred browse species.</td>
<td>First flush (first season) of grasses usually short-term opportunists released from shading etc; deferment designed to allow vigorous development of key species.</td>
<td>Deferral period must be adjusted to rainfall conditions; under drought conditions, utilize proper amount of accumulated fuel and delay burn.</td>
<td>Late winter when wind speed 10-15 km/hr., RH 60-65%, fine fuel water content &lt;20%, backfire 30-45 m before headfiring; if RH &gt; 70%, fuel water &gt;10% wind speed of steady 6-11 mph will effectively burn.</td>
<td>Grazing deferral to build adequate fine fuel and post burn to allow grass recovery.</td>
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<td><strong>RESULTS</strong></td>
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<td>Brush defoliation &gt;90% for first growing season; then 65% original cover replaced third growing season if not burned; grass released by spray may more than double that on unsprayed areas first growing season; forbs will be controlled by spray for at least 1 growing season.</td>
<td>Proportion of grass stand of good-to-excellent grazing dramatically increases by second growing season.</td>
<td>Accumulate 2,500-3,000 kg/ha of fine fuel with only minor discontinuities.</td>
<td>Fire covers &gt;90% of area; brush stem &lt;1.5 cm diam; consumed or dropped; warm season perennials increased; brush regrowth killed to ground line; forb population restored.</td>
<td>Continual suppression of brush sprouts; remove rough vegetation, improve grazing distribution and range condition, etc.</td>
</tr>
</tbody>
</table>
Appendix H

Contacts for Tamrisk Control

1. Southern California Area Manager
   The Nature Conservancy:
   Cameron Barrows
   P.O. Box 188
   Thousand Palms, California, 92276
   (619) 343-1234

2. Salt Cedar Eradication:
   The Desert Protective Council
   P.O. Box 4294
   Palm Springs, CA 92263

3. Garlon 4 Herbicide:
   Jesse Richardson
   Dow Chemical Representative
   Hesperia, CA
   (619) 949-2565

For Herbicide Application Effects on Dyer’s woad

John Evans
Department of Plants, Soils, and Biometeorology
Utah State University
Logan, UT
(801) 797-2242

Utah State University Extension Weed Specialist

Steven A. Dewey
Department of Plants, Soils and Biomeorology
Utah State University
Logan, UT
(801) 797-2233
Appendix I

OUTLINE OF AREAS FOR FURTHER RESEARCH:

I. ENHANCEMENT OF EXISTING DESIRABLE VEGETATION COMMUNITIES
   A. Evaluation of Site Potential
   B. Selection of Plant Communities to enhance or encourage
      Possibilities include:
      1. Northeast Corner of Site
         a. Possible Benchland Community
         b. Possible Seasonal Playa - type wetland
         c. Possible Native Grassland
      2. Arrowhead Pond West Bank
         a. Regrade
         b. Dress bank with topsoil
         c. Revegetate bank
      3. Teal pond and Dragonfly pond
         a. Dress banks with topsoil where appropriate
         b. Revegetate banks.
         c. Provide cover for birdlife near Dragonfly pond and potholes
      4. Plain City Canal and Mill Creek Riparian Corridor
         a. Expand Riparian corridor on West Bank of the Canal
         b. Diversify tree canopy (pole plantings?)
         c. Long term goal - Obtain mill creek corridor from DDOU at North end of property (habitat connectivity)
      5. Shelterbelt
         a. Diversify vegetation
         b. Create drift effect, modify form
         c. Determine habitat possibilities.
   C. Selection of appropriate enhancement techniques
      1. Dependent on:
         a. Management objectives
         b. Funding and human resources (?)
         c. Plant physiology/ site ecology
   D. Implementation of Techniques
      1. Timing and Phasing of Implementation
      2. Educational opportunities
      3. Management Decision Tree (?)
   E. Monitoring of Transects
      1. Size, Location and Type of Transects
      2. Educational opportunities
II. ENHANCEMENT OF WILDLIFE HABITAT

A. Possibility to attract bird species not previously observed on site?
   1. Target species
   2. Determine habitat requirements

B. Congruent with some of the vegetation enhancement possibilities described above.

C. Routing of circulation, trails to accommodate wildlife needs

III. ENVIRONMENTAL EDUCATION

A. Community Education/Involvement
   1. Vegetation management program designed as a long-term project for science students within community schools or implemented by the Ogden Nature Center Staff
   2. Community Service Project, development of a community work force such as the Flame-N- Goes developed by State prison officials.

B. Interpretive opportunities
   1. Shift emphasis away from "Nature Center" to "Urban Wildlife/Ecology Project or Environmental Education Center These emphases allow a broader interpretation of site ecology, including disturbances which have occurred over time, ie. there is very little "native" vegetation due to farming; the naturalized riparian corridor exists due to canal construction and river diversion, etc.
Appendix J

INFORMATION AND HUMAN RESOURCE LIST

For further information an extensive list of potential resources is provided in:
Appendix F of *A Wildlife Conservation Manual for Urbanizing Areas In Utah*

Ogden City/Weber County Offices

Ogden City Contact: Greg Montgomery, Planner

Ogden City Planning Department
2484 Washington Blvd.
Ogden, UT 84401

Ogden City Planning Commission
(801) 629-8930

Long Range Planning Commission
(801) 629-8920

Weber County Planning Commission
2510 Washington Blvd.
Ogden, UT 84401

(801) 399-8170

Weber County Weed Department
County Agricultural Services and Weed Extension Agent
James Barnhill
2222 South, 1900 West
Ogden, UT 84401

(801) 399-8356

Utah State University

Department of Landscape Architecture and Environmental Planning
Utah State University
Logan, UT 84322-4005

Prof. Craig Johnson, Prof. Jerry Fuhriman
(801) 797-0500
Utah State University

Range Science Extension Services
Department of Range Science
Utah State University
Logan, UT 84322-5230

Prof. G. Allen Rasmussen
(801) 797-2469

Extension Weed Specialist
Department of Plants, Soils, and Biometeorology
Utah State University
Logan, UT 84322-4820

Prof. Steven A. Dewey
(801) 797-2233

Department of Fisheries and Wildlife
Utah State University
Logan, UT 84322-5210

Humane Predator Control Practices
Prof. Robert Schmidt
(801) 797-3219

State of Utah

Leo Lentsch
June Sucker Recovery Team
Utah Department of Natural Resources
Division of Wildlife Resources
1596 West, North Temple
Salt Lake City, UT 84116-3195

Leo Lentsch
(801) 538-4756
Patricia Lock-Dawson  
Wetlands Specialist  
Utah Department of Natural Resources  
Division of Wildlife Resources  
1596 West, North Temple  

Patricia Lock-Dawson  
(801) 538-4864  

Sheila Smith  
Water Rights Specialist  
Utah Department of Natural Resources  
Division of Water Rights  
Weber River Area Office  
1636 West, North Temple  
Suite 220  
Salt Lake City, UT 84116-3156  

Sheila Smith  
(801) 538-7399  

Lotti Wann  
Planner  
Utah Department of Natural Resources  
Division of Parks and Recreation  
1636 West, North Temple  
Salt Lake City, UT 84116  

Lotti Wann  
(801) 538-7220  

John Knudsen  
Utah Trails Coordinator  
Utah Department of Natural Resources  
Division of Parks and Recreation  
1636 West, North Temple  
Salt Lake City, UT 84116  

John Knudsen  
(801) 538-7220
Utah Department of Environmental Quality
Division of Environmental Response and Remediation
1950 West, North Temple
Salt Lake City, UT 84116

Brad Johnson, CERCLA Section Manager
Muhammad Slam, Environmental Engineer
(801) 536-4100

Utah Department of Environmental Quality
Division of Water Quality
Adopt-A-Waterbody Program

Leanne Lamb
(801) 538-6146

Utah Department of Natural Resources
Division of State Lands and Forestry
Lone Peak Nursery
14650 South Prison Road
Draper UT

Propagation of Wetland Plants
(801) 571-0900

Flame-N- Goes
Utah Corrections Department
6100 South, 300 East
Murray, UT 84107
(801) 265-5500

Red Butte Garden and Arboretum of Utah
University of Utah
Salt Lake City, UT 84112

Director, Mary Pat Matheson
(801) 581-4747

Bear River Migratory Bird Refuge
(801) 723-5887
Regional Resources

Carson Nature Center
7301 South Platte River Parkway
Littleton, CO 80120
Contacts:
Melissa Clark
Ray Sperger
(303) 730-1022

San Pedro Riparian National Conservation Area
San Pedro Riparian National Conservation Area
Bureau of Land Management
RR1 Box 9853
Huachuca City, AZ 85616
(602) 457-2265

OR:

Safford District Office
Bureau of Land Management
425 East 4th Street
Safford, AZ 85546
(602) 428-4040

Contact: Director, Dot Rhodes
(602) 458-0542
National Resources

U.S. Environmental Protection Agency, Region 8
Hazardous Waste Management Division
Superfund Management Branch
Technical Section
999 18th Street
Suite 500 (8HWM-SM)
Denver, CO 80202-2405

Luke Chavez
Environmental Engineer
Site Assessment Manager
(303) 293-1869

National Institute of Urban Wildlife
10921 Trotting Ridgeway
Columbia, MD 21044

(301) 596-3311
LEGEND

PLANT POPULATIONS APPEARED IN TABLES ACCORDING TO THEIR RELATIVE IMPORTANCE
1 = Dominant species which are covering 50% or more of the plant community
2 = Abundant species present in 25 - 50% of the plant community
3 = Frequent species present in 10 - 25% of the plant community
4 = Sparse species present in 5 - 10% of the plant community
X = Non-native species indicated by * above plant names

DRY GRASSLAND

PASTURE

POTHOLE

PARKS

COTTONWOOD PLAGUE

WILDLIFE FOOD PLOT

HILTERBILT

STREET SCREEN

WATER HARVESTING

DONATION PLANTING

NATURALIZED LARGE TREES

OGDEN NATURE CENTER
EXISTING VEGETATION

JANUARY 1994

Designed for the Ogden Nature Center by: Beth Pyle

Scale: 1"=100'

OGDEN NATURE CENTER
EXISTING VEGETATION

JANUARY 1994

Designed for the Ogden Nature Center by: Beth Pyle

Scale: 1"=100'

DEPARTMENT OF LANDSCAPE ARCHITECTURE AND ENVIRONMENTAL PLANNING - UTAH STATE UNIVERSITY
PLANT POPULATIONS AERIAL PHOTO INTERPRETATION

LEGEND

PLANT POPULATIONS ARE LINED IN RED BOUNDARIES ACCORDING TO THE FOLLOWING SYSTEM

1 = Dominant, species which are becoming dominant, or present in the plant community
2 = Abundant, species present in 75-99% of the plant community
3 = Frequent, species present in 50-74% of the plant community
4 = Rare, species present in 1-50% of the plant community
5 = Colonist

PLANT POPULATIONS

FORM

1. Salix tristis (Suckering Balsam Poplar)
2. Populus tremula (Trembling Aspen)
3. Betula papyrifera (Paper Birch)
4. Pinus ponderosa (Western Ponderosa Pine)
5. Thuja plicata (Western Red Cedar)

WEED

1. Chrysanthemum segetum (Field Chrysanthemum)
2. Capsella bursa-pastoris (Sheep's-Orchardgrass)
3. Datura stramonium (Jimson Weed)
4. Solanum nigrum (Black Nightshade)
5. Conyza canadensis (Buckhorn)

VEGETATION

1. Quercus gambelii (Gambel Oak)
2. Rhus typhina (Toxic Oak)
3. Juglans nigra (Black Walnut)
4. Fraxinus americana (Tulip Poplar)
5. Fraxinus pennsylvanica (Eastern Redbud)

DIRECTIONS

1. Ribbon (Field of White)
2. Willow (Field of Willow)
3. Poplar (Field of Poplar)
4. Alder (Field of Alder)
5. Maple (Field of Maple)

OGDEN NATURE CENTER
WEEDY VEGETATION
JANUARY 1994

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