Land Retirement Demonstration Project
1999 Annual Report

May 2000

Prepared for: Robert May (USBR), Bea Olsen (FWS), and
Tracy Rowland (BLM)
Interagency Land Retirement Team
2666 N. Grove Industrial Drive, Suite #106
Fresno, CA 93727

Prepared by: Michelle Selmon, Patrick Kelly and Curt Uptain
Endangered Species Recovery Program
1900 N. Gateway Blvd. #101
Fresno, CA 93727

and

Stephen Lee
USBR/Interagency Land Retirement Team
2666 N. Grove Industrial Drive, Suite #106
Fresno, CA 93727

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Acknowledgments

Many individuals deserve credit for the establishment of the land retirement demonstration project and the collection of first-year project data. The authors would like to thank Gene “Woody” Moise for his contributions as project botanist through December 1999, and for ongoing consultations regarding the project. Karen Dulik, project botanist since February 2000, has been a valuable new team member. ESRP field biologists that were instrumental in experimental plot establishment and data collection were Tamra Sandoval, Rachel-Zwerdling Morales, Geoff Gray, Darren Newman, Foung Vang, Rhianna Lee, Roberta Fargo, Paul Brandy, Kim Kreitinger, and student interns Patrick Morrison, Justine Smith and Ahmed Soliman. Computer and GIS support was provided by Scott Phillips of ESRP and Siran Erysian of BOR. Administrative support was provided by Cecilia and Cristina Lopez, Alicia Villegas, and Jacqueline Furr.

Many thanks to all for their hard work and enthusiasm!

Executive Summary

Retirement of west-side San Joaquin Valley lands characterized by high selenium levels in soil and shallow groundwater is an option that has been recommended for decreasing the amount of agricultural drainwater produced in that region (SJVDPa). Many concerns revolve around the issue of drainwater disposal, including cost and toxicity to wildlife.

A multi-agency team (LRT) consisting of representatives from the Bureau of Reclamation (USBR), United States Fish and Wildlife Service (FWS), and the Bureau of Land Management (BLM) has been assembled to accomplish the goals of the Central Valley Project Improvement Act (CVPIA) Land Retirement Program. Concerns about the unknown physical and biotic effects of land retirement on a large scale led to the establishment of a "small-scale" demonstration project, expected to encompass approximately 15,000 acres of land.

The LRT has initiated a five-year Land Retirement Demonstration Project (Demonstration Project) in cooperation with the California State University Stanislaus' Endangered Species Recovery Program (ESRP) in two regions on the west-side of the central Valley. The Demonstration Project will consist of two project sites in geographically and physiographically different drainage-impaired basins, in order to generate data representative of large scale land retirement. The western Fresno county site (Westlands) will consist of approximately 7,000 acres and the site located in Kings and Tulare counties (Alpaugh) will be approximately 8,000 acres.

An 800-acre research experiment has been established on the Westland's site to examine restoration techniques such as microtopographic contouring and direct planting and seeding of desired native species and their efficacy for facilitating native community reestablishment. Four different treatments representing varying levels of financial input and active management were assigned to 20 experimental plots. Baseline biological monitoring on experimental plots began in April 1999.

A companion study has been designed for the Alpaugh project site. Monitoring of biota, soils, and surface and groundwater depth and quality will occur on the entire 15,000 acres of Demonstration Project lands as they are purchased in the next few years. This first annual report contains results from 1999 physical and biological monitoring only at the Westlands site in western Fresno county. The first Alpaugh site Demonstration Project lands were acquired in late January 2000. Monitoring results from those lands will be presented in future annual reports along with Westlands project site data.

Results presented and discussed in this first annual report include vegetation, insect, avian, small mammal, and herpetological survey data from experimental plots, in addition to spotlighting, track station and raptor survey data collected from the entire project site. Baseline contaminants monitoring data are also presented and discussed. Physical monitoring results and discussion are presented in a separate section from the biological monitoring results.

The desired outcome for these retired agricultural lands is drainage reduction and the reestablishment of self-sustaining upland communities such as California prairie, Valley Sink Scrub and Valley Saltbush Scrub (Holland 1986). Since relatively little information is available regarding upland community restoration on retired agricultural land in the Central Valley, the land retirement Demonstration Project will provide an opportunity to study the effects of rehabilitation techniques prior to implementation on a larger scale.

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INTRODUCTION

BACKGROUND

Water diversions from northern California and the Sacramento-San Joaquin Delta to arid lands on the west-side of the San Joaquin Valley (the Valley) of California have allowed for the widespread conversion of hundreds of thousands of acres of native grassland and freshwater marsh habitats to irrigated agricultural production. Decades of irrigating the drainage-impaired west-side lands has created shallow, contaminated water tables. To prevent the water table from rising to the crop root zone and affecting productivity following irrigation, many fields have tile-drains to collect the water once it has passed through the root zone. Drainwater collected in the tile-drains is removed from the fields altogether and disposed of at an off-site location. Disposal options at this time include discharging to regulated evaporation ponds or in some cases into the San Joaquin River.

Irrigation drainwater from west-side soils has been shown to produce serious effects in wildlife due to marine-derived constituents such as selenium (Lemly 1994; Ohlendorf et al 1986; Ohlendorf 1989; Skorupa 1998), which are toxic at levels found in the drainwater. Although there are several programs exploring drainwater treatment and decontamination options (SJVDP 1990a), cost-effective treatment technologies which remove selenium from drainwater to a level safe for wildlife have not yet been identified.

A report was prepared in 1990 by the San Joaquin Valley Drainage Program (SJVDP) which recommended various options for addressing drainage problems in the Valley (SJVDP 1990a). One recommended action to reduce the volume of drainwater produced on the west-side and simultaneously provide additional water supplies for other uses was the selective retirement of drainage-problem lands.

A multi-agency team consisting of representatives from the Bureau of Reclamation (USBR), United States Fish and Wildlife Service (FWS), and the Bureau of Land Management (BLM) has been assembled to accomplish the goals of the Central Valley Project Improvement Act (CVPIA) Land Retirement Program. The CVPIA Land Retirement Program is a voluntary program whereby the Department of Interior (Interior) may purchase land, water, and other property interests from willing sellers who receive Central Valley Project (CVP) water allocations. There will be no condemnation of land by federal authorities as part of this program.

The broad goals of the land retirement program are to:

- Reduce the volume of drainwater produced by retiring lands from irrigated agriculture on the west-side of the Valley,
- Acquire water for CVPIA purposes, and
- Enhance fish and wildlife resources.

According to the Interim Land Retirement Program Guidelines, lands eligible for retirement under the program must receive CVP water and have shallow groundwater and high selenium levels (USDI 1997). The Interagency Land Retirement Team (LRT) accepts proposals from landowners wishing to sell and considers a number of criteria in selecting parcels for retirement, including:

- High selenium concentrations in the groundwater,
  Shallow groundwater (< 10 feet),
  Poor drainage and low productivity,
  Potential for re-establishment of native upland habitat,
  Connectivity with other natural areas, and
  Availability of large blocks of land, or occurrence within a specified wildlife movement corridor (USFWS 1998).

Ceasing irrigation of the poorest quality lands with high selenium levels in the soil and groundwater should lead to a reduction in the volume of agricultural drainage water produced and decreased loading of salts and trace elements such as selenium in the remaining drainwater. The effect will be decreased exposure of wildlife to toxic levels of those elements.

LAND RETIREMENT DEMONSTRATION PROJECT

Concerns were raised during the comment period for the Land Retirement Program Draft Environmental Assessment (EA) regarding the magnitude of the project and the lack of knowledge regarding the potential effects, positive and negative, of retirement of agricultural land on a large scale (USDI 1999).

To address these concerns, the LRT has initiated a five-year Land Retirement Demonstration Project (Demonstration Project) in cooperation with the California State University Stanislaus' Endangered Species Recovery Program (ESRP) in two regions on the west-side of the central Valley. A resource monitoring plan has been prepared which outlines habitat restoration research designed to determine the effectiveness of different techniques in restoring native communities and protocols to monitor for potential contamination of wildlife resulting from the high selenium levels in shallow groundwater, soils, and surface accumulation of water (Selmon et al. 1999).

Water acquired along with land purchases will be used in the restoration of Demonstration Project lands to upland wildlife habitat and will be applied in a manner that will not contribute to deep percolation to the shallow groundwater underlying the project lands (USDI 1999). Water acquired in excess of the anticipated need will be sold to eligible landowners within the districts on an annual basis to be applied for irrigation purposes on non-drainage impacted lands, or may be transferred to other CVPIA purposes. At the end of the five-year project, Interior will evaluate the need for continued use of acquired water on Demonstration Project lands. If not needed for habitat restoration or continued management of these lands, Interior may sell the water to another user within the water district for CVPIA uses or may transfer the water outside the district for CVPIA uses (USDI 1999).

The Demonstration Project will provide a way to assess impacts of land retirement on physical and biotic parameters and to test various habitat restoration and management strategies on a relatively small scale prior to implementation of land retirement on larger acreages.

Two primary concerns of the LRT are:

- land left unmanaged would be a potential source of weeds and pests to neighboring farms, and
- return to a self-sustaining upland community comprised primarily of native species would take 10-20 years or more without active restoration.

One reason for the long time frame predicted for the reestablishment of a native upland plant community is the lack of vegetation remaining to serve as a seed source for the retired land. This time frame must be compressed by active restoration of retired parcels so that desired native plant species become established and have advantage over non-natives and pest species within a few years of retirement.

DEMONSTRATION PROJECT GOALS

The Land Retirement Demonstration Project was initiated to address concerns about the scope and degree of impacts of retirement on wildlife, drainage volume reduction, socio-economics, and overall cumulative effects of removal of land from irrigated agriculture. Results from monitoring and research on the 15,000 acre Demonstration Project will be used to prepare environmental documentation for further land retirement, and guide restoration and management decisions on retired lands.

The desired outcome for these retired agricultural lands is for drainage reduction and the reestablishment of self-sustaining upland communities such as California prairie, Valley Sink Scrub and Valley Saltbush Scrub (Holland 1986). Since relatively little information is available regarding upland community restoration on retired agricultural land in the Central Valley, the Demonstration Project will provide an opportunity to study the effects of rehabilitation techniques prior to implementation on a larger scale. Monitoring of the biotic response to habitat restoration efforts will allow for detailed examination of the impacts of various types of specific habitat manipulation on plants and wildlife.

Specifically, the goals of the land retirement Demonstration Project are to:

1) Provide site-specific scientific data to guide implementation of the larger Land Retirement Program and develop tools for predicting the potential benefits and impacts of retiring lands from irrigated agriculture;
2) Research cost-effective means of restoring self-sustaining communities of native upland plant and animal communities on Demonstration Project lands which will be applicable to larger acreages;
3) Use adaptive management principles[1] (Holling 1978, Walters and Holling 1990) to maximize efficiency of the restoration research program; and,
4) Educate stakeholders about the Land Retirement Program.

DEMONSTRATION PROJECT LOCATIONS AND SITE DESCRIPTIONS

The Demonstration Project will consist of project sites in two geographically and physiographically different drainage-impaired basins to generate data representative of large scale land retirement. The western Fresno county site (Westlands) will consist of approximately 7,000 acres and the site located in Kings and Tulare counties (Alpaugh) will be approximately 8,000 acres.

Monitoring of biota, soils, and surface and groundwater depth and quality will occur on the entire 15,000 acres of Demonstration Project lands as they are purchased over the next few years. This first annual report contains results from physical and biological monitoring only at the Westlands site. The first Alpaugh site Demonstration Project lands were acquired in late January 2000 and monitoring results from those lands will be presented in future annual reports.

Westlands Site

The Demonstration Project has been initiated on approximately 1,646 acres in western Fresno county on the Westlands site (Figure 1). Much of the land had been in recent cultivation prior to purchase by the LRT. A cover crop was planted in 1999 on approximately 1,200 acres for weed and erosion control. The remaining acres were fallowed for longer than five years and had sufficient cover so they were left undisturbed. A large-scale habitat restoration experiment has been established and first year baseline monitoring was conducted at this site in 1999.

Alpaugh Site

As of January 2000, 2,643 acres of land has been purchased in Kings and Tulare Counties in the Tulare Basin area near Alpaugh (Figure 2). Nearby natural areas that will serve as reference

[1] Adaptive management is an approach to resource management that involves learning from the outcomes of management actions, and adjusting the management program accordingly based on the new knowledge. Monitoring is a way of providing feedback for decision-making in the adaptive management process.

sites and seed sources include Kern National Wildlife Refuge, Pixley National Wildlife Refuge, and Allensworth Ecological Reserve.

Current acquisitions include lands recently released from the Conservation Reserve Program that have not been cultivated in over ten years. Surveys conducted by ESRP in 1998 indicated that several sensitive species inhabit or use the site (Uptain et al. 1998). Other sensitive species may be found during monitoring conducted for the Demonstration Project.

Habitat restoration research will be conducted at the Alpaugh site on a smaller magitude than at the Westlands site. A research plan for this southern portion of the Demonstration Project is described in Appendix D of this report.

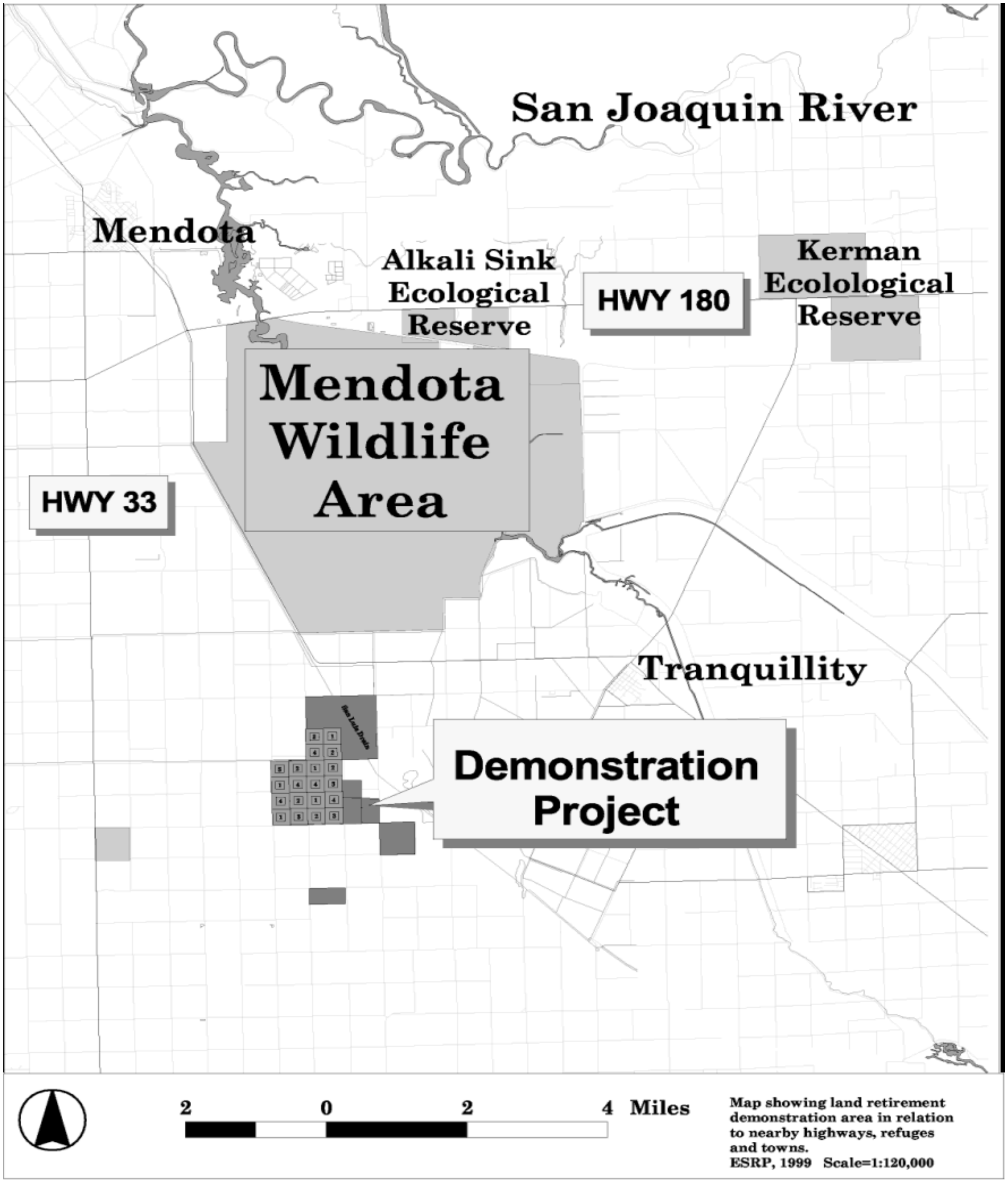


Figure 1. Land Retirement Demonstration Project Site - Western Fresno County

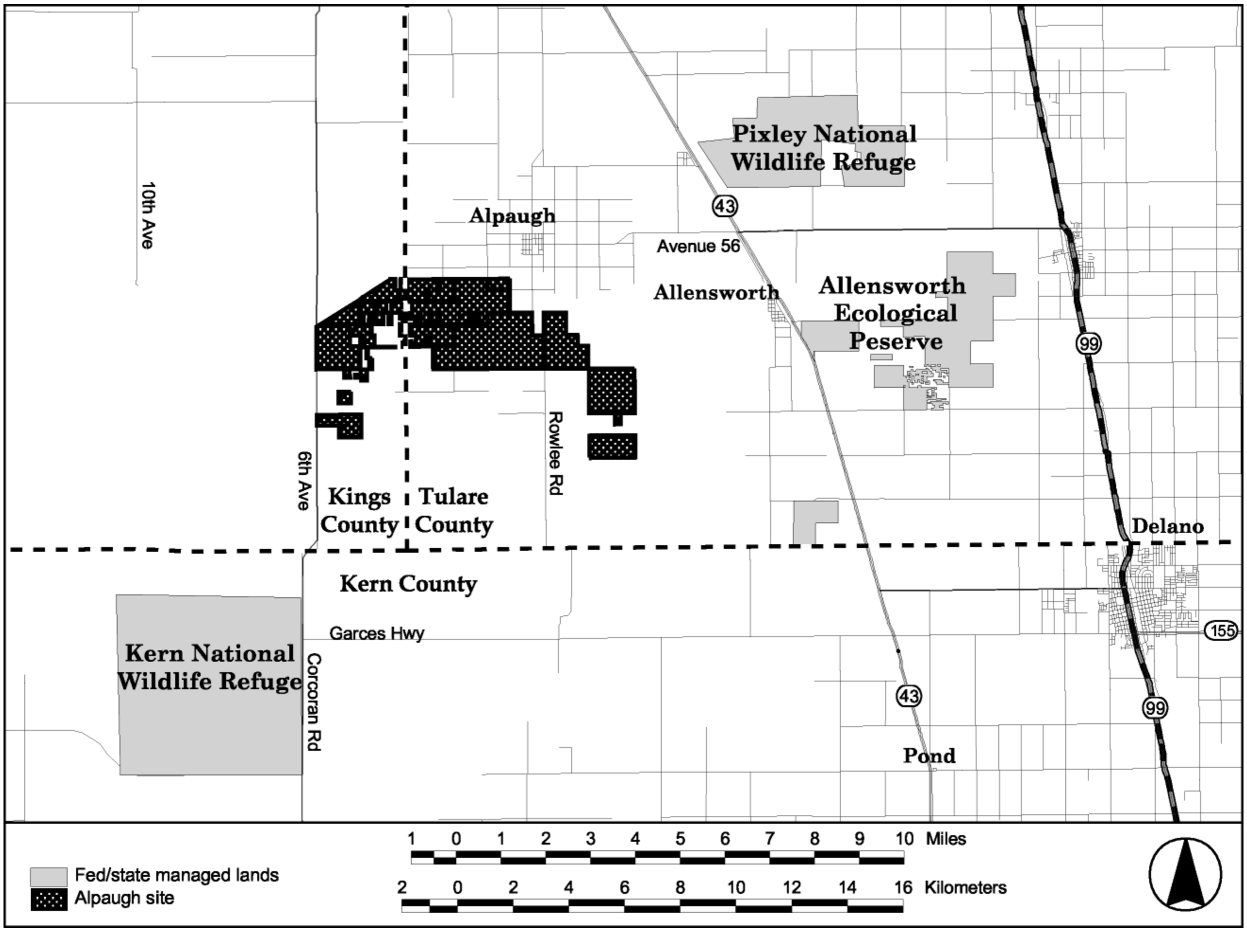


Figure 2. Land Retirement Demonstration Project Site - Kings and Tulare Counties

RESTORATION AND MANAGEMENT OF DEMONSTRATION PROJECT LANDS

Over the course of the five-year Demonstration Project, a variety of restoration and management activities will be initiated on retired lands. Some acreage will be part of restoration-related experiments, some will be undergoing active restoration, and other lands will be in some form of wildlife-friendly land management.

HABITAT RESTORATION STUDY (HRS)

An 800-acre Habitat Restoration Study (HRS) was established at the Westlands Demonstration Project site in 1999 to examine specific restoration techniques and the responses of plants and wildlife in a scientifically rigorous manner. Data will be collected and analyzed to assess differences between experimental treatments for a minimum of five years.

Specific objectives of the HRS are to:

> Determine the efficacy of revegetation with native plants as a means to facilitate upland habitat restoration,
> Determine the efficacy of microtopographic contouring as a means to facilitate upland habitat restoration, and
> Examine the effects of phased reintroductions of selected small vertebrates.

The size of the HRS was determined based on a compromise between the amount of acreage that could be reasonably manipulated and monitored with a high degree of experimental rigor, and yet had potential to yield significant results in a relatively short amount of time (five years or less). Twenty study plots, each 40 acres in size, have been established on 800 acres of the Westlands site (Figure 3). Plots were arranged to create a randomized block design, which will allow for rigorous statistical analysis. Blocking was used because of the heterogenous physical characteristics on the site and the large plot size. Randomizing treatments within blocks ensures that all the replicates for a given treatment won't be clumped together. A two-factor analysis of variance with equal replication is the statistical test used for most data analyses (Sokal and Rohlf 1995; Zar 1996).

The central 10 acres of each of the 20 plots will be subjected to one of four experimental treatments to evaluate different land restoration options while the surrounding 30 acres will function as a buffer area. These buffer areas around each plot will help to exclude or reduce interactions between treatments among neighboring plots. While the entire Demonstration Project area will be monitored to some extent, the most intensive monitoring will occur on the 20 experimental plots.

Experimental Plot Treatments

The four HRS experimental treatments, which were randomly assigned within each of the five blocks, are described below in Table 1. The two-letter codes given to each of the four treatments represent the presence (C or R) or absence (N) of the two restoration techniques begin explored.

Table 1. Experimental Treatment Descriptions and Codes

Number	Code*	Description
1	CR	Microtopographic contouring (berm-making) with reintroduction of desired native plant species
2	CN	Microtopographic contouring (berm-making) with no reintroduction of desired native species
3	NR	Reintroduction of desired native plant species with no contouring
4	NN	No contouring and no reintroduction of desired native plant species (control treatment)

*C = contouring; R = reintroduction; N = none/no application of this technique

Experimental Plot Establishment

Experimental study plots were established in April of 1999. Plot corners were permanently marked with three-foot sections of rebar. Pin flags were added to help locate plot corners. Plot corners were located with a Global Positioning System (GPS) receiver and data points were archived.

Birds have been observed using the rebar marking corner posts for perches, which could negatively impact the small mammal populations on the study plots. Therefore, t-posts modified with spikes to discourage bird use will replace the rebar markers in the 2000 calendar year and will remain as the permanent markers of plot corners for the remainder of the project.

Plot Perimeter Planting Scheme

Barley was planted in the fall of 1998 on 1,220 of the 1,646 acres at the Westlands site as a cover crop to prevent soil erosion and inhibit weed growth. For the first year of the Demonstration Project, all HRS experimental plots were planted in barley along with perimeter buffer areas. Extensive ground preparation was conducted, including single or multiple discings, cultipak and bedrolling. The reason for planting a cover crop was to make the study area as homogeneous as possible, in addition to preventing weeds from dominating buffer areas between plots and other non-experimental areas. Soil was prepared until it was of uniform texture across the site and barley was planted at approximately 170 lb. per acre.

Barley growth in early 1999 was sufficient to control weeds and prevent soil erosion. A reasonably wet spring would have allowed for dryland farming with no applied irrigation water. Despite predictions of rainfall in February 1999, very little precipitation occurred. Such conditions necessitated irrigation of the barley. A total of 271 acre-feet of water was applied to the 1,220 acres. The irrigation helped to prevent a complete loss of harvestable seed, but due to the late timing of watering and possibly a lack of fertilizer, only a modest grain crop was produced. The spring 2000 barley will be irrigated regardless of anticipated rainfall, to ensure an economically harvestable seed crop.

A total of 275 tons of barley was produced on the Westlands Demonstration Project lands in 1999. The harvested seed was sold to a local grain company, Penny-Newman Grain Co., where seed was originally purchased. The balance remaining after paying for harvesting covered approximately 70% of the cost of the year 2000 seed purchase.

Harvesting of the barley cover crop occurred in mid-July 1999. Harvesting was delayed until the end of the spring nesting season, a wildlife-friendly farming technique (Clark and Rollins 1997) which will be practiced on Demonstration Project lands whenever feasible. Following consultation with a professional barley harvester, it was decided that only fields with especially good barley growth would be profitable to harvest completely. Other fields were harvested only around the borders where seed production was highest. Uneven growth around field borders occurred mainly due to the overflow of water from neighboring fields that aren't part of the Demonstration Project. All experimental study plots were harvested in 1999 for consistency, regardless if the buffer areas surrounding the plots had poor barley growth and were not harvested. In future years, experimental plots will not be planted in barley and volunteer barley will not be harvested.

Due to the effectiveness of the 1999 crop at controlling weeds and providing vegetative cover on retired lands, barley was again selected as the cover crop for the year 2000. The seed is inexpensive ($0.10-$0.15 per pound) and can be planted without extensive ground preparation. With normal spring rainfall, irrigation of the barley crop isn't necessary, further reducing the cost of production. However, irrigation is necessary to obtain a profitable crop in dry years.

Alternative cover crops to barley, including some native grass species, will be explored in research trials to determine if there is a particular species or mix that will discourage weeds yet not need to be replanted annually (see Ancillary Restoration Studies). Based on good germination in early 2000 on areas not actively reseeded, barley may reseed well enough on its own to provide adequate cover in the second year, negating the need for expensive annual ground preparation and seeding.

Barley may ultimately end up serving solely as a cover crop in some areas, and as a harvestable grain crop in other areas of the Demonstration Project. The difference in the outcome for each field would relate to the water and fertilizer inputs, level of ground preparation, amount of seed per acre, and judicious use of herbicides to decrease weed seeds that would ultimately be harvested with the grain.

Biological Monitoring

A baseline biological survey was conducted on the Demonstration Project site in December 1998 to generate an initial species list for the site. Results are reported in Appendix A of the Demonstration Project Resource Monitoring Plan (Selmon et al. 1999).

Baseline biological monitoring on experimental plots began in April 1999 (Appendix A). The following biological surveys were completed in 1999:

3 Avian Surveys
1 Vegetation Survey(Composition)
1 Invertebrate Survey
1 Herpetological Survey
1 Small-Mammal Survey
2 Spotlighting Surveys
2 Track Station Surveys
1 Winter Raptor Survey

Results from all surveys are reported and discussed later in this document.

Treatment Application to Experimental Plots

Contouring (berm creation) and active reintroduction of native plants constitute the two primary habitat restoration techniques which will be explored as experimental treatments on the 20 HRS plots. Berms were established in January 2000. While treatment application to experimental plots was scheduled to be completed by January 2000, a period of frequent precipitation prevented access to the fields and seeding the plots with native species wasn't completed until March 2000. Planting of native plugs was also delayed until March and April 2000.

Microtopographic Contouring

In most retired agricultural areas the fields have been leveled, and any increase in microtopographic heterogeneity should be of benefit to wildlife. Microtopographic contouring equipment was initially explored in September of 1999. Berms created with a berm-maker, which is commonly used to make "cells" for flood-irrigation of alfalfa fields, were found to be of sufficient width but were not as tall as desired. Modifications were made and a second "berm trial" took place in November 1999. Satisfactory berms were made with the modified berm maker.

The berms on the experimental plots range in height from 1.5 to 2.5 feet, and they create suitable microhabitats for plants and wind-protected sites for burrowing animals. These subtle differences are expected to provide beneficial effects for colonizing species. With limited resources and the goal of finding cost-effective restoration strategies applicable on a large scale, a berm design that was relatively inexpensive and easy for a farm equipment operator to create was selected. Berm construction was completed on experimental plots in January 2000.

The berm design described in the Demonstration Project Resource Monitoring Plan (Selmon et al. 1999) was modified from a pattern containing both N/S and E/W oriented berms to a design with a single berm orientation. This was easier for set-up and eliminated some logistical problems related to seeding over the other berm pattern. If differences in plant establishment and survival are going to occur on berms, they will likely be a result of solar exposure or prevailing winds (generally from the NW).

Varying berm heights and orientations will be examined in a research trial established outside the HRS experimental plots (see Ancillary Restoration Studies below). This trial will help to determine if berm height and orientation affects native species and if the additional financial investment required to create larger berms would result in improved restoration effects.

Native Plant Reintroduction - Direct Seeding with an Imprinter

A list of target plant species for the Westlands site was developed based on species lists from nearby ecological reserves and known species composition of the desired plant communities: Alkali Sink, Alkali Scrub, and California prairie (Holland 1986, Appendix B). A native seed mix was then developed for the experimental plots that includes key species from each of the targeted plant communities (Table 2). This mix costs approximately $310 per acre.

Table 2.   Native Seed Mix for the HRS Experimental Study Plots.

Scientific Name	Common Name	Source*	Pounds/Acre
Allenrolfea occidentalis	iodinebush	unknown	2
Atriplex polycarpa	valley saltbush	Taft	2
Atriplex spinifera	spiny saltbush	Taft	1.5
Bromus carinatus	California brome	San Francisco Bay area	3
Frankenia salina	alkali heath	San Diego County	0.5
Heliotropum curassavicum	heliotrope	Temecula	0.5
Hemizonia pungens	common spikeweed	unknown	0.1
Isocoma acradenia	goldenbush	Indio	1
Lasthenia californica	goldfields	Hemet	0.5
Leymus triticoides	creeping wild rye	Rio	2
Sporobolus airoides	alkali sacaton	unknown	1
Sueda moquinii	bush seepweed	Lakeside	0.5
Vulpia microstachys	Nuttall's fescue	San Bernadino	2
*Source information was provided by the seed vendor			

A majority of the seed used on the HRS was commercially purchased because of a lack of nearby native areas to collect from and poor seed production in 1999 for some species (Table 2). An aggressive seed collection and propagation plan will be implemented in spring 2000 to increase the amount of locally collected seed in future seed mixes. Nursery areas will be established on Demonstration Project lands to expand the seed source for local genotypes.

To prepare the seed mix, the appropriate amount of seed for each species was measured out in equal proportions on ten plastic tarps, one for each plot receiving the plant reintroduction treatment. Bran was mixed with the native seed to prevent the seeds from sorting according to size. All piles of seed and bran were thoroughly mixed, bagged, and stored until planting.

Seeding methods were researched early in 1999 to determine which methods would minimize disturbance and maximize germination rates. Imprinting has been shown to be an effective seeding technique for natives in some areas in California (St. John 1995; Dixon 1998; St. John et al. 1998). Imprinting creates impressions in the soil and simultaneously deposits seed in the trough of the impression. It has the advantages of promoting good seed-soil contact and providing safe-sites for seeds which provide protection from wind and predators.

Based on past successes with imprinters on other sites and considering the obvious benefits described above, the decision was made to proceed with imprinting as the preferred method of seeding. A research trial will be established to test the effectiveness of imprinting vs. traditional seeding techniques on Demonstration Project lands outside the HRS boundaries.

Imprinting is most effective after the first winter rains so that consistent and firm imprints are formed in the soil (T. St John, pers. comm.). Due to a late onset of winter rains and technical difficulties with farm equipment, imprinting was not completed until March 2000. While the imprinting was completed a little later than generally recommended for native seedings, the benefit of planting with some soil moisture should help make up for the late timing of planting. The seeds were irrigated along with the barley in March and April 2000, which should increase the chance of germination.

Native Plant Reintroduction - Transplanting Nursery Stock

Native plugs were commercially grown as an additional reintroduction method to seeding. Plugs of *Allenrolfea occidentalis*, *Atriplex polycarpa*, *Isocoma acradenia*, *Sporobolus airoides*, and *Leymus triticoides* were planted between February and April 2000.

Shrub islands were established with clusters of native plugs within each island. Grouping the shrubs in such a way should allow for a mycorrhizal network to establish more quickly than if the shrubs were evenly dispersed across the plots. Two types of shrub islands were created, one containing *Sporobolus*, *Leymus* and *Allenrolfea* (Figure 5), and another type with *Atriplex* and *Isocoma*. Fire-sensitive species were grouped together so that they could be protected if fire is ever used as a management tool on experimental plots. Shrub islands were positioned across berms on plots receiving both treatments, so that differences in survival of each species relative to position on north/south berm slope, or in a trench or on the flat area, can be examined (Figure 5). Plugs were watered by sprinkler irrigation in March and April along with the barley in buffer areas.

ANCILLARY RESTORATION STUDIES

During the course of researching the important considerations in restoring native communities, it became apparent that questions on the efficiency of certain methods would arise that could not be explored within the boundaries of the 800-acre HRS. Too many introduced variables would obscure the effects of the treatments and weaken the experimental design. Also, it appears as though some techniques may turn out to be useful in facilitating native plant establishment, yet be cost-prohibitive on a large scale. We anticipate ultimately developing a flow chart-like restoration scheme which will lead to different outcomes for recommended restoration steps based on factors such as available finances and other resources, size of the area to be restored, and condition of the parcel at the time of restoration (ie. recently cultivated, fallowed for a number of years, etc.).

Ultimately, this research program will explore many such methods in ancillary research trials located outside the HRS experimental plots. Three such research trials have been identified and are described below. Additional research trials will be described in future Land Retirement Demonstration Project Annual Reports as they are developed. Due to dry conditions in the fall of 1999, establishment of ancillary trials was postponed until the fall of 2000.

Imprinting

Imprinting as a seeding method for native species was explored in the spring of 1999. A demonstration was held to see how an imprinter worked in general, and specifically to determine if it appeared practical or even necessary for successful establishment of desired species on Demonstration Project lands (Appendix C). The purpose of the imprinting demonstration and test plots was to generate some information to guide decision-making for fall 1999 plantings on the HRS experimental plots.

Small test plots were established and seeded with various combinations of native seeds and potential cover crop species. Mycorrhizal inoculum was introduced to a few of the test plots to examine any effects it might produce. We attempted to explore the best options that would be appropriate to apply to the 10-acre study plots, keeping in mind the goal of identifying the most cost-effective restoration techniques. Unfortunately, very little germination occurred in the spring or summer of 1999, probably due to the late timing of seeding and lack of sufficient rainfall following the planting effort. As of spring 2000, however, approximately 30 *Atriplex polycarpa* plants were found in the test plot which was imprinted and received inoculum.

Because of the absence of germination of any of the planted native species on the test plots when examined in the fall of 1999, decisions regarding which techniques to use on the 10-acre experimental plots were made based primarily on financial considerations and previous success with techniques used in other restoration efforts. While imprinting could feasibly be implemented on a large scale on retired lands, adding mycorrhizal inoculum to the restoration formula considerably increased the cost per acre ($150 or more). Therefore, the decision was made to proceed with imprinting of seeds on HRS plots, and explore mycorrhizal inoculation on smaller ancillary research plots (described below).

Imprinting will also be explored outside the HRS plots, both for planting native seed and as an alternative seeding method for barley or other cover crops. If imprinting is found to be an effective seeding technique for barley, it would entail significant cost-savings by reducing the need for extensive ground preparation recommended for traditional seeders, and also reduce the overall level of soil disturbance produced by seeding itself. Less soil disturbance should decrease weed density and promote the establishment of mycorrhizal networks in the soil, both of which tend to favor natives.

Experimental plots approximately 1.5 acres in size will be used to explore imprinting vs. traditional seeding of native species. Six plots consisting of three replicates of the two levels of treatment (imprinting vs. traditional seeding) will be established to examine the effects of the different seeding methods on native species (Figure 6). Equal-sized plots will be used to examine the same seeding methods with two different cover crop mixes: barley and a combination of barley, *Bromus carinatus,* and *Leymus triticoides*. A total of 12 experimental plots will be established to examine seeding methods of cover crops. There will be two levels of seed mix in addition to the two levels of seeding, and three replicates of each combination (Figure 7).

Monitoring will be conducted each spring once vegetation surveys on the HRS are completed. Percent cover and percent native species will be determined for each plot.

Mycorrhizal Inoculation of Soils

Mycorrhizal inoculation of soils was deemed cost-prohibitive for large-scale use on the HRS due to the cost per acre of application. However, it could be an important factor in restoration of desired communities on Demonstration Project lands despite its high cost. As such, a research trial has been designed which will allow for examination of the effects of adding mycorrhizal inoculum to the native seed mix.

A total of nine study plots, each 0.25 acres in size, will be established to examine the effects of adding liquid or pelletized mycorrhizal inoculum (Figure 8). Three replicates of each treatment (liquid, pelletized and no inoculum) will be created with this design. A native seed mix will be used to test differences in germination rates between the various treatments. Monitoring will be conducted in the spring following vegetation surveys on HRS plots and will consist of determining percent cover of native and non-native species.

Berm Size/Orientation

A discussion regarding the decision to position all berms on the HRS plots in east/west orientation can be found in the Micrographic Contouring section of this report. Study design restrictions prevented random positioning and orientation, as would likely be recommended on restored Demonstration Project lands beyond the experimental areas. However, to address this restriction to berm orientation along the east/west axis, a research trial has been designed which includes berms positioned relative to the north/south as well as east/west orientation (Figure 9). An area will also be created for this trial with random berm patterns, similar to the more natural patterns that would be established on non-experimental areas.

Since berm height is another factor that could influence the effects observed, berms will be created which are twice the height of the berms established on HRS plots. These will likely cost more to construct. They may require extra passes with the berm-maker or additional equipment may be necessary to obtain the desired height. If dramatic differences are found with establishment of natives on higher berms, the added cost may be warranted. A native seed mix will be imprinted over all the berms to prevent excessive weed establishment which would obscure the effects of berm height and orientation on the desired native species.

Mounds were not established on HRS plots, but may provide equally important and possibly different benefits to plants and wildlife than long berms. An area with mounds approximately 3-4 feet in height will be established within the matrix of berms to examine the effects of mounding vs. berms.

ALPAUGH SITE RESEARCH

A research study plan has been prepared to examine habitat restoration techniques at the Alpaugh site with similar methods but on a smaller scale than the 800-acre HRS. Retired lands in the Tulare Basin area will be different from the Westlands parcels with regard to soils, rainfall patterns, proximity to natural areas containing desired species, and other parameters. A comparable experimental design to the Westlands site study has been developed which examines cost-effective restoration techniques and will supplement results of other restoration research to guide the adaptive management process and decision-making for the Demonstration Project (Appendix D). Results of baseline surveys from the Alpaugh project site will be presented in the calendar year 2000 annual report for the Demonstration Project.

Research Blocks

A “research block” containing 16 plots 2-acres in size can be established within the borders of one 1/4 section of land. This is an easily replicatable design and will require fewer personnel to establish and monitor than the 800-acre HRS. The primary difference between the Westlands and Alpaugh research areas will be the size of the experimental plots and buffer areas. Rather than 10-acre plots centered in a 40-acre plot, we plan to establish 2-acre plots centered within 10-acres plots at Alpaugh (Figure 11).

Three research blocks will be established at the Alpaugh Demonstration site (Figure 12). These research blocks would each be located on different soil types, and monitoring data collected to compare differences between treatments within blocks, between research blocks, and ultimately an index will be created which will allow for comparisons with the Westlands research site.

A study plan which describes in detail the biotic surveys and contaminants monitoring activities for the Alpaugh site can be found in Appendix D.

MANAGEMENT OF NON-EXPERIMENTAL DEMONSTRATION PROJECT LANDS

The Demonstration Project will provide an opportunity to explore habitat restoration methods and changes in the soils and hydrology due to land retirement, but also will provide an opportunity to research alternative farming and grazing practices which may provide wildlife benefits. Demonstrating that active land use and practices that encourage wildlife can be compatible with one another could provide immeasurable benefits to Valley species which suffer from widespread losses of habitat.

Barley/Cover Crop Production

Cover crops can be produced for profit and simultaneously provide important sources of food and cover for wildlife. As much as 6 inches of water can be applied to retired soils per year to water native plants or irrigate a cover crop, in accordance with the Land Retirement Program Interim Guidelines (USDI 1999). A harvestable crop can be grown on lands receiving sufficient rainfall and/or irrigation. Barley has been established for the first two years on the Westlands Demonstration Project site and has successfully prevented excessive weed growth and provided food and cover for wildlife.

It is likely that barley or other grain or cover crops will be grown on retired lands, either by the LRT during initial phases of restoration, or by lessees of retired lands. Lessees must be willing to work under the program guidelines regarding irrigation limits, chemical controls, and practices to encourage wildlife on areas of cultivated fields.

Grazing

Grazing is another management practice that could be used to manage retired lands on the Demonstration Project until restoration is initiated. Not all parcels will be restored at once, due to both financial and logistical constraints. In the interim, some lands will be leased for either wildlife-friendly farming demonstrations as discussed above or for grazing of sheep, cows or goats. Experimental grazing management techniques that favor native plant species will be explored to the extent possible on Demonstration Project lands.

Recreational Uses and Educational Opportunities

As lands are acquired and retired from irrigation and native plant and animal communities return to these lands, there will be increased opportunities for wildflower and wildlife viewing, photography, and environmental education. In addition, some lands will be developed and managed for gamebird hunting programs in cooperation with the Department of Fish and Game (DFG). On the Alpaugh project lands, there is a freshwater pond which has been managed as a private duck hunting club. BLM will retain and manage this wetland. Waterfowl hunting opportunities will be managed by DFG (USDI 1999).

Additional educational and interpretive opportunities exist due to the character and historical background of these lands. The Alpaugh properties lie on the shores of the ancient Tulare Lake and represent paleoindian occupation of an inland lake system which dominated central California until the lakes were drained for agricultural use in the late 1880s. Along with the acquisition of these lands, several privately owned collections of artifacts will be donated to the people of the United States. Together, these collections represent a large and important assemblage of artifacts from the Central Valley peoples, with some items dating back 13,000 years. These collections will be used for research and will be curated in a facility meeting federal standards. Portions of the collections may be placed on loan to local and regional museums.

Partnerships are being explored between the California State University system, local tribal groups, local and regional school districts and affected counties, and the new Central Valley Regional Historical Museum that will be constructed in Fresno within the next 2 to 5 years to provide increased educational opportunities. These opportunities may be in a classroom, museum, or field setting.

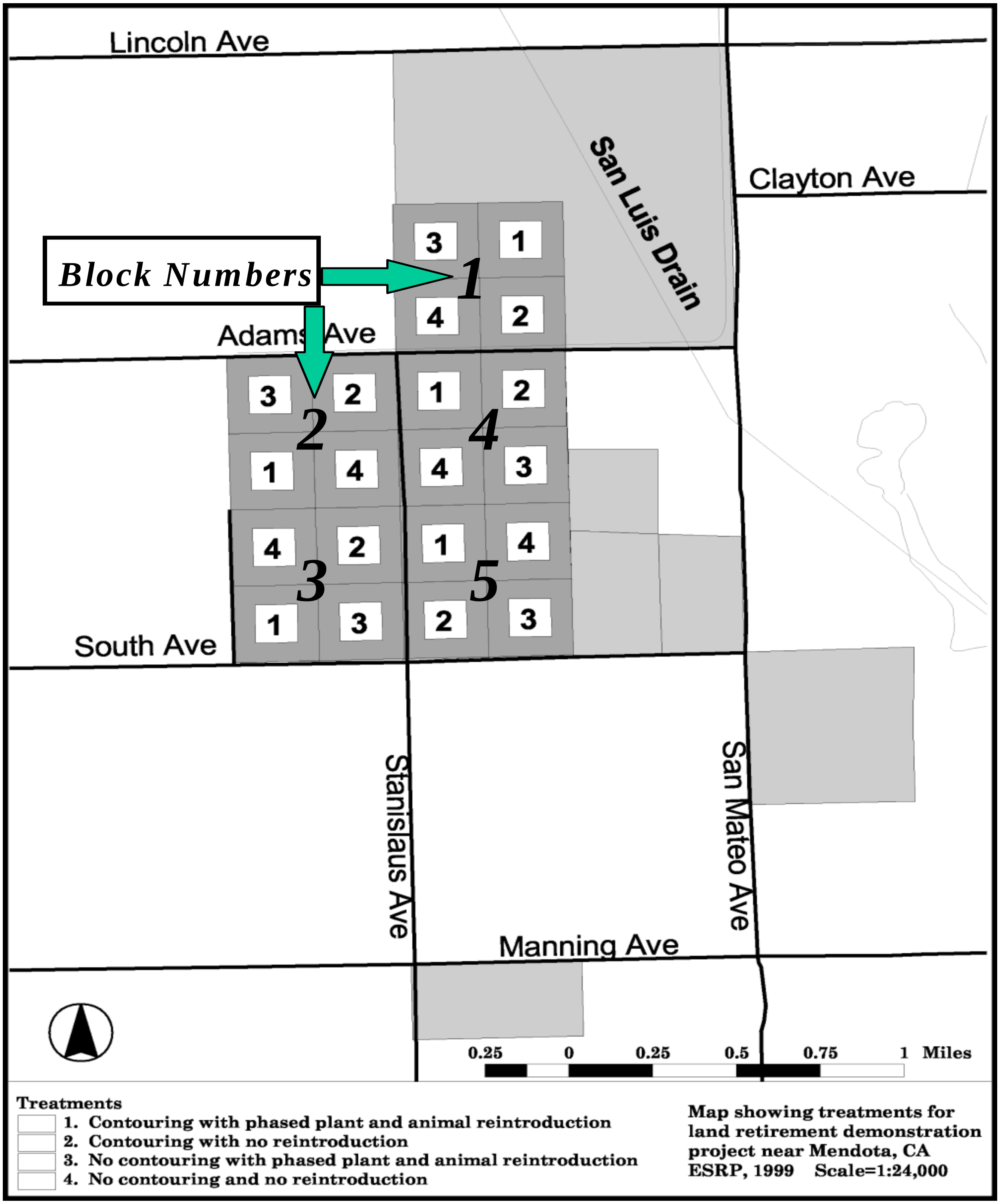


Figure 3. Land Retirement Demonstration Project Habitat Restoration Study Experimental Plots and Treatments

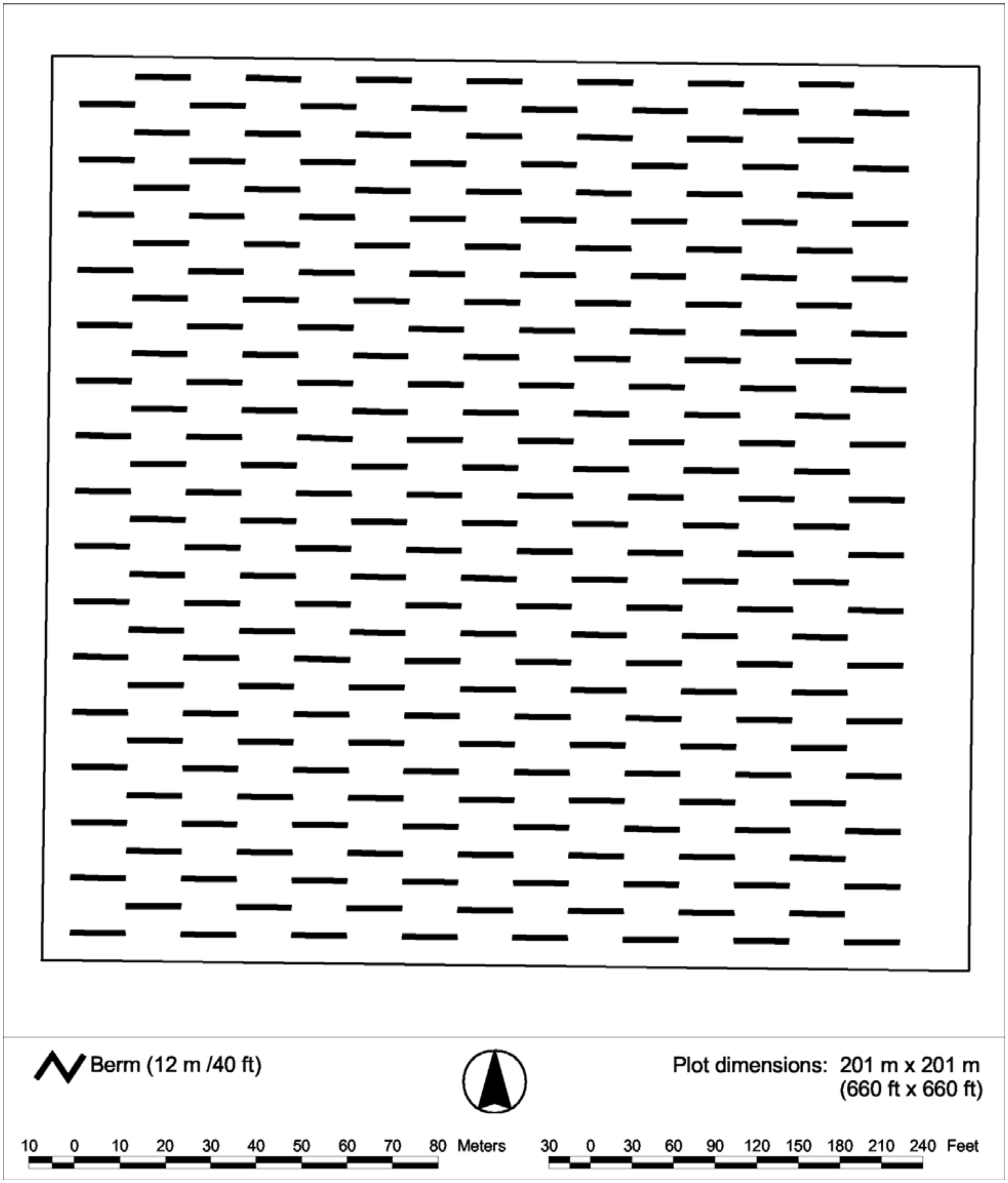


Figure 4. Microtopographic Contouring (Berms) on a 10-Acre HRS Plot

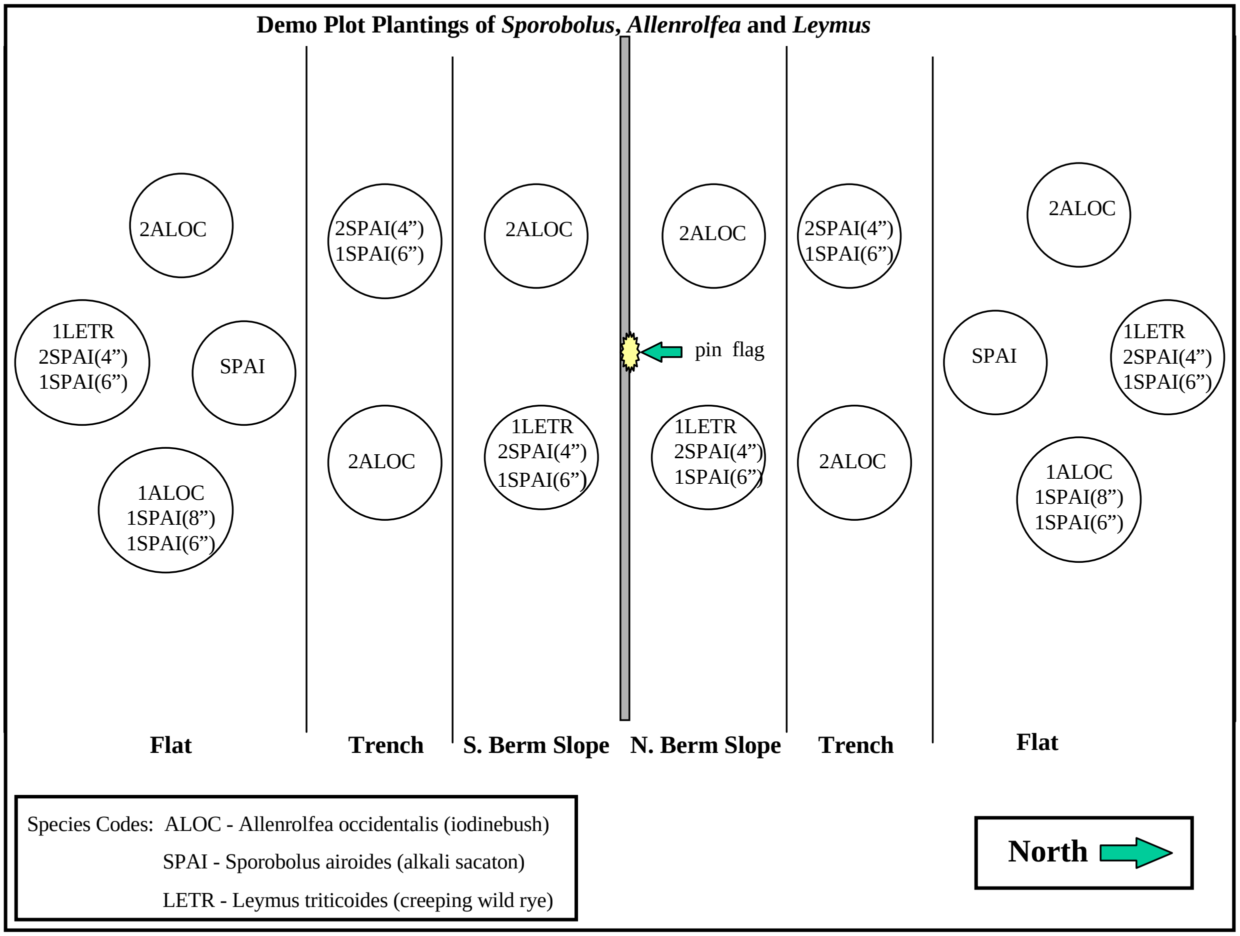


Figure 5. Example of a Shrub-Island on a 10-Acre HRS Plot

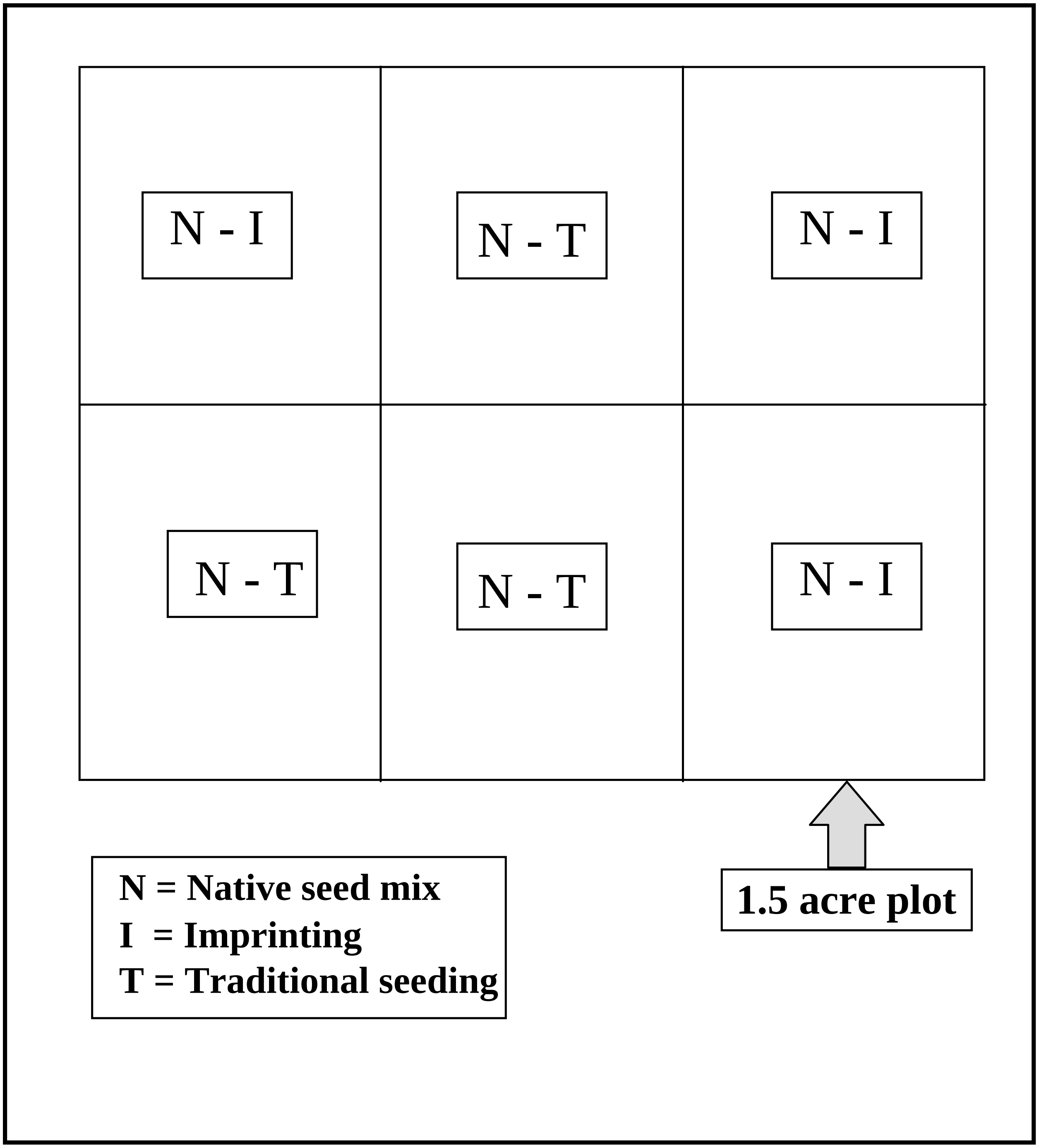


Figure 6. Native Seed Imprinting Trial Study Design

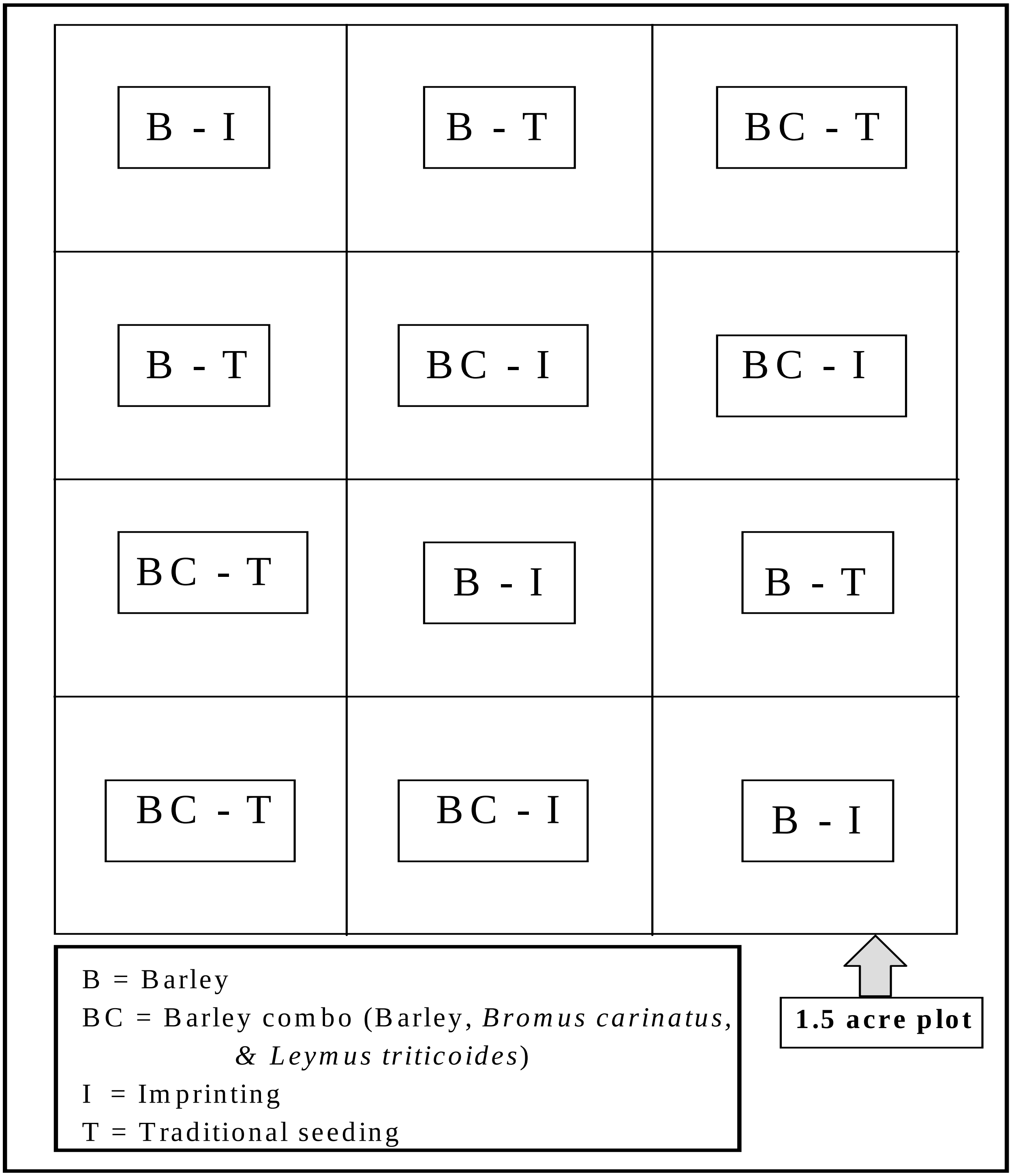


Figure 7. Cover Crop Imprinting Study Design

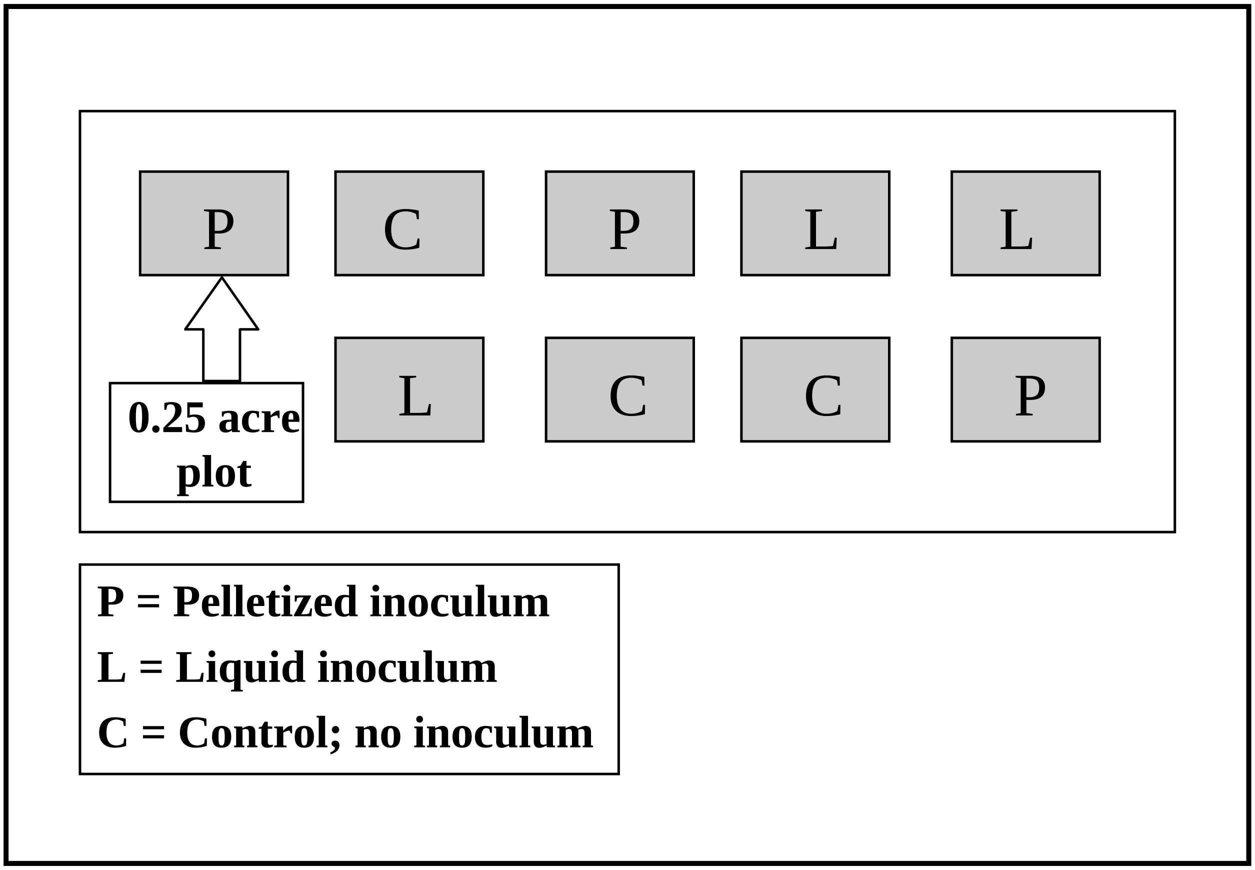


Figure 8. Mycorrhizal Inoculation Trial Study Design

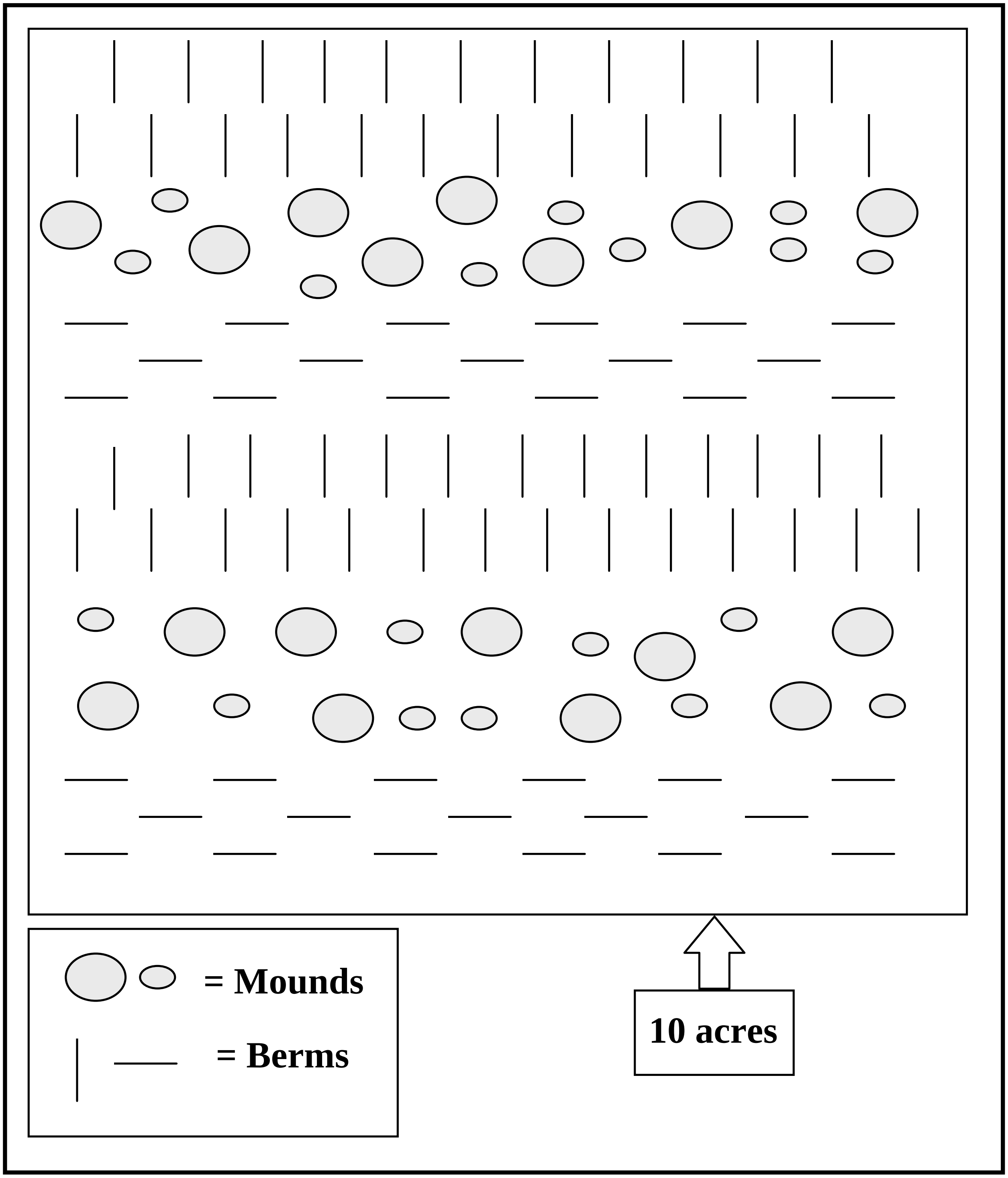


Figure 9. Microtopographic Contouring (Berm) Trial Study Design

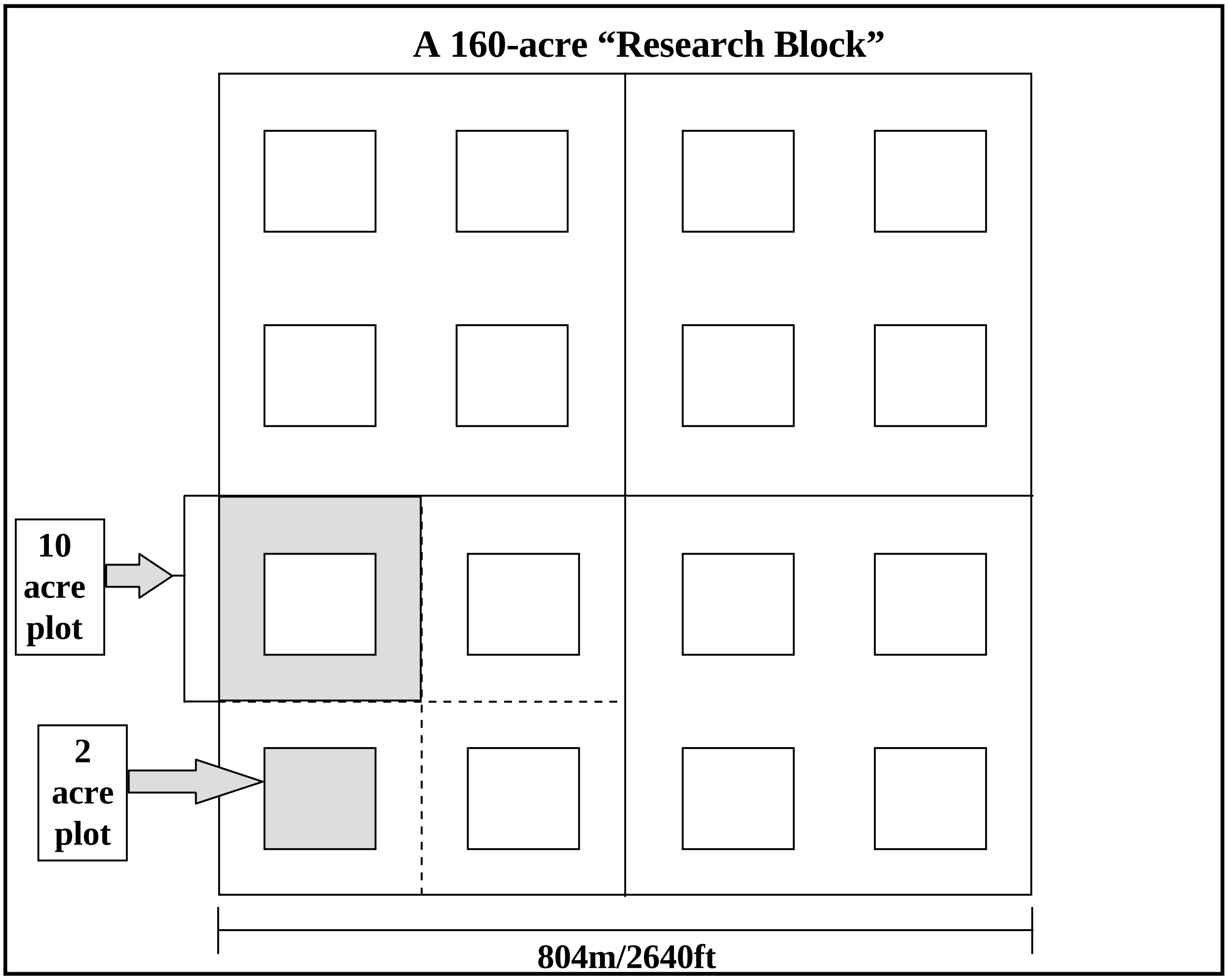


Figure 10. Alpaugh Project Site Sampling Design - A 160-acre Research Block

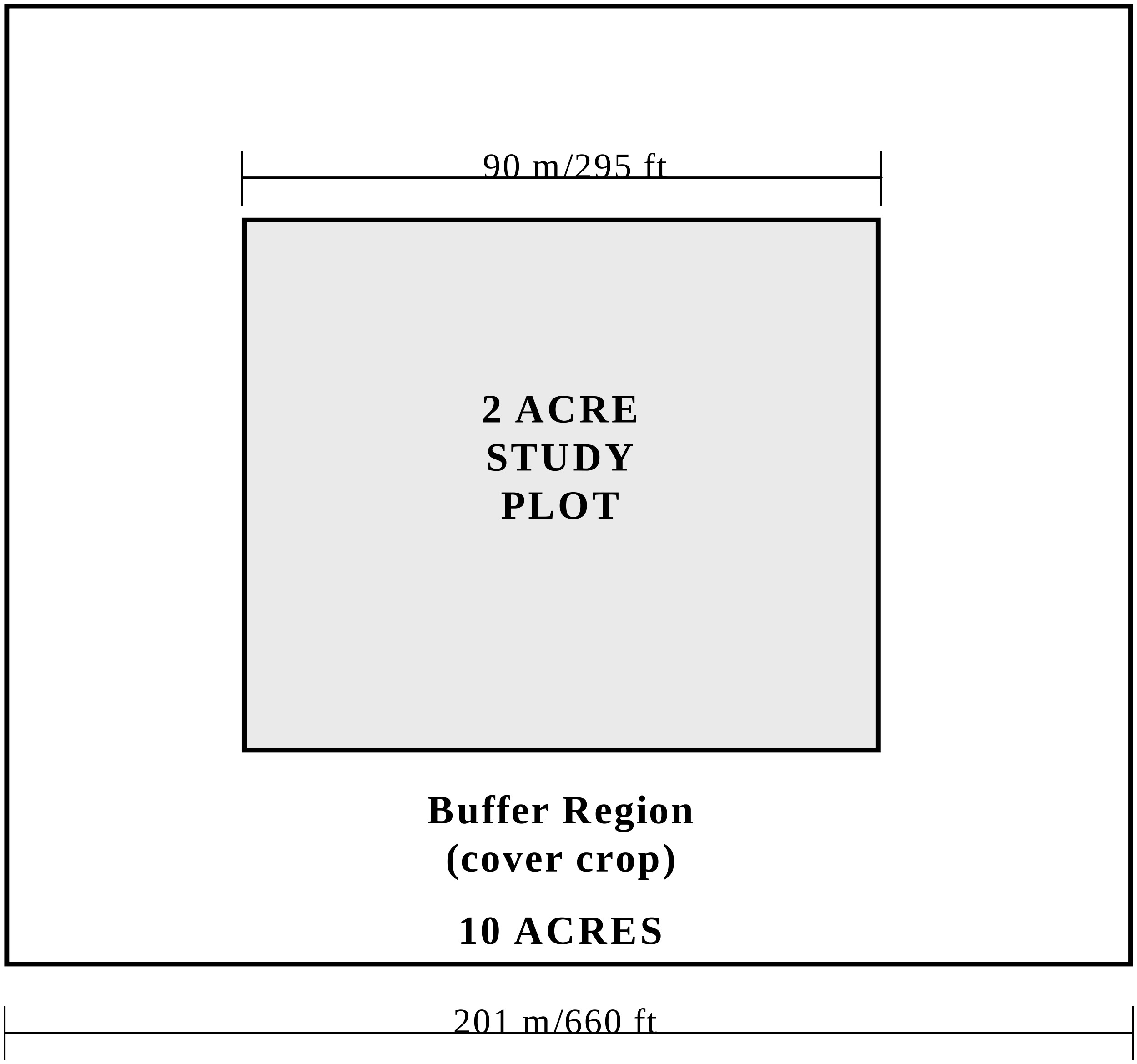


Figure 11. Alpaugh Study Plan - A 2-acre Experimental Plot within a 10-acre Plot

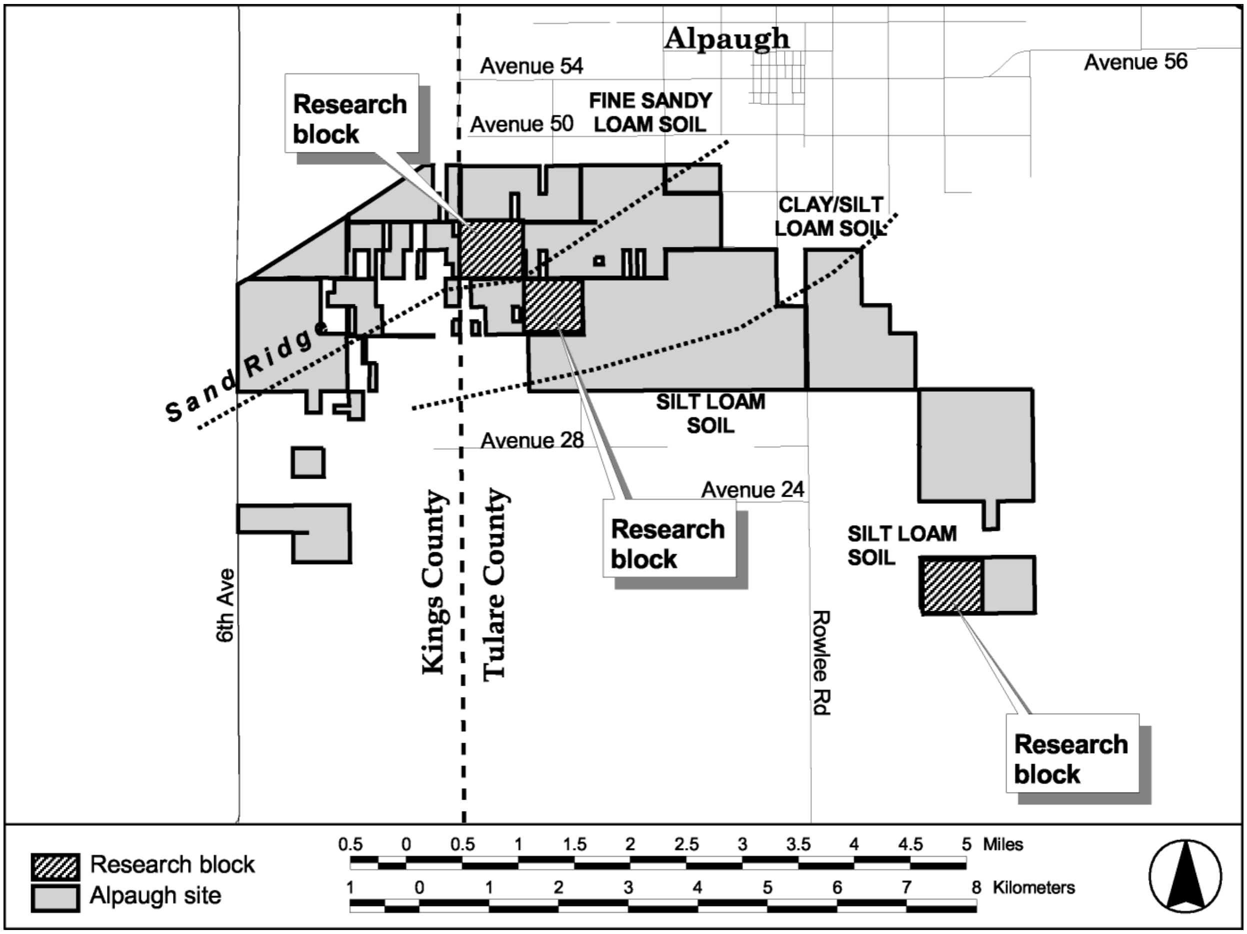


Figure 12. Proposed Locations of Research Blocks at the Alpaugh Project Site

1999 BIOLOGICAL MONITORING RESULTS

Baseline biological surveys were conducted in 1999 on Demonstration Project lands at the Westlands Demonstration Project site (Appendix A). Results from those surveys are presented and discussed below, along with briefly summarized methods. Detailed descriptions of methods for these surveys can be found in the Resource Monitoring Plan for Land Retirement Demonstration Project Lands in Western Fresno County (Selmon et al. 1999). Modifications to survey methods that were made after publication of the Monitoring Plan and reasons for the changes are discussed as appropriate.

HABITAT RESTORATION STUDY LANDS

Baseline data collected on HRS experimental plots provides a measure of differences between study plots at the beginning of the project. An attempt was made to homogenize the plots prior to treatment application by planting a cover crop of barley in 1998/99 on the entire experimental area to remove excess nutrients remaining from past farming activities and allow time for residual chemicals applied during past cultivation to dissipate. However, varied crop histories, differences in soil conditions, proximity of some plots to a nearby seasonal aquatic habitat, and natural variation in plant and animal populations likely affected survey results and may explain pre-existing differences between plots and treatments. At this point, differences are definitely not related to true "treatment effects", since all surveys reported in this document occurred before the experimental treatments were established. However, results are presented as treatment and block summaries for future comparisons with post-treatment effects.

All datasets from HRS plots with adequate sample sizes for statistical analysis were examined with a 2-factor ANOVA. Experimental treatments constituted one of the factors with the four different treatment combinations representing four levels of that factor. Blocking constitutes the second factor and contains five levels, one for each block of four plots containing randomly assigned treatments. Blocking of experimental plots was considered necessary because of the large plot sizes and physical gradients across the site.

Treatment and block effects were found in some cases when data were subjected to statistical analysis, which is not ideal considering we had hoped to begin this experiment with as much uniformity between plots as possible. However, while statistical differences may be detectable at this point, increases in the differences between plots and emerging patterns in the data over the next 5 years will allow for many meaningful comparisons and analyses.

Vegetation Monitoring

Methods

Vegetation monitoring was conducted on HRS plots in April 1999. Species composition, richness, and percent cover of individual species were determined for each experimental plot using the modified Daubenmire cover scale (Bonham 1989) with 35 cm by 70 cm rectangular plots (quadrats). Total percent cover was determined with an estimated value rounded to the nearest 5%.

To determine quadrat locations for cover samples, each experimental plot was divided into quarters and six quadrat sampling points were chosen at random within each quarter-plot. This resulted in examination of twenty-four quadrats per study plot. Stratification of samples into the four quarter-plots was done to facilitate dispersion of random samples across each 10-acre plot. Estimates of percent cover of barley and other individual species and percent total cover were recorded on datasheets in the field. Species composition lists were derived from these datasheets.

Productivity samples were not collected from experimental plots in 1999. Productivity will be estimated beginning in spring 2000 and will be reported in the 2000 calendar year annual report for the Demonstration Project.

Results

Vegetative species composition by experimental treatment is presented in Table 3. Species composition by block is also reported in Table 4 to provide a clear picture of baseline vegetation conditions on the site. Results of statistical analysis for treatment and block effects for percent cover barley and percent total cover are presented in Tables 5 and 6.

A total of 20 plant species were identified during the spring 1999 vegetation survey, including the barley cover crop (Tables 3 and 4). A total of 5, or 25% of the total number of species observed were native. Four of the 5 native species observed were located within a single plot in block 1. However, those species actually constituted a very small percentage of the total cover on the plots. Aside from plot 1, most plots contained only 1 or 2 native species. The difference between percent cover barley and percent total cover provides some indication of the average cover of non-barley species on experimental plots in April 1999. Care should be taken with direct comparisons between the two values since the percent total cover was estimated using a different classification system (single value estimate) than percent cover for barley and other individual species (Daubenmire cover classes which are each comprised of a range of values).

The low density of natives across experimental plots is desirable at this point in terms of homogenization of initial conditions across plots. However, the higher percent cover and richness of species in block 1 (Table 6) is important to document. A total of 18 of the 20 species were found in block 1 compared to blocks 2 to 5, which contained 8 or 9 species each. Although the density of those species is currently low, over time treatment effects may be different for this block compared to others due to differing starting conditions.

Treatment and block effects were found for both barley cover and total cover in 1999. Post-hoc analysis ($p<0.05$) revealed that the mean total cover for block 4 was significantly higher than other blocks and that treatment 2 had a significantly higher mean than other treatments (Tables 5 and 6). However, this difference may be explainable. Plot 14, which is located in block 4 (Figure 3), is adjacent to a drainage canal which became clogged with vegetation and overflowed early in 1999, providing extra water to the barley in parts of that plot. The drainage canal typically carries tailwater from neighboring fields to a location east of the Demonstration Project site. The extra water and possibly fertilizer addition from this tailwater likely influenced the vegetative cover on this plot, hence affecting the treatment mean. Ongoing maintenance will be conducted on the site beginning in 2000 to control vegetation in canals and on roadsides to prevent future overflows from occurring and affecting experimental plots.

Table 3. Vegetation Monitoring Results - Species Composition per Treatment. Native species are indicated by boldface type.

		TREATMENT			
Scientific Name	**Common Name**	**1 (CR)**	**2 (CN)**	**3 (NR)**	**4 (NN)**
Atriplex patula	**spear oracle**	X		X	X
Avena fatua	wild oats		X		
Hordeum vulgare	barley (cultivated)	X	X	X	X
Beta vulgaris	beet (cultivated)	X	X	X	X
Bromus madritensis rubens	red brome	X	X	X	X
Brassica nigra	black mustard	X	X	X	X
Capsella bursa-pastoris	shepherd's purse	X	X	X	X
Chenopodium album	lamb’s quarters				X
Convolvulus arvensis	bindweed		X		X
Erodium cicutarium	red-stemmed filaree	X	X	X	X
Eremalche parryi parryi	**Parry's mallow**	X			
Hordeum depressum	**low barley**	X	X		
Hordeum murinum	foxtail barley	X	X	X	
Lactuca serriola	prickly lettuce	X	X	X	X
Malvella leprosa	**alkali mallow**	X			X
Melilotus indica	yellow sweet clover	X	X	X	
Phacelia distans	**common phacelia**	X			
Senecio vulgaris	common ragwort	X	X	X	X
Sonchus oleraceus	common sow thistle	X	X	X	X
Sisymbrium irio	London rocket	X	X	X	X

Table 4. Vegetation Monitoring Results - Species Composition per Block. Native species are indicated by boldface type.

Scientific Name	Common Name	BLOCK 1	2	3	4	5
Atriplex patula	**spear oracle**	X				
Avena fatua	wild oats	X				
Hordeum vulgare	barley (cultivated)	X	X	X	X	X
Beta vulgaris	beet (cultivated)	X	X			
Bromus madritensis rubens	red brome	X			X	
Brassica nigra	black mustard	X	X			X
Capsella bursa-pastoris	shepherd's purse	X	X	X	X	X
Chenopodium album	lamb’s quarters		X			
Convolvulus arvensis	bindweed	X		X		
Erodium cicutarium	red-stemmed filaree	X				
Eremalche parryi parryi	**Parry's mallow**	X				
Hordeum depressum	**low barley**	X				
Hordeum murinum	foxtail barley	X			X	
Lactuca serriola	prickly lettuce	X		X	X	
Malvella leprosa	**alkali mallow**					X
Melilotus indica	yellow sweet clover	X	X	X	X	X
Phacelia distans	**common phacelia**	X				
Senecio vulgaris	common ragwort	X	X	X	X	X
Sonchus oleraceus	common sow thistle	X	X	X	X	X
Sisymbrium irio	London rocket	X	X	X	X	X

Table 5. Vegetation Monitoring Results - Percent Cover Barley and Percent Total Cover per Treatment. Means not sharing the same letter are significantly different at or above the 95% confidence level.

April 1999	TREATMENT 1 (CR)		2 (CN)		3 (NR)		4 (NN)	
RICHNESS - Total (Native)	17 (5)		15 (1)		13 (1)		14 (2)	
% COVER BARLEY - MEAN (SE)	33.6 (1.87)	**A**	46.5 (2.45)	**B**	34.1 (1.77)	**A**	31.4 (1.54)	**A**
% TOTAL COVER - MEAN (SE)	41.3 (1.95)	**A**	52.3 (2.37)	**B**	38.0 (1.80)	**A**	35.6 (1.62)	**A**

Table 6. Vegetation Monitoring Results - Percent Cover Barley and Percent Total Cover per Block. Means not sharing the same letter are significantly different at or above the 95% confidence level.

	BLOCK				
April 1999	**1**	**2**	**3**	**4**	**5**
RICHNESS - Total (Native)	18 (4)	9 (0)	8 (0)	9 (0)	8 (1)
% COVER BARLEY- MEAN (SE)*	26.2 (1.32) **A**	35.7 (1.94) **B**	41.9 (2.45) **BC**	49.48 (2.16) **C**	28.5 (2.92) **AB**
% TOTAL COVER -MEAN (SE)*	36.9 (1.67) **AB**	40.34 (1.93) **A**	44.17 (2.37) **A**	55.44 (2.15) **C**	32.26 (2.47 **B**

Discussion

Barley was an effective cover crop on the Demonstration Project site in 1999. The barley provided numerous benefits such as weed control, wildlife food and cover, and probably decreased undesired excess nutrient levels in the recently cultivated fields. The cover crop also created uniform conditions across experimental plots for the first year of the project. Few native plant species occur on experimental plots at this time. A majority of them were localized to one particular area (plot 2, block 1). These relatively homogeneous starting conditions should allow for treatment effects to be seen within the first few years of monitoring.

Insect Surveys

Methods

The baseline invertebrate survey was conducted in May 1999 using the pitfall arrays established in April 1999. Each pitfall array consists of four, 3-gallon buckets sunken to ground level. Buckets were connected with sections of 20-foot long galvanized steel flashing (Figure 13). Lids are removed from the buckets during surveys and positioned above the rim using wooden stakes. Insects and other ground-dwelling invertebrates are guided to the buckets by the metal flashing and fall into the buckets where they are trapped. Trap checks occurred daily just after sunrise for 4 consecutive days. Sweeps were not taken due to time constraints in the first survey year and the low numbers of flying insects found in the barley crop, but will be part of the year 2000 insect survey.

Shrews (*Sorex*) and deermice (*Peromyscus*) were captured in pitfall traps in 1999, which was unexpected due to a recent history of heavy cultivation on fields containing HRS plots. They may have been persisting in the canals bordering the fields. Due to mortality of some small mammals captured in the pitfalls, probably from heat stress and/or dehydration, a protocol was established for checking all buckets to release mammals (after recording the capture on a data sheet) prior to proceeding to count and release invertebrates. The gap between the bucket lid and the rim of the bucket was also decreased to approximately 1" to discourage mammals. Mortality of small mammals declined to zero after these changes were made.

Invertebrate abundance is reported as richness and relative abundance. Richness values reflect the number of different insect orders represented in the samples from each treatment or block. Relative abundance is calculated as the total number of insects per array, divided by the total number of array-nights. This is a slight modification from the Demonstration Project resource monitoring plan, which indicated that relative abundance would be calculated based on individual pitfall traps (Selmon et al. 1999).

Results

Richness was fairly consistent across treatments and blocks, with richness ranging from 12 to14 orders per treatment and 9 to14 orders per block (Tables 7, 8, 9, and 10). The higher richness value for block 1 is possibly due to the adjacent long-term fallowed lands and previous history of fallowing for the field that block is located within. Blocks 1 and 3 had significantly higher relative abundance values than blocks 2, 4 or 5 ($p>0.05$). A treatment effect was also found; treatment 2 had significantly lower species richness than treatments 1 and 3 (Table 9). However, treatment 4 wasn't significantly different from treatments 1 and 3 (or treatment 2) and had only about 6 more insects per array on average than treatment 2 (Table 9). Biologically-speaking, this difference is not as dramatic as statistics would imply. Insect numbers are inherently variable and such small differences could simply reflect random variation in insect distribution across plots.

Table 7. Invertebrate Survey Results - Species Composition per Treatment

		TREATMENT			
ORDER	**DESCRIPTION**	**1 (CR)**	**2 (CN)**	**3 (NR)**	**4 (NN)**
Araneae	spiders	X	X	X	X
Blattodea	cockroaches	X	X	X	X
Coleoptera	beetles	X	X	X	X
Dermaptera	earwigs	X	X	X	X
Diptera	flies	X	X	X	X
Hemiptera	true bugs	X	X	X	X
Hymenoptera	ants, bees, wasps	X	X	X	X
Isopoda	isopods (pill bugs)	X	X	X	X
Lepidoptera	moths, butterflies	X		X	X
Opiliones	daddy-longlegs	X		X	
Orthoptera	crickets, grasshoppers	X	X	X	X
Scorpiones	scorpions	X	X	X	X
Thysanoptera	thrips	X	X	X	X
Thysanura	silverfish	X	X	X	X

Table 8. Invertebrate Survey Results - Species Composition per Block

		BLOCK				
ORDER	DESCRIPTION	1	2	3	4	5
Araneae	spiders	X	X	X	X	X
Blattodea	cockroaches	X		X		
Coleoptera	beetles	X	X	X	X	X
Dermaptera	earwigs	X	X	X	X	X
Diptera	flies	X	X		X	X
Hemiptera	true bugs	X	X	X	X	X
Hymenoptera	ants, bees, wasps	X	X	X	X	X
Isopoda	isopods (pill bugs)	X	X	X	X	X
Lepidoptera	moths, butterflies	X		X		X
Opiliones	daddy-longlegs	X	X			
Orthoptera	crickets, grasshoppers	X	X	X	X	X
Scorpiones	scorpions	X				
Thysanoptera	thrips	X	X	X	X	X
Thysanura	silverfish	X	X			

Table 9. Invertebrate Survey Results - Relative Abundance per Treatment. Relative abundance calculated as the total number of insects per array divided by the total number of array-nights. Means not sharing the same letter are significantly different at or above the 95% confidence level.

	TREATMENT			
May-99	1 (CR)	2 (CN)	3 (NR)	4 (NN)
RICHNESS (Orders)	14	12	14	12
RELATIVE ABUNDANCE	73.5(5.86) A	52.01(4.33) B	75.67(5.12) A	58.1(5.78) AB

Table 10. Invertebrate Survey Results - Relative Abundance per Block. Relative abundance calculated as the total number of insects per array divided by the total number of array-nights. Means not sharing the same letter are significantly different at or above the 95% confidence level.

	BLOCK				
May-99	1	2	3	4	5
RICHNESS (Orders)	14	11	10	9	10
RELATIVE ABUNDANCE	96.82(8.29) A	56.5(5.21) B	85.1(5.15) A	39.82(4.0) B	45.87(2.08) B

Discussion

Overall, invertebrate abundances were surprisingly high, given that most fields containing experimental plots have undergone intensive cultivation in recent years. Richness was reasonably similar across all plots for this baseline survey. Future surveys could be improved by a more detailed breakdown of types of invertebrates captured, at least to the taxonomic level of family. Sweep surveys, scheduled to begin in April/May 2000 coinciding with pitfall surveys, will provide additional information regarding invertebrate use of the experimental plots and changes over time in response to treatments.

Avian Surveys

Methods

Three baseline bird surveys were completed prior to establishment of experimental treatments on HRS experimental plots. Surveys consisted of recording bird observations from 4 point-count positions and while walking 2 transects for each plot (Figure 14). Walking time and time spent at point-count locations were standardized among observers. Bird activity and location within the plots were noted for all birds using the plots. Many birds were observed flying over study plots during the surveys, but only those which were actually found on the plot are reported below. Incidental observations were recorded for additional information. Those data are not reported in this section, but the species were added to the cumulative species list for the Demonstration Project site for 1999 (Appendix E).

Results

Results for May, July and October 1999 avian surveys are reported in Tables 11-14. While many more individuals and species were seen flying over study plots during surveys than were observed actually on the plots, species were documented using the barley crop for foraging, cover and even nesting.

Number of birds observed per treatment over the course of the year ranged from 13 to 15, a fairly close yearly total (Table 11). Block totals, however, ranged from 8 to 17 species observed (Table 12). Blocks 3 and 5 were the lowest with 8 species apiece, and block 1 had the highest richness with 17 species for the year.

Block 1 had dramatically higher richness during the first survey in May (Table 14), but was similar to other blocks during the July and October surveys. Richness and abundance were generally lowest during July 1999 for both treatments and blocks, and highest during October (Tables 13 and 14). Significant statistical differences were not found between treatments, and only in the case of one survey for blocks. Block 2 had significantly higher average bird numbers on plots in October, and block 3 had significantly lower numbers.

Table 11 . Avian Survey Results - Species Composition per Treatment

		TREATMENT			
Common Name	**Scientific Name**	**1 (CR)**	**2 (CN)**	**3 (NR)**	**4 (NN)**
American crow	*Corvus brachyrhynchos*			X	X
American kestrel	*Falco sparverius*	X	X	X	X
American pipit	*Anthus rubescens*	X	X	X	X
barn swallow	*Hirundo rustica*	X	X		
Brewer's blackbird	*Euphagus cyanocephalus*	X	X	X	X
cliff swallow	*Hirundo pyrrhonota*				X
horned lark	*Eremophila alpestris*	X	X	X	X
house finch	*Carpodacus mexicanus*		X		
killdeer	*Charadrius vociferus*	X	X		X
lark sparrow	*Chondestes grammacus*			X	
long-billed curlew	*Numenius americanus*		X		X
loggerhead shrike	*Lanius ludovicianus*	X	X		
mallard	*Anas platyrhynchos*		X	X	X
northern harrier	*Circus cyaneus*	X	X	X	X
northern mockingbird	*Mimus polyglottos*			X	X
red-tailed hawk	*Buteo jamaicensis*		X	X	
red-winged blackbird	*Agelaius phoeniceus*	X	X	X	X
sage sparrow	*Amphispiza belli*	X	X	X	X
savannah sparrow	*Passerculus sandwichensis*		X	X	
white-crowned sparrow	*Zonotrichia leucophrys*	X			
western kingbird	*Tyrannus verticalis*				X
western meadowlark	*Sturnella neglecta*	X	X	X	X
white-tailed kite	*Elanus leucurus*		X	X	
yellow-rumped warbler	*Dendroica coronata*	X			
unidentified swallow				X	
	RICHNESS (CUMULATIVE)	**13**	**17**	**16**	**15**

Table 12. Avian Survey Results - Species Composition per Block

		BLOCK				
Common Name	**Scientific Name**	1	2	3	4	5
American crow	Corvus brachyrhynchos	X			X	
American kestrel	Falco sparverius	X	X			X
American pipit	*Anthus rubescens*	X	X		X	X
barn swallow	*Hirundo rustica*	X				X
Brewer's blackbird	*Euphagus cyanocephalus*	X	X	X	X	
cliff swallow	*Hirundo pyrrhonota*		X			
horned lark	*Eremophila alpestris*	X	X	X	X	X
house finch	*Carpodacus mexicanus*	X				
killdeer	*Charadrius vociferus*	X	X		X	
lark sparrow	*Chondestes grammacus*	X				
long-billed curlew	*Numenius americanus*	X	X			
loggerhead shrike	*Lanius ludovicianus*				X	
mallard	*Anas platyrhynchos*	X		X		
northern harrier	*Circus cyaneus*	X	X	X		X
northern mockingbird	*Mimus polyglottos*	X	X			
red-tailed hawk	*Buteo jamaicensis*		X	X		
red-winged blackbird	*Agelaius phoeniceus*	X	X	X	X	X
sage sparrow	*Amphispiza belli*	X		X	X	X
savannah sparrow	*Passerculus sandwichensis*		X			
white-crowned sparrow	*Zonotrichia leucophrys*				X	
western kingbird	*Tyrannus verticalis*	X				
western meadowlark	*Sturnella neglecta*	X	X	X	X	X
white-tailed kite	*Elanus leucurus*				X	
yellow-rumped warbler	*Dendroica coronata*		X		X	
	RICHNESS (CUMULATIVE)	**17**	**14**	**8**	**12**	**8**

Table 13. Avian Survey Results - Relative Abundance per Treatment. Relative abundance is calculated as the number of birds observed divided by the total number of survey days. Means not sharing the same letter significantly different at or above the 95% confidence level.

	TREATMENT			
	1 (CR)	2 (CN)	3 (NR)	4 (NN)
May-99				
RICHNESS	5	8	8	10
RELATIVE ABUNDANCE*	1.87 (0.92) A	5.28 (1.88) A	2.2 (0.92) A	3.93 (1.97) A
Jul-99				
RICHNESS	5	5	4	2
RELATIVE ABUNDANCE*	0.53 (0.29) A	0.60 (0.24) A	0.60 (0.21) A	0.13 (0.13) A
Oct-99				
RICHNESS	8	10	13	6
RELATIVE ABUNDANCE*	19.67 (7.24) A	11.47 (3.74) A	16.27 (7.65) A	14.2 (6.77) A

Table 14. Avian Survey Results - Relative Abundance per Block. Relative abundance is calculated as the number of birds observed divided by the total number of survey days. Means not sharing the same letter are signific different at or above the 95% confidence level.

	BLOCK				
	1	2	3	4	5
May-99					
RICHNESS	11	6	5	5	3
RELATIVE ABUNDANCE	2.92 (1.08) A	6.08 (2.53) A	4.83 (2.29) A	2.17 (0.82) A	0.58 (0.29) A
Jul-99					
RICHNESS	1	5	1	2	3
RELATIVE ABUNDANCE	0.36 (0.2) A	0.75 (.025) A	0.17 (0.17) A	0.38 (0.24) A	0.66 (0.36) A
Oct-99					
RICHNESS	9	8	4	7	6
RELATIVE ABUNDANCE	6.5 (1.36) AB	35.25 (10.39) A	1.0 (0.83) B	14.42 (6.23) AB	19.83 (7.91) AB

Discussion

Bird activity on plots for the first year was mostly limited to resting and foraging on the ground. Some annual *Atriplex* plants germinated on the plots among the barley and birds were commonly seen perching and foraging for insects on them. Bird numbers are expected to increase dramatically on experimental plots as permanent vegetation becomes established. Baseline information collected in 1999 will provide a very important standard for future comparisons between experimental treatments and blocks.

Small Mammal Surveys

Methods

A small mammal survey was conducted on HRS study plots in October 1999. Three 150 meter-long trapping lines, each containing 10 Sherman traps spaced 15-meters apart, were established in each experimental plot yielding a total of 30 traps per plot (Figure 15, Jones et al. 1996). Four nights of trapping yielded 2,400 total trap nights, with 600 trap-nights per treatment and 480 trap-nights per block. Results are presented as species richness (number of different kinds of mammals) and relative abundance (trap success) per treatment and per block.

Results

A total of 27 animals were captured, mostly deermice (*Peromyscus maniculatus*) although 2 house mice (Mus musculus) were also captured (Tables 15 and 16). Interestingly, captures were much higher for treatments 3 and 4 than for treatments 1 and 2. Since treatments had not yet been established on the plots, differences must have been due to pre-existing conditions. An examination of block differences shows that block 5 yielded the majority of captures for this survey.

Table 15. Small Mammal Trapping Results per Treatment. Trap success calculated as the number of individuals trapped divided by the total number of trap nights. M=Male, F=Female, A=Adult, J=Juvenile, PEMA=*Peromysc maniculatus,* MUMU=*Mus musculus.*

	SPECIES	M		F		TOTAL CAPTURES	TRAP SUCCESS*
OCTOBER 99		**A**	**J**	**A**	**J**		
TREATMENT 1 (CR)							
	PEMA	0	0	1	1	2	0.0033
	MUMU	1	0	0	0	1	0.0017
						Richness = 2	
TREATMENT 2 (CN)							
	PEMA	2	0	0	2	4	0.0067
	MUMU	0	0	0	0	0	0
						Richness = 1	
TREATMENT 3 (NR)							
	PEMA	4	3	3	1	11	0.0183
	MUMU	0	0	0	0	0	0
						Richness = 1	
TREATMENT 4 (NN)							
	PEMA	3	1	1	3	9	0.0150
	MUMU	0	1	0	0	1	0
						Richn	

Table 16. Small Mammal Trapping Results per Block. Trap success calculated as the number of individuals trapped divided by the total number of trap nights. PEMA=*Peromyscus maniculatus,* MUMU=*Mus musculus,* M=Male, F=Female, A=Adult, J=Juvenile.

	SPECIES	M		F		TOTAL CAPTURES	TRAP SUCCESS*
OCTOBER 99		A	J	A	J		
BLOCK 1							
	PEMA	2	0	0	0	2	0.0042
	MUMU	0	0	0	0	0	0
BLOCK 2							
	PEMA	5	0	0	0	5	0.0104
	MUMU	0	1	0	0	1	0.0021
BLOCK 3							
	PEMA	0	0	0	0	0	0
	MUMU	1	0	0	0	1	0.0021
BLOCK 4							
	PEMA	0	1	1	1	3	0.0063
	MUMU	0	0	0	0	0	0
BLOCK 5	PEMA	2	4	3	6	15	0.0313
	MUMU	0	0	0	0	0	0

Discussion

Block 5 had the greatest number of captures during the first small mammal survey (Table 16). Currently we have no explanation for this. As with other biotic surveys, abundance and diversity are expected to increase the longer the land is retired from cultivation. The first post-treatment survey is scheduled to occur in April 2000.

Herpetological Surveys

A herpetological survey was conducted in May 1999 using the pitfall arrays established in April 1999. No herptiles were captured during 3 consecutive survey days. Only one lizard has been observed on the site since November 1998. A western whiptail (*Cnemidophorus tigris*) was observed in the summer of 1999 on the far eastern border of the property along the "Lateral 7" canal.

Photo Stations

Photos were taken in September of 1999 to document pre-treatment conditions on the experimental plots. Two 35-mm and 2 digital photos were taken from the southern boundary of each plot looking north. Photographs were developed and have been placed in a binder for easy review. Digital photos were archived on a compact disc.

NON-EXPERIMENTAL DEMONSTRATION PROJECT LANDS

Spotlighting

Methods

Spotlighting surveys were scheduled to occur on a bi-annual basis according to the Demonstration Project Resource Monitoring Plan (Selmon et al. 1999). However, further research and discussion on the issue led to the decision to increase the survey frequency from bi-annually to quarterly. The low numbers of vertebrates on the project site necessitate more frequent surveys to adequately document changes over time.

Spotlighting surveys were conducted in September and December 1999. The route covers the entire extent of the current Demonstration Project lands at the Westlands site (Figure 16). Two biologists using 1,000,000 candle-power spotlights drove the spotlighting route at approximately 15 to 20 mph for three consecutive nights for each survey. Surveys began within an hour of sunset. All animals encountered were identified and the information recorded on standardized data sheets.

Spotlighting results are reported as percent frequency of occurrence and rate of occurrence. Percent frequency of occurrence is the number of nights during a survey an animal species was observed, and rate of occurrence is the average number of individuals of a species observed per mile of the survey.

Results

Barn owls (*Tyto alba*) were the most common species observed during the September 1999 survey, with a total of 39 individuals observed over the course of the three night survey (Table 17). Other bird species observed included burrowing owls (*Speotyto cunicularia*), ducks, and a short-eared owl (*Asio flammeus*). The most common mammal species encountered was the black-tailed jackrabbit (*Lepus californicus*), with a total of 3 observations (Table 17). Three western toads (*Bufo boreus)* were also observed in September.

Red-tailed hawks (*Buteo jamaicensis*) dominated the December survey, with a total of 16 birds observed (Table 17). Barn owls followed with 14 bird observations. They were the only two species in the December spotlighting survey to be observed on all three nights. Lagomorphs (rabbits and hares) dominated the mammal observations in this survey, comprising 9 out of 11 total observations.

Table 17. Demonstration Project Spotlighting Results. % Freq = Percent frequency of occurrence calculated as the number of nights a species was observed divided by the total number of survey nights X 100. Rate = Rate of occurrence calculated as the number of individuals of a species observed divided by the total number of miles in the survey.

		September					
SPECIES	**Scientific name**	**14**	**15**	**16**	**Total**	**% Freq.**	**Rate**
Birds							
short-eared owl	*Asio flammeus*	0	0	1	1	33%	0.0285
burrowing owl	*Speotyto cunicularia*	1	1	1	3	100%	0.0855
barn owl	*Tyto alba*	15	9	15	39	100%	1.111
bird		0	1	0	1	33%	0.0285
duck		0	0	3	3	33%	0.0855
heron		1	0	0	1	33%	0.0285
unidentified owl		0	1	0	1	33%	0.0285
Mammals							
black-tailed jackrabbit	*Lepus californicus*	1	0	2	3	67%	0.0855
California vole	*Microtus californicus*	1	0	0	1	33%	0.0285
desert cottontail	*Sylvilagus audubonii*	0	1	1	2	67%	0.0570
bat		1	0	0	1	33%	0.0285
unidentified lagomorph		0	0	1	1	33%	0.0285
Amphibians/Reptiles							
western toad	*Bufo boreus*	1	0	2	3	67%	0.0855
TOTAL		**21**	**13**	**26**	**60**		
		December					
SPECIES	**Scientific name**	**20**	**21**	**22**	**Total**	**% Freq.**	**Rate**
Birds							
red-tailed hawk	*Buteo jamaicensis*	6	4	6	16	100%	0.4558
falcon	*Falco* spp.	0	1	0	1	33%	0.0285
burrowing owl	*Speotyto cunicularia*	1	0	1	2	67%	0.0570
barn owl	*Tyto alba*	5	7	2	14	100%	0.0389
unidentified owl		1	1	0	2	67%	0.0570
Mammals							
black-tailed jackrabbit	*Lepus californicus*	1	6	0	7	67%	0.1994
desert cottontail	*Sylvilagus audubonii*	1	1	0	2	67%	0.0570
unidentified fox		1	0	0	1	33%	0.0285
unidentified rodent		0	1	0	1	33%	0.0285
TOTAL		**16**	**21**	**9**	**46**		

Discussion
Spotlighting results for 1999 indicate that some nocturnal species are currently using the Demonstration Project site. Although the spotlighting route will be expanded as additional lands are acquired for the project, the route used for these baseline surveys will be followed in future years and results reported separately from the expanded route. This will allow for ongoing comparisons with first-year baseline conditions.

The first post-treatment spotlighting survey occurred in March 2000.

Winter Raptor Survey

Methods
The first annual winter raptor survey occurred in December 1999. The survey was conducted for three consecutive mornings using the same route as the spotlighting surveys. Surveys began within an hour of sunrise by two observers driving approximately 15 to 20 mph along the route with binoculars and a spotting scope. All raptors observed were identified and the information recorded on standardized data sheets. Raptor survey results are reported as percent frequency of occurrence and rate of occurrence.

Results
The first winter raptor survey documented usage of the site by 6 (possibly 7) different raptor species (Table 18). American kestrels (*Falco sparverius*) were the most common bird, with a total of 34 and rate of 0.97. Red-tailed hawks were next, with 21 birds observed and a rate of 0.60 (Table 18). Northern harriers (*Circus cyaneus*) were almost as common as red-tailed hawks, with 19 total observed and a rate of 0.54. Other raptors observed were rough-legged hawks (*Buteo lapopus*), white-tailed kites (*Elanus leucurus*), and a prairie falcon (*Falco mexicanus*).

Table 18. 1999 Demonstration Project Winter Raptor Survey Results. % Freq = Percent frequency calculated as the number of days a species was observed divided by the total number of survey days X 100. Rate = Rate of occurrence calculated as the number of animals of a species observed divided by the total number of survey miles.

		DECEMBER					
SPECIES	**Scientific name**	21	22	23	Total	**% Freq.**	**Rate**
red-tailed hawk	*Buteo jamaicensis*	5	7	9	21	100%	0.60
rough-legged hawk	*Buteo lagopus*	1	1	1	3	100%	0.09
unidentified hawk	*Buteo* spp.	1	3	1	5	100%	0.14
northern harrier	*Circus cyaneus*	5	5	9	19	100%	0.54
white-tailed kite	*Elanus leucurus*	0	3	2	5	67%	0.14
prairie falcon	*Falco mexicanus*	0	0	1	1	33%	0.03
American kestrel	*Falco sparverius*	8	13	13	34	100%	0.97
TOTAL		**20**	**32**	**36**	**88**		

Discussion
The 1999 winter raptor survey indicated that many resident or migrating raptors used the Demonstration Project site prior to any restoration efforts. As habitat complexity increases and vertebrate populations increase over time, greater numbers and diversity of raptors should be observed.

Track Stations

Methods
Track station surveys were conducted in September and December 1999, concurrently with spotlighting surveys. Track plates were set out at 17 different locations on the Westlands project site, yielding approximately 4 track plates per 1/4 section (Figure 16). Stations were dusted with fire clay and baited with a can of cat food.

Results
Insects were the most common visitors to track stations in September 1999, with a frequency of 19.6 %, followed by mice, which had a frequency of 7.8 % (Table 19). One kangaroo rat print was found in September 1999, providing hope that some individuals may be surviving in the agricultural fields surrounding the Demonstration Project and will move into experimental plots and the rest of Project lands. Additionally, one vole, three rabbits and two sets of canid tracks were found (Table 19). One of the canid tracks was almost certainly a dog track, based on visual sightings of dogs in the vicinity belonging to a nearby residence. The other set of tracks were of the appropriate size and shape to be a coyote. Coyotes have been observed in the vicinity of the track station that had the prints.

There was less activity in December than in September; fewer than half the number of observations were recorded on the track stations. Mice were the most common animal, with a total of 6 tracks and a frequency of 11.7%. Desert cottontails and black-tailed hare tracks were also found, along with another domestic dog visit. As a result of the frequent disturbance to track station #4 by dogs from the nearby residence, the station was moved approximately 200 meters north from its original location (Figure 16).

Table 19. 1999 Demonstration Project Track Station Results. % Freq = Percent frequency calculated as the number of visits by each animal divided by the total number of monitoring nights X 100. Rate = Rate of visitation calculated as the number of track stations visited by each animal divided by the total number of stations

	September					
Animal	**15**	**16**	**17**	**Total**	**%Freq.**	**Rate**
insects	4	5	1	10	100%	19.6%
coyote	1	0	0	1	33%	1.9%
domestic dog	0	1	0	1	33%	1.9%
kangaroo rat	0	0	1	1	33%	1.9%
mouse	0	3	1	4	67%	7.8%
rabbit	1	2	0	3	67%	5.9%
vole	0	1	0	1	33%	1.9%
TOTAL	**6**	**12**	**3**			
	December					
Animal	**21**	**22**	**23**	**Total**	**%Freq.***	**Rate****
black-tailed hare	1	0	0	1	33%	1.9%
desert cottontail	0	0	2	2	33%	3.9%
domestic dog	0	1	0	1	33%	1.9%
mouse	4	2	0	6	67%	11.7%
TOTAL	**5**	**3**	**2**			

Discussion

Track station surveys in 1999 indicate that some vertebrates are currently inhabiting the Demonstration Project lands, although at fairly low abundance and diversity levels. As vertebrate abundance increases on the project site as a result of decreased disturbance and/or active restoration efforts, greater numbers are expected to be observed moving about the project site and leaving tracks during surveys.

CONTAMINANTS MONITORING RESULTS

Analysis of Biotic Samples

Contaminants samples were sent to Laboratory and Environmental Testing Inc. (L.E.T.), Columbia, Missouri in November 1999 for analysis. Once received at the lab, samples are prepared by lyophilization (freeze-drying), homogenization, and digestion. The selenium detection limit for plant and animal tissue is 0.2 ppm dry weight, as long as at least 0.5 g of a dry sample is available.

L.E.T. quality control procedures include:

> Using 5 percent blanks to assess contamination,
> Duplicate analysis of 10 percent of the samples,
> Analysis for recovery of spiked amounts in 10 percent of samples, and
> Blind reference standards in 5 percent of samples with a minimum of one of each of the above (Ed Hinderberger pers. comm.).

Results of contaminants analyses are reported below as the geometric mean (GM) and range of selenium (mg/kg) per group.

Vegetation

Methods

Samples of vegetation for contaminants analysis were collected in July 1999 from areas within experimental plots near the invertebrate contaminants collection sites (randomly selected pitfall arrays). Vegetative and reproductive parts were collected and bagged separately when both were available. While samples represent composites of a few different individual plants of the same species collected from each site, not all plant species were available at each sampling site (Figure 17). Some plants were only found in one location. Various grass species were present at the uncultivated site, but seed heads were not clearly distinguishable, which prevented positive identification.

While these sample sizes are generally too small for statistical comparisons, they nevertheless provide important baseline data for selenium levels in some of the most common species currently occupying the site. In calendar year 2000, contaminants monitoring collection will be scheduled earlier in the season when vegetation is more dense so that minimum sample sizes of 5 of both vegetative and reproductive structures can be obtained.

Results

Cultivated barley seed and vegetative parts had very low selenium levels ranging from <0.2 to 0.4 mg/kg total Se (Table 20). Similarly, other vegetation samples collected from within the cultivated areas were also 0.4 mg/kg Se or less. Uncultivated areas yielded low Se values as well, ranging from undetectable at <0.2 mg/kg up to 0.6 mg/kg Se (Table 20).

Table 20. Vegetation Contaminants Monitoring Results

Sample Description	N	Collection Site	Range Se (mg/kg)
Barley vegetative	5	Cultivated	<0.2-0.4
Barley seed	5	Cultivated	<0.2-0.3
Atriplex vegetative	1	Cultivated	0.2
Brassica vegetative	1	Cultivated	0.3
Brassica seeds	1	Cultivated	0.4
Sysimbrium veg+seeds	1	Cultivated	0.4
Atriplex vegetative	3	Uncultivated	<0.2-0.5
Bromus vegetative	3	Uncultivated	<0.2
Bromus seeds	3	Uncultivated	<0.2-0.6
Heliotropum vegetative	1	Uncultivated	<0.2
Heliotropum seeds	1	Uncultivated	<0.2
Hordeum vegetative	1	Uncultivated	<0.2
Hordeum seeds	1	Uncultivated	<0.3

Discussion

These baseline results and those collected over the next 4 or more years will provide critical information regarding the effects of land retirement on selenium in biota on the west-side of the San Joaquin Valley.

Invertebrates

Methods

Collection of invertebrate contaminants samples occurred in July 1999, using one randomly selected pitfall array per experimental block (Figure 17). Some insect groups were not captured in all arrays, yielding less than 5 total samples overall for those groups. Due to time constraints and the need to complete baseline surveys, additional sampling was not completed until the fall of 1999. Fall is too late in the year for most invertebrates to still be active, hence few additional samples were acquired. Sampling will be conducted for a longer period in future years to assure a composite sample of 5 for all groups.

Results

Invertebrate selenium levels were higher than vegetation levels for some invertebrate groups (Table 21). Beetles ranged from <1.0 to 1.2 mg/kg Se. One grasshopper was captured opportunistically while collecting other invertebrate contaminants samples and had a total Se level of 0.5 mg/kg. Crickets had fairly low selenium levels, ranging from 0.3 to 0.6 with a geometric mean of 0.33 mg/kg (Table 21). Representatives of the predator (spiders) and detritivore (isopods) invertebrate groups had higher levels in some samples. Isopods ranged from 1.0 to 5.6 mg/kg Se while spiders ranged from 1.1 to 3.6 mg/kg Se.

Table 21. Invertebrate Contaminants Monitoring Results

Group	N	Collection Site	GM Se	Range Se (mg/kg)
Beetles	2	HRS pitfall arrays		<1.0-1.2
Crickets	4	HRS pitfall arrays	0.33	0.3-0.6
Grasshopper	1	HRS pitfall arrays		0.5
Isopods	3	HRS pitfall arrays	4.03	1.0-5.6
Spiders	5	HRS pitfall arrays	1.72	1.1-3.6

Discussion

While some samples exceed the target threshold of 2.0 mg/kg Se established in the tiered contaminants monitoring chart outlined in the resource monitoring plan (Selmon et al. 1999), these selenium levels are not likely a response to activities related to the Demonstration Project. Given that a cover crop of barley was grown on the Demonstration Project during 1999 after standard ground preparation and a light irrigation, the invertebrates collected are more of a representation of selenium levels in areas with ongoing agricultural production in that region than of retired lands.

Vertebrates

Methods

Vertebrate contaminants samples were collected in November 1999 from both cultivated and non-cultivated regions of the Demonstration Project, which each contained 5 sampling locations (Figure 17). Thirty Sherman small mammal traps were set at each location. Traps were baited with white proso millet and crumpled paper towel was added. Traps were set for 4 nights at each of 5 sampling locations within cultivated and uncultivated regions of the project site, until 1 animal was captured per sampling location, if possible. Some locations didn't yield any animals, so they were collected from other locations as needed to bring the sample size up to 5 animals.

Results

A total of 5 deermice *(Peromyscus maniculatus)* were captured from both cultivated and uncultivated regions of the project site. Two house mice (*Mus musculus*) were captured in the uncultivated region, but none were captured in the areas containing barley.

Selenium concentration in deermouse bodies and livers were similar among cultivated and uncultivated areas (Table 22). Bodies from uncultivated locations ranged from 0.75 to 1.1 mg/kg Se, while those from the cultivated locations were 1.0 to 1.5 mg/kg Se. Liver selenium values were higher than body values in both areas, ranging from 2.9 to 4.4 mg/kg Se and 3.3 to 3.9 mg/kg Se in the uncultivated and cultivated areas, respectively. House mice bodies and livers followed a similar pattern (Table 22).

Table 22. Vertebrate Contaminants Monitoring Results. PM = *Peromyscus maniculatus*, MM = *Mus musculus.*

Sample Description	N	Collection Site	GM Se	Range Se (mg/kg)
PM body	5	uncultivated	1.0	0.75-1.1
MM body	2	uncultivated	0.8	0.72-1.0
PM liver	5	uncultivated	3.4	2.9-4.4
MM liver	2	uncultivated	3.8	3.7-4.0
PM body	5	cultivated	1.1	1.0-1.5
PM liver	5	cultivated	3.6	3.3-3.9

Discussion

The levels of selenium in small mammals may be of concern on Demonstration Project lands if additional selenium becomes available to them as a result of project activities and levels increase. One way this could occur is if contaminated groundwater rose to the point where surface plants could use the water and incorporate selenium into their tissues. Invertebrates or other animals would then have to consume those plants at levels which would entail further bioaccumulation. Based on preliminary results which are discussed in detail in the next section of this report, it doesn't appear as though groundwater levels will rise following land retirement, but rather will continue to drop over time.

The other most likely scenario for selenium to become available to wildlife is through the ponding of surface water. No ponding occurred on retired lands in 1999 that persisted more than 30 days, based on bi-weekly site visits. Contaminants monitoring will continue for a minimum of 4 more years.

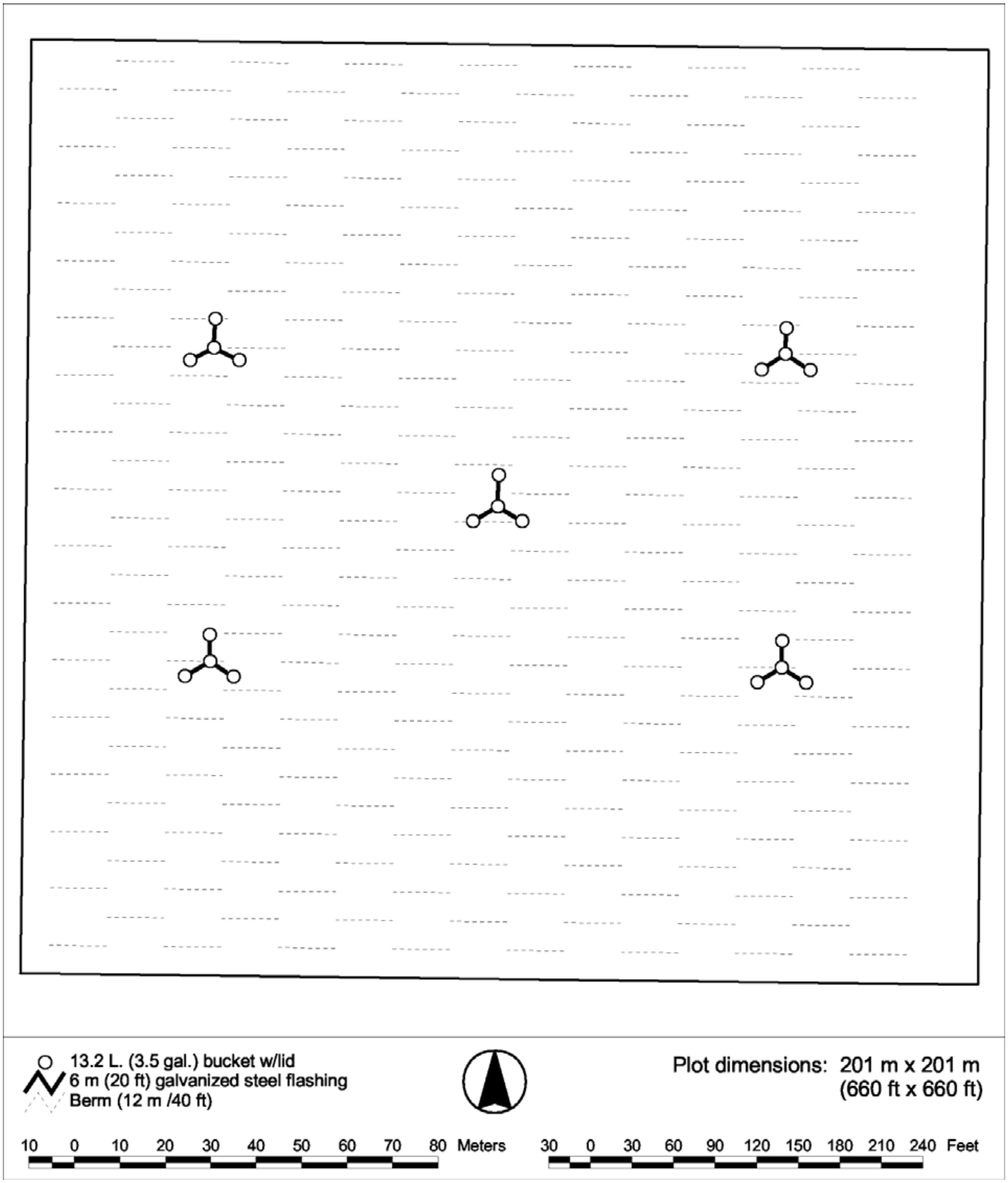


Figure 13. Pitfall Array Locations on a 10-Acre HRS Plot

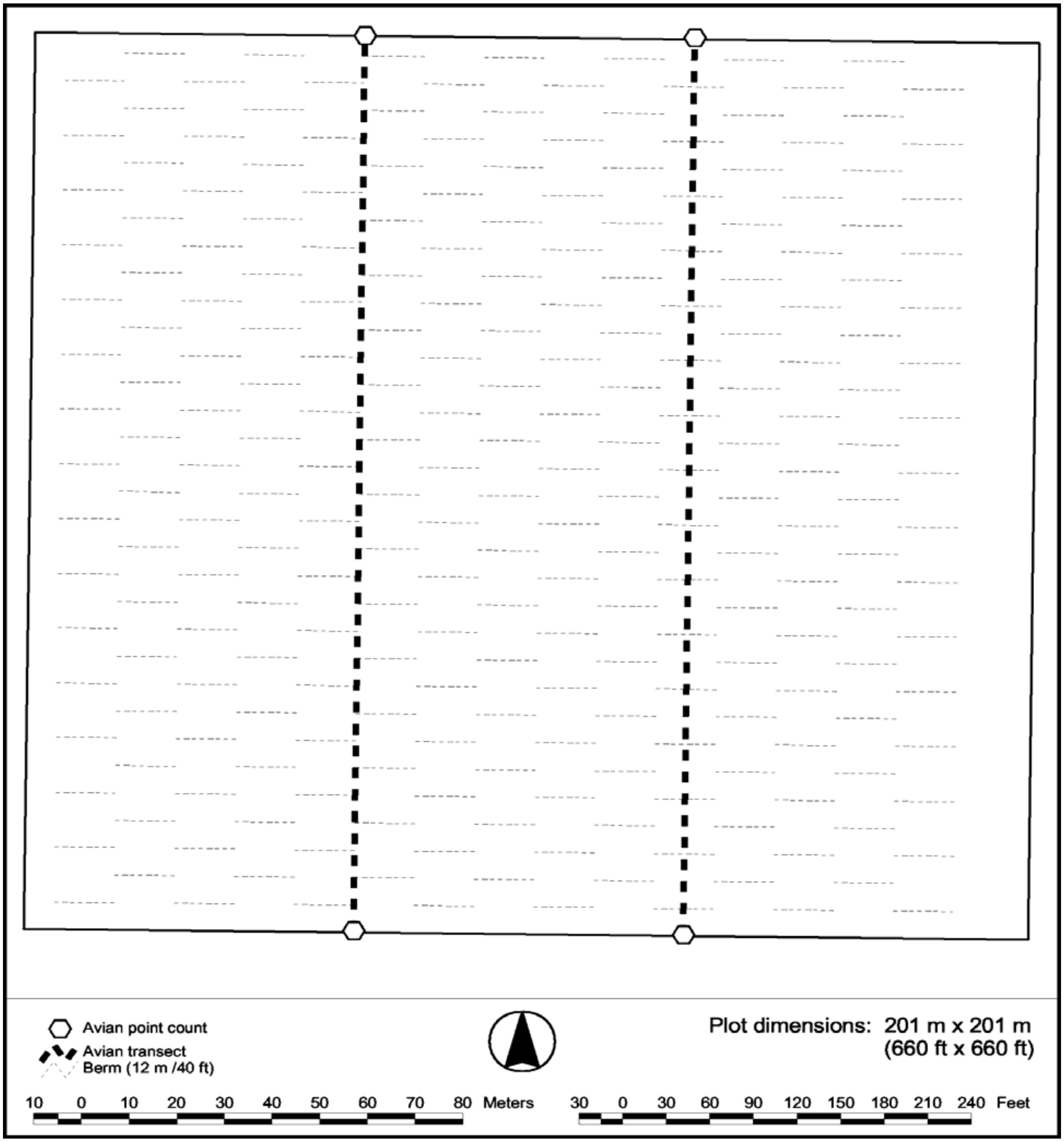


Figure 14. Avian Transect and Point Count Locations on a 10-Acre HRS Plot

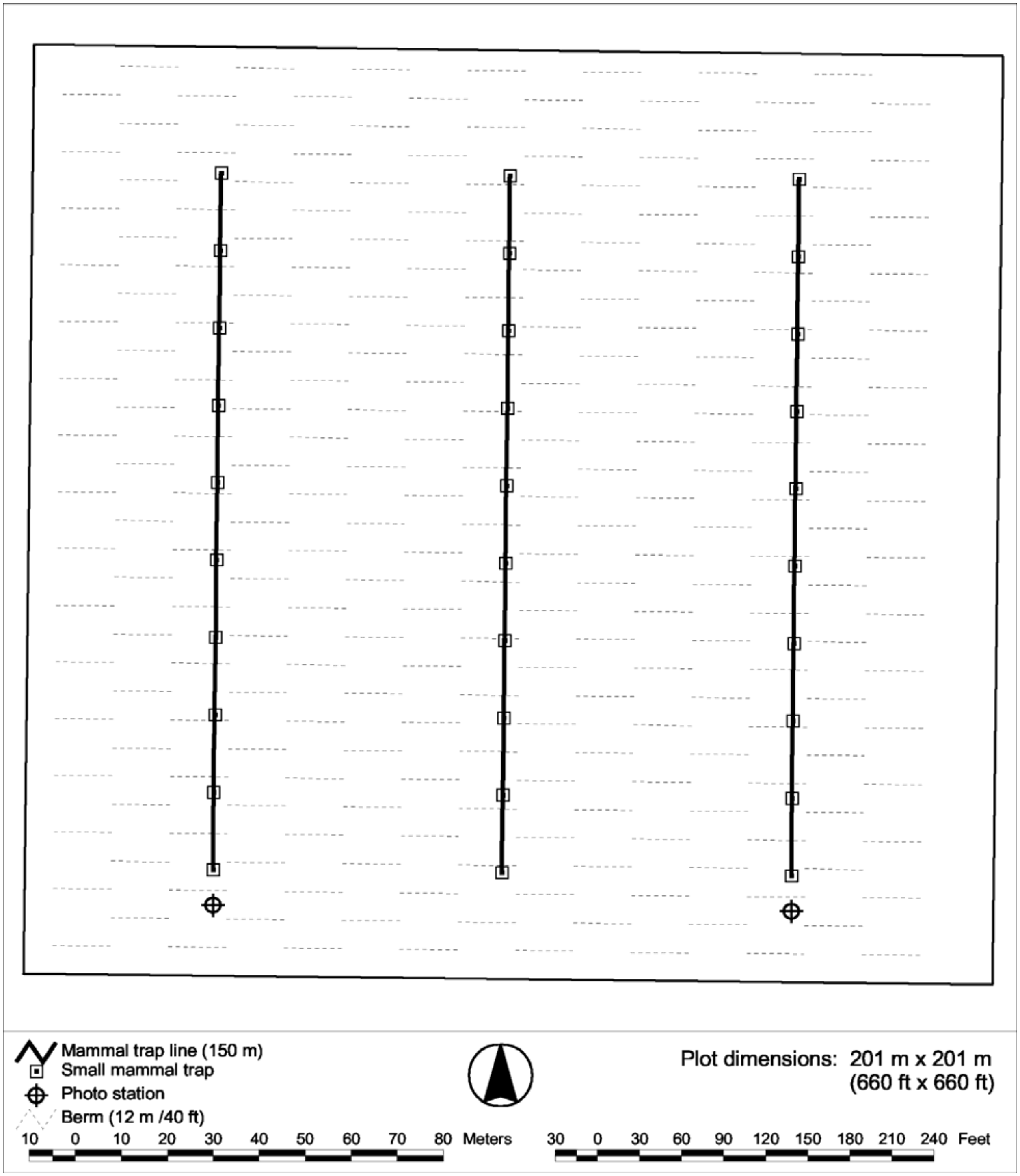


Figure 15. Small Mammal Trapping Lines on a 10-Acre HRS Plot

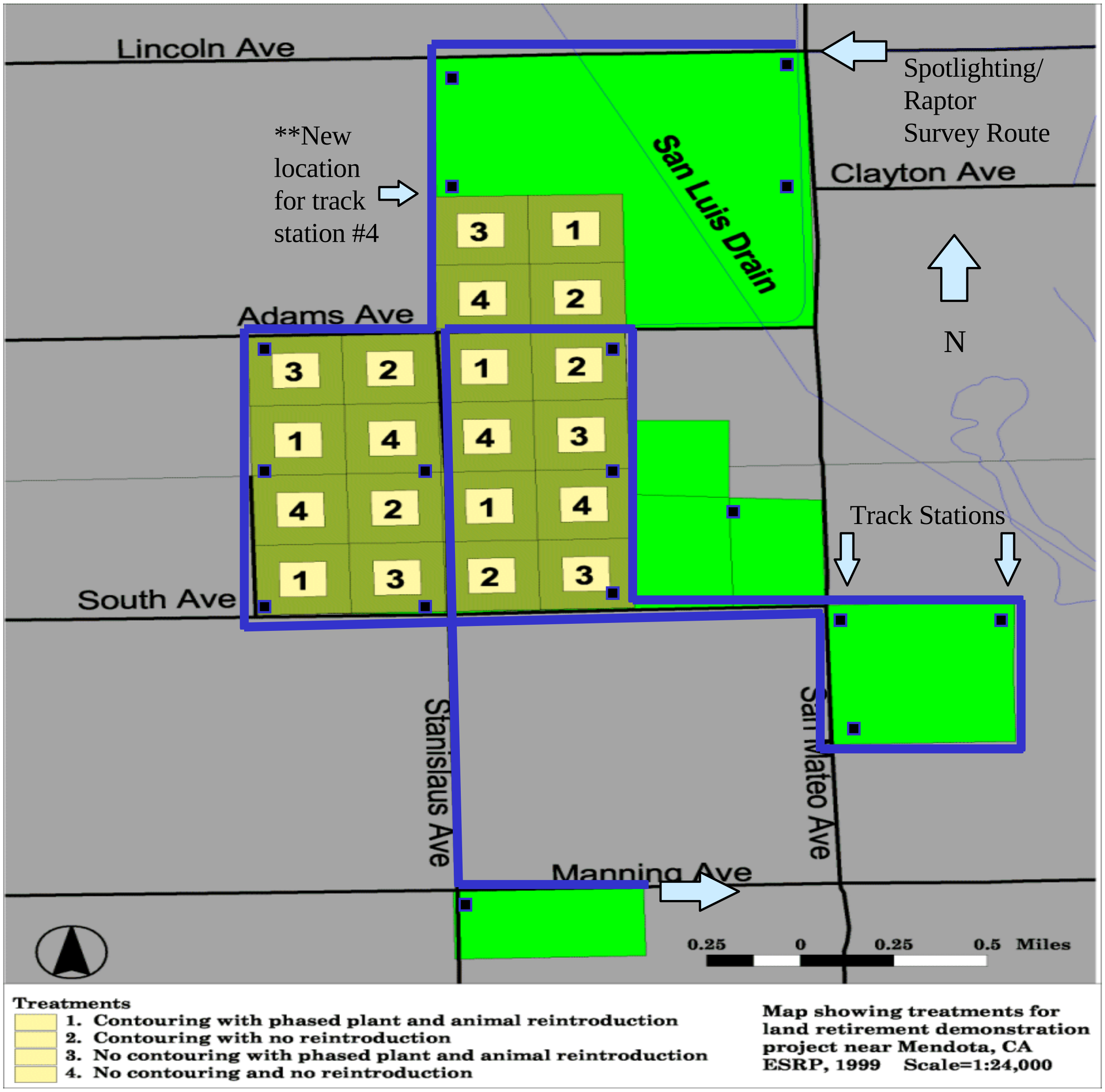


Figure 16. Spotlighting and Raptor Survey Route and Track Station Locations at the Westlands Project Site

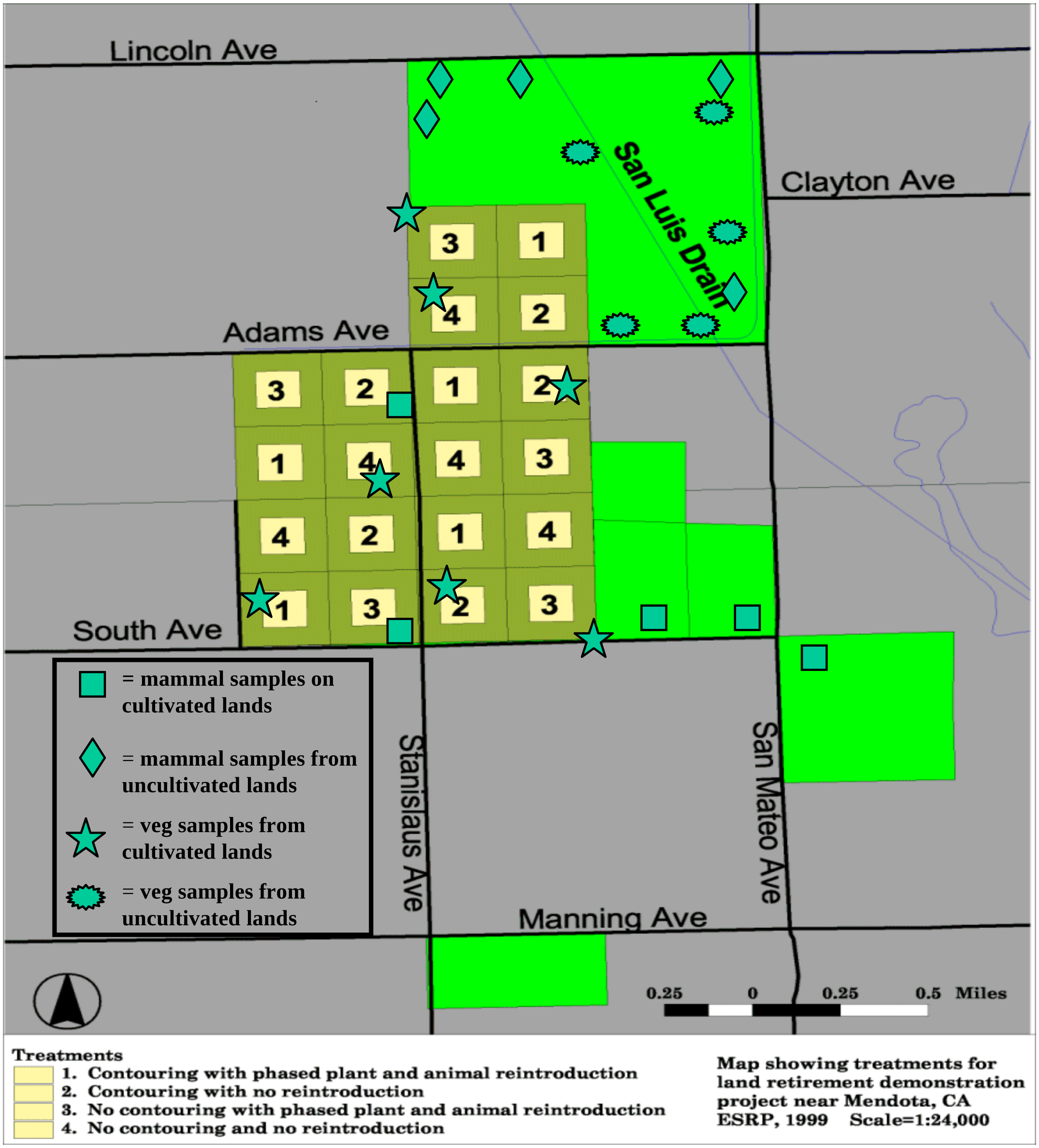


Figure 17. Contaminants Monitoring Collection Locations at the Westlands Project Site

1999 PHYSICAL IMPACTS MONITORING RESULTS

GEOLOGY

The Westlands Demonstration Project site is located in the western San Joaquin Valley, an asymmetrical basin bounded by the Coast Ranges on the west, the Tehachapi Mountains on the south, the Sierra Nevada on the east and the delta of the San Joaquin and Sacramento Rivers on the north. The axis of the valley trough is closer to the Coast Ranges than to the Sierra Nevada. The basin is filled with alluvium overlying older Mesozoic and Cenozoic marine and continental sediments. The alluvial deposits underlying the central San Joaquin Valley were shed from the adjacent Coastal and the Sierra Nevada ranges and vary in thickness from 900 to 3,300 feet (Miller et al. 1971). The Sierra Nevada consists mainly of granitic and metamorphic rocks of pre-Tertiary age while the Coast Ranges are composed primarily of folded and faulted beds of Cretaceous age marine shale and sandstone in the north and Cenozoic age sandstone and shale in the south (Prokopovich 1987). Bull (1964a,b) identified a series of alluvial fans derived from sediments from the coastal ranges that form the western margin of the San Joaquin Valley in the study area.

The Westlands site is located in the trough of the San Joaquin valley in western Fresno County. The site is underlain directly by flood basin deposits derived from overbank deposition from the San Joaquin River and Fresno Slough. The flood basin deposits consist of fine textured, moderately to densely compacted clays that range in thickness from 5 to 35 feet (Belitz and Heimes 1990). The flood basin clays have low permeability and greatly impede the downward movement of water. The flood basin deposits at the site rest upon well sorted micaceous sand derived from the Sierra Nevada. The Sierran sands are highly permeable, reduced in oxidation state, and vary in thickness between 400 to 500 feet in the project vicinity. The Corcoran clay is a regionally extensive fine grained lake bed deposit that underlies the site at a depth of approximately 500 feet.

SOILS

Soils in the Demonstration Project area consist of clays and loams which formed in alluvium derived from igneous and sedimentary rock. Individual soil mapping units in order of abundance in the project area include the Tranquility clay, Lillis Clay, and the Lethent Silt Loam.

The Tranquility mapping unit is the predominant soil type in the study area and covers approximately 80% of the site, while the Lillis and Lethent mapping units occur exclusively in Section 10 and cover the remainder of the site (Figure 18). The Tranquility clay is a very deep, poorly to moderately drained saline-sodic soil found on low-lying alluvial fans and flood plains with slopes between 0 and 1%. The permeability of this soil is slow and the unit is suited to growing irrigated salt tolerant crops, or for wildlife habitat (USDA 1996). Runoff is low, and the hazard of water erosion is slight. The depth to the water table varies and is commonly highest during irrigation applications in the winter and early spring. These soils generally require intensive management to reduce salinity and maintain agricultural productivity.

The USDA took soil samples from a test pit located in the NW 1/4 of Section 16 at the site in 1992. The samples were analyzed in the laboratory for particle size, chemistry and mineralogy. These soils consist predominantly of clay sized particles less than 0.002 mm in diameter. The USDA reported that the clay fraction from 6 samples taken from the test pit ranged from 48 to 52% of the total samples. Silt size particles (.002 - .05 mm in diameter) ranged from 36-37% of the total samples, and sand size particles made up from 11-16 % of the total samples (USDA 1992). Total selenium concentrations ranged from 0.5 to 1.1 ppm, and the Electrical Conductivity (EC) of soil water extracts ranged from 3.7 to 10.9 deciSiemens/meter (dS/m). These soils are highly plastic with Plasticity Indices ranging from 23-52%. The predominant clay mineral is Montmorillonite, which can take on water in the crystal lattice, resulting in high shrink, swell potential and development of deep cracks at the soil surface upon drying.

The Lillis clay mapping unit covers about 10 % of the study area in the eastern half of Section 10 (Figure 18). These soils are very deep, poorly drained, saline-sodic soils found typically on flood plains and basins. Permeability of the Lillis soil is extremely slow. The water infiltration rate is high, however when the soil is dry and the surface cracks are open. As the soil becomes wet and the cracks close, the infiltration rate greatly decreases. Surface water runoff is low and the hazard of water erosion is slight. The unit is used mainly for wildlife habitat and recreation.

The USDA took soil samples from a test pit located in the SW 1/4 of Section 10 at the site in 1992. The samples were analyzed in the laboratory for particle size, chemistry and mineralogy. These soils consist predominantly of clay sized particles less than 0.002 mm in diameter. The USDA reported that the clay fraction from 9 samples taken from the test pit ranged from 59 to 66% of the total samples. Silt size particles (.002 - .05 mm in diameter) ranged from 29-36% of the total samples, and sand size particles made up from 2-7 % of the total samples (USDA 1992). Total selenium concentrations ranged from 0.3 to 0.7 ppm, and the Electrical Conductivity (EC) of soil water extracts ranged from 9.6 to 38.6 deciSiemens/meter (dS/m). These soils are highly plastic with Plasticity Indices ranging from 33-61%. The predominant clay mineral is Montmorillonite, which can take on water in the crystal lattice, resulting in high shrink, swell potential.

The Lethent silt loam mapping unit covers about 10 % of the site in the north half of Section 10 (Figure 18). These soils are deep, moderately well drained, saline-sodic soil found on low lying alluvial fans and basin rims. Permeability of this soil is very slow, runoff is slow, and the hazard of water erosion is slight (USDA 1996).

Soil Sampling Methods

The objective of the soil monitoring program for the first year of the demonstration project was to establish baseline soil chemistry for certain parameters of concern. The parameters of concern include salinity, selenium, boron, nitrate, pH, and major cations and anions.

The soil sampling was carried out by members of the LRT during September and October 1999. A rectangular sampling grid was chosen for long term monitoring of soil chemistry at the Demonstration Project site (Figure 19). Surficial soil samples were taken at a total of 123 locations. Composite surfacial soil samples were taken at the corners of the 10-acre study plots from a depth of 0-1 foot (0-30.48 cm) using a shovel. The samples were homogenized in the field at field moist conditions using a putty knife and stainless steel mixing bowls. The samples were collected at each site within a radius of about 1 meter of the staked locations. The coordinates of the sample locations were recorded in the field with a Global Positioning System (GPS) reciever with an accuracy of 4 meters (Appendix F).

Discrete soil samples were taken at depths of 0-1 foot, (0-30.5 cm), 2-3 feet (60.9 - 91.4 cm), and 4-5 feet (121.9-152.4 cm) at the centers of the 10-acre experimental plots, in order to assess baseline soil chemistry with depth from the land surface (Figure 19). The depth samples were taken with a 10.1 cm inside diameter split barrel core sampler to a depth of 5 feet (152.4 cm). A continuous core was obtained at each site by pushing the core barrel with the hydraulic system of a Mobile Drill Model B-90 drill rig. Discrete depth samples were taken at a total of 26 locations at the site. The discrete depth samples were homogenized in the field at field moist conditions using a putty knife and stainless steel mixing bowls. The coordinates of the sample locations were recorded in the field with a GPS receiver with an accuracy of 4 meters (Appendix F).

The depth intervals actually sampled (0-1, 2-3, 4-5 ft) deviate from the planned sample depths (0-1, 3-4, 6-7 ft) identified in the Quality Assurance Project Plan (CH2MHill 1999). The soil sampling interval was changed for two reasons. After examining depth to shallow groundwater data, it became evident that the originally planned 6-7 ft depth soil sample chemistry would be affected by high, saline shallow water-table (saturated) conditions at some sampling locations. A secondary consideration was that a five foot core barrel sampler was readily available and could obtain a continuous sample at each sampling location using one push of the hydraulic drill rig, resulting in lower sampling costs.

Chemical Analysis of Soils

All soil samples were analyzed for total and water soluble selenium, sulfate, chloride, electrical conductivity, and moisture. In addition, all surface soil samples were analyzed for boron, magnesium, potassium, sodium, carbonate, and nitrate. The Quality Assurance Project Plan (QAPP) for the Land Retirement Demonstration Project describes in detail the analytical procedures and quality assurance measures taken to ensure soil data quality (CH2MHill 1999). The soils analyses were performed by the U.S. Geological Survey analytical laboratory in Denver, Colorado. The analytical data were not available from the laboratory at the publishing time of this report. The baseline soil chemistry data will be analyzed and included in the calender year 2000 annual report.

WEATHER DATA

Hourly precipitation, temperature, wind and relative humidity data are collected at the California Irrigation Management Information System (CIMIS) weather station # 105, which is located 1.5 miles west of the Westlands Demonstration Project site at the Westlands Water District (WWD)

Tranquility Field Office. The CIMIS station is operated and maintained by the California Department of Water Resources (DWR), and can be used to guide crop irrigation scheduling and estimate consumptive water use for various crops. The weather at the site for calender year 1999 is best described as cool and dry which is typical of a regional La Nina weather pattern. A total of 4.5 inches of rainfall was recorded at the CIMIS station, with most of the rainfall occurring between January and April (Table 23). The maximum and minimum air temperatures recorded at the CIMIS station were 91 and 31 degrees F in July and December, respectively.

A daily Reference Evapotranspiration (ETo) is calculated from the CIMIS weather data by the DWR. ETo is a term used to estimate the evapotranspiration rate of a reference crop expressed in either inches or millimeters. The reference crop used for the CIMIS program is grass, which is close clipped, actively growing, completely shading the soil, and well watered. ETo varies by location, time, and weather conditions. The main factors that influence ETo include incoming radiation (energy from the sun), outgoing radiation (sensible energy leaving the earth), the amount of moisture in the air, air temperature, and wind speed (DWR 2000). The ETo value can be used to estimate the consumptive water demand of an agricultural crop.

Eto can be estimated quite accurately through the use of a "model" (a series of mathematical equations). The "model" that is used in CIMIS is a version of Penman's equation modified by Pruitt/Doorenbos **(**Pruitt/Doorenbos 1977). It also employs a wind function developed at UC Davis. The version used in CIMIS uses hourly weather data to calculate daily ETo instead of daily weather data. Hourly averages of weather data are used in the "model" to calculate an hourly ETo value. The 24 hourly ETo values for the day (midnight to midnight) are summed to result in a daily ETo (DWR 2000).

The inputs used in this equation from the CIMIS weather stations are these hourly values:

Net Radiation
Air Temperature
Wind Speed
Vapor Pressure

Air temperature, wind speed, and vapor pressure are measured directly at each weather station. Hourly net radiation is estimated using a method developed by the University of California. This method uses solar radiation, vapor pressure, air temperature, and a calculated monthly cloud coefficient (DWR 2000).

IRRIGATION

A cover crop of sterile barley was planted at the site to provide weed and dust control. Approximately 3 inches of irrigation water was applied to the barley crop at the site during 1999 (271 acre-feet of water applied over an area of 1220 acres). The water was applied using a hand moved sprinkler irrigation system in 12 hour sets during the month of April. The consumptive water use for the barley crop was estimated by multiplying the CIMIS reference evapotranspiration (Eto) data by published crop coefficients (Table 23). As shown in Figure 20 and Table 23, the estimated consumptive water demand of the barley crop (ET barley) exceeded the combined monthly precipitation and applied irrigation water during the irrigation period in April. It is therefore unlikely that any of the applied irrigation water contributed significantly toward deep percolation (recharge) to the shallow groundwater underlying the site during this time. Precipitation at the site exceeded consumptive crop demand only in the months of January and August (Figure 20, Table 23). It is likely that due to dry soil conditions and the timing of the rainfall this moisture was either evaporated or added to the soil moisture reservoir and thus did not contribute toward deep percolation (recharge) to the shallow groundwater. Declining groundwater level trends observed in the shallow monitor wells and sumps at the site support this inference.

HYDROLOGY

The natural drainage in the study area is to the east and northeast with ground surface elevations ranging from 169 feet above mean sea level (AMSL) in the southwest corner of the site to about 162 feet AMSL in the northeast portion of the site. The land surface in most of the study area has been laser leveled to facilitate irrigation of row crops. There are no perennial surface water bodies on the site. Shallow ephemeral surface water ponds may form on low lying portions of the study area due to localized sheet flow runoff during prolonged winter storm events. Surface water courses within the area consist principally of irrigation supply canals, and irrigation return flow ditches. Three irrigation tailwater ditches traverse the site on Sections 15 and 16. Tailwater is irrigation water that does not penetrate the soil, and runs off the irrigated cropland. Tailwater is usually collected in a surface water pond and recirculated into the irrigation system.

Fresno Slough, which is located approximately one mile east of the study area, is the largest perennial surface water body in the vicinity of the project. Fresno Slough receives flood flow releases from the North Fork of the Kings River and serves as a storage reservoir for federal irrigation water from the Delta Westlands Canal. Fresno Slough also occasionally receives flood flows from Panoche Creek, which rises in the Coast Ranges to the west, and flows out onto the Panoche Fan during winter storm events.

Regional Groundwater System

The groundwater flow system on the west side of the San Joaquin Valley is strongly influenced by a fine textured, low permeability clay layer known as the Corcoran Clay member of the Tulare Formation. The Corcoran Clay is a thick lake-bed deposit that divides the groundwater flow system into an upper semi-confined aquifer and a lower confined aquifer. The Corcoran Clay is present at a depth of approximately 500 feet beneath the site. The semi-confined aquifer underlying the west side of the San Joaquin groundwater basin consists of three distinct hydrogeologic units: Coast Ranges alluvium, Sierran Sand and flood basin deposits (Figure 21). These units all differ in texture, hydrologic properties and oxidation state.

The groundwater flow system has undergone considerable change since the development of irrigated agriculture in the region. Under natural conditions recharge to the upper aquifer was primarily from infiltration of stream water from intermittent streams flowing from the Coast Ranges. According to Davis and Poland (1957) and Belitz and Heimes (1990), rainfall was an insignificant mechanism for recharging the aquifer system. Discharge from the aquifer system under natural conditions was primarily from evapotranspiration and to streams along the valley trough.

The following two paragraphs are excerpts from Belitz and Heimes (1990), and provide an excellent description of the history of groundwater development on the west side of the central San Joaquin Valley (SJV).

> "Agricultural activity in the area and the groundwater flow system response on the west side of the SJV began as early as the 1870s, but large-scale farming and irrigation did not occur until the First World War. Irrigation with groundwater expanded rapidly in the 1920s and steadily increased until World War II. After World War II, the price of commodities stimulated increased agricultural growth and by the early 1950s nearly one million acre-feet of water was being pumped from the aquifer system within WWD. Most of the water was pumped from beneath the Corcoran Clay member of the Tulare Formation. The increase in irrigated acreage and in pumpage significantly altered the groundwater flow system. Percolation of irrigation water past crop roots greatly exceeded infiltration of intermittent stream water and replaced the latter as the primary mechanism of recharge. Discharge of water through wells and evapotranspiration from crops replaced natural evapotranspiration as the primary mechanism of discharge. Post-development recharge during 1961-77 was more than 40 times greater than the estimated predevelopment values for the Central Valley. Pumping of groundwater affected the hydraulic head and the direction of flow in the system. The most pronounced changes occurred in the lower confined zone. By 1952, the potentiometric surface of the confined zone was drawn down 100 to 200 feet from the presumed predevelopment altitude. Agricultural pumpage in excess of recharge continued for more than a decade after 1952 and led to further lowering of the potentiometric surface of the confined zone. By 1967, the potentiometric surface had been lowered by hundreds of feet over much of the western valley. Pumping lifts exceeded 890 feet over parts of the area, and land subsidence of more than 2 feet occurred throughout the area, with local subsidence reaching as much as 28 feet."

As a result of land subsidence, increased pumping lifts, and water quality limitations, surface water was imported to the western SJV in order to decrease pumpage. Beginning in 1967, surface water imported via the California Aqueduct began to replace groundwater as the primary source of irrigation supply in the area south of Mendota. The availability of surface water led to an increase in the total quantity of water applied, whereas the quantity of water removed from the system by wells decreased. The marked decrease in pumpage has allowed a recovery in hydraulic head. The rise in the potentiometric surface from 1967 to 1984 was nearly one-half the drawdown that occurred from predevelopment conditions to 1967. The potentiometric surface is defined as the level that water from the confined aquifer would rise to in a tightly cased well completed in the confined aquifer. Agricultural development also has affected the semiconfined zone. Increased rates of recharge resulting from percolation of irrigation water, combined with the rapid post-1967 decrease in pumpage, caused a rise in the altitude of the water table over much of the western valley (Belitz and Heimes 1990).

A regional tile-drain collector system, which was installed during 1980-81, has also had appreciable effects on the groundwater flow system. This system underlies about 42,000 acres of land west and southwest of Mendota. During 1981-84, the drains collected an average of 6,900 acre-feet per year. By lowering water levels 1 to 3 feet in the drained area, the tile drain collector system was effective in decreasing the total area characterized by a water table within 5 feet of the land surface. Maps of depth to water table indicate that in April 1976 about 41 percent of the area later serviced by drains had a water table within 5 feet of the land surface. By April 1984, the size of this area had decreased to 6 percent of the drained area. In contrast, in an area of equivalent size, topographic relief, and geomorphic character, but not underlain by regional tile drains, the size of the area underlain by a water table within 5 feet of the land surface increased from 8 square miles in 1976 to 18 square miles in 1984 (Belitz and Heimes 1990).

The subsurface drainage system in the vicinity of the Westlands Demonstration Project site was plugged in 1986 using a system of earthen and steel plugs and slide gate structures. The plugs were placed on a spacing of approximately one-quarter mile along the drain laterals, which are located generally upslope of the Demonstration Project. Ground water monitoring in the vicinity of the plugs indicated the plugs performed adequately in stopping the flow of subsurface drain water through the system (USBR 1986).

The semi-confined aquifer above the Corcoran Clay is now nearly fully saturated in much of the western San Joaquin Valley. Over 200,000 acres in the Westlands Water District are now underlain by a water-table within 10 feet of the land surface (Westlands Water District 1998) .

The concept of mitigating the drainage problem by retiring the land from irrigated agriculture is straightforward. The high water table results from an imbalance in the water budget as water is being applied at the land surface at a rate that exceeds the carrying capacity of the groundwater system, resulting in high groundwater levels in the absence of a subsurface drainage system. By ceasing irrigation, the primary source of recharge to the shallow aquifer system is terminated, conceptually resulting in a falling water-table beneath the site.

Conceptual Site Model - Groundwater

Depths to the water table in vicinity of the study area vary seasonally with the highest water levels generally corresponding to the irrigation season in the winter and spring, and the lowest water levels occurring in the summer and fall. The depth to the groundwater table beneath retired parcels of land is an important consideration. Direct evaporation of groundwater from a shallow water table can result in increasing soil salinity and increasing concentrations of trace elements on or near the land surface. In general, the closer the water-table is to the land surface, the higher the rate of direct evaporation and associated soil salinization. The conceptual model for land retirement assumes that the high water table conditions exists due to percolation of irrigation water applied on site. When the land is retired irrigation ceases, and therefore the source of recharge to the high water table is cut off, resulting in a declining water table. This conceptual model assumes that lateral inflow from "up slope" lands that continue to be irrigated is small, and that the predominant direction of groundwater flow in the upper aquifer system is downward. Groundwater monitoring data obtained at the Demonstration Project site to date supports this conceptual model.

The Westlands Demonstration Site is located in the Valley trough and is underlain by a flood basin clay deposit with a thickness of about 30 feet that rests directly upon coarser Sierran Sand deposits. Groundwater monitoring data indicate that perched water table conditions exist at the site. Belitz and Heimes (1990) noted perched conditions in the study area. According to the authors, "Pumping from the Sierran deposits has lowered groundwater levels in the Sierran Sand below the interface between the overlying flood basin deposits and the Sierran sands, producing an unsaturated zone" (between the two units). "The low diffusivity of the clays in the flood basin deposits has allowed these deposits to remain saturated as the water table in the semi-confined zone declined below the interface".

Ground water level measurements at well clusters at the site indicate perched conditions. Downward groundwater flow gradients measured at well clusters at the site exceeding 1.0 are common, and provide evidence that perched water table conditions exist in the shallow groundwater system. The hydrographs for wells 15A1 and 15A2 shown in Figure 22 illustrate typical downward gradients observed at the site. Wells 15A1 and 15 A2 constitute a well cluster, which means that the two wells are located side by side but monitor different depths. Well 15A1 is completed at a depth of 26 feet and monitors the shallow groundwater system, while well 15A2 is completed at a depth of 60 feet, and monitors the underlying semi-confined groundwater system. Water levels observed in well 15A1 are typically 30 feet higher than those in the adjacent well 15A2. Vertical hydraulic gradients of this magnitude are indicative that the upper perched system is not in direct hydraulic connection with the underlying semi confined system, and that unsaturated conditions exist between the two units. These conditions are highly conducive to unsaturated vertical seepage losses from the upper perched groundwater to the underlying semi-confined aquifer. Water levels measured in the flood basin deposits (shallow, perched groundwater system) range from less than 5 to greater than 10 feet below land surface, while water levels in the underlying Sierran Sands range from about 40 to 50 feet below land surface.

Water levels in the shallow, perched groundwater system at the site vary in response to the amount of water added to the system (recharge) and the water removed from the system (discharge). If the recharge to the system exceeds the discharge from the system, additional water is stored in the system, resulting in a rising water-table. The drainage problem in the western SJV results from the fact that the water is added to the system (recharge) at a rate that greatly exceeds the discharge capacity of the system. A quantitative water budget for the shallow groundwater system at the Demonstration Project site has not been computed as part of this study, however, it is useful to qualitatively examine the different components of the system in order to better understand the response of the shallow perched water table to land retirement.

Recharge to the shallow "perched" groundwater system at the site occurs as a result of deep percolation of irrigation water applied onsite, seepage losses from irrigation tailwater ditches that traverse the site, infiltration of ponded stormwater runoff, and lateral inflow from upgradient irrigated lands. As previously discussed, deep percolation of applied irrigation water past crop roots did not contribute significantly toward recharging the perched groundwater system at the site during 1999. Seepage of surface water from tailwater ditches that cross the site probably provided the most significant component of recharge to the perched groundwater during 1999. During the spring and summer months these tailwater ditches were observed to be running full on numerous occasions with tailwater runoff from the irrigation of adjacent cotton and alfalfa crops. The Westlands Water District lateral seven water supply canal that bisects the site was not used during 1999, and therefore did not contribute seepage losses toward recharge of the shallow groundwater system. The site received very little stormwater runoff or direct rainfall.

Precipitation data from the CIMIS station indicate that the site received 4.5 inches of precipitation during 1999. Due to dry soil conditions and the timing of rainfall events, infiltration of ponded stormwater did not provide a significant amount of recharge to the shallow groundwater system. No ponded surface water was observed on the site persisting for greater than thirty days. Lateral inflow of shallow groundwater from adjacent irrigated lands undoubtedly provided some recharge to the shallow groundwater system at the site, however, due to the extremely low horizontal gradients in the perched groundwater system and low hydraulic conductivities of the clay soils, lateral subsurface flow onto the site is estimated to be minimal.

Discharge from the shallow "perched" groundwater system at the site occurs as a result of direct evaporation from the shallow water table, transpiration of groundwater by vegetation, downward seepage losses of water to the underlying regional groundwater table, and lateral flow to adjacent down gradient properties. The most significant components of discharge from the shallow groundwater system at the site are direct evaporative losses from the shallow water table and seepage losses to the underlying semi-confined aquifer. Lateral outflow of shallow groundwater to adjacent lands is expected to be minimal due to the extremely low horizontal gradients in the perched groundwater system and low horizontal hydraulic conductivities of the clay soils. Transpiration of perched groundwater by vegetation was also minimal. The barley cover crop was the predominant vegetation present at the site, and the roots do not reach deeply enough to utilize the shallow groundwater.

Groundwater Level Monitoring

One of the objectives of the Demonstration Project is to measure the response of the shallow water table to land retirement. There are 50 monitor wells and three drain sumps in the project vicinity that are used to measure groundwater levels beneath the site on a quarterly basis. The well and sump locations and summary statistics are shown in Figure 23 and Appendix G.

Existing wells constructed prior to the 1998 purchase of the Demonstration Project lands were installed by Westlands Water District (WWD) and the USBR for the primary purpose of measuring depths to groundwater beneath drainage impacted lands in WWD. These existing wells are constructed of PVC casing ranging in diameter from 3/4 to 4 inches and vary in depth from 3 to 86 feet below the ground surface. These wells were installed using various construction techniques that range from jetting a short length of pipe into the ground to standard rotary drilling with hydraulic drill rigs.

During the summer of 1999, USBR installed 15 additional wells for the purpose of measuring groundwater levels and obtaining representative groundwater samples for water quality analyses for the Demonstration Project. The new wells were installed using a hollow stem auger drill rig and are constructed of 2 inch PVC casing. Well construction diagrams for the new wells are shown in Appendix H. Well construction diagrams for the previously existing wells are unavailable. There are also 18 subsurface drain water collection sumps located in a north to south alignment bisecting the northern half of Section 15 at the site. The sumps are part of an experimental drainage system that was installed at the site during the 1960's. Subsurface tile drains lines were installed beneath the northwest quarter of Section 15 at a depth of approximately 8 feet, with a drain spacing of approximately 150 feet. The drain lines are approximately 6 inches in diameter and discharge to 3 foot diameter concrete sumps that are open to the atmosphere. Water levels have been measured quarterly in three of the drain sumps (Figure 23).

Groundwater Levels in 1999

Groundwater monitoring at the Westlands Demonstration Project site to date supports the conceptual model of a declining shallow groundwater table in response to land retirement. Dry climatic conditions observed during the first year of monitoring undoubtedly also contributed toward a declining shallow water-table.

A hydrograph is a commonly used way to examine groundwater level trends. Hydrographs are plots of water levels measured in monitor wells over time. A declining trend in groundwater levels for the shallow perched groundwater system at the site is illustrated by the hydrographs shown in Figure 24. The hydrographs represent water levels measured in three drain sumps (15C1, 15F2, and 15K1) during the time period from July 1998 to October 1999. The drain sumps are connected to tile drain lines that underlie the northwest quarter of Section 15, and are useful for measuring shallow groundwater trends in that portion of the site. The drain sump locations are shown in Figure 23. All three of these sumps show an overall declining trend in groundwater levels for the 15 month period of record. Total water-level declines observed in sumps 15C1, 15F2 and 15K1 are 3.4, 2.5, and 2.4 feet, respectively.

A similar trend was observed at the southwest corner of Section 15 in monitor wells 325 and 326. The hydrographs and locations for these wells are shown in Figure 25. The total water-level declines observed in wells 325 and 326 for the period of record are 3.8 and 3.4 feet respectively. A similar declining trend for the remaining shallow wells was observed, however, the hydrographs are not shown due to the short period of record available for these wells.

The extent to which the declining shallow water-table trend is attributable to land retirement alone is not known. The combination of dry climatic conditions and greatly reduced irrigation applications associated with land retirement have resulted in measurable short term shallow water-table declines during the first year of monitoring. The hydrograph for well 15A1 (Figure 22) shows that the declining shallow groundwater level trend is not confined to the Demonstration Project site. A water level decline of 6.8 feet was observed at this well for the period of record. This well is located in the northwest corner of Section 15 along the San Luis Drain right of way (Figure 23). The land immediately surrounding the well site has never been irrigated and thus provides insight into “background” shallow water-table conditions in the project vicinity. Continued ground water level monitoring over the 5-year planned monitoring period for the Demonstration Project under a variety of climatic conditions will provide further insight into the effects that land retirement has on shallow water table conditions in the project area.

A synoptic depth to groundwater map is presented in Figure 26. This map shows the depth to groundwater from the land surface as measured in monitor wells at the site on October 27, 1999. The depth to groundwater data was contoured using Environmental Systems Research Institute (ESRI) Arcview Spatial Analyst software. This time of year generally corresponds to seasonal low groundwater levels in the region. The minimum depth to water recorded was 3.3 feet at Well 16B1, while the maximum depth to groundwater was 40.6 feet, recorded at Well 10B3. During October 1999, approximately 30% (600 acres) of the site was underlain by a water-table within 7 ft. of the land surface.

The site can be divided into two distinct areas based on the depth to groundwater observations. The depth to the water-table north of Adams Avenue (Section 10) is significantly greater than that observed south of Adams Avenue. This area of the site (Section 10) is known as the Donohoe parcel and has been retired from irrigated agriculture since 1994. Groundwater observations in the monitor wells installed on this portion of the site provide the best evidence that shallow groundwater levels will decline beneath Demonstration Project lands over time, regardless of irrigation applications on adjacent upslope parcels.

Depths to water on the Donohoe parcel ranged from 8.7 to 40.6 feet, and several wells (10D3, 10A1, 10J1) were completely dry. The perched shallow groundwater that is still present beneath the retired parcels south of Adams Avenue is conspicuously absent beneath the Donohoe parcel. It is likely that the perched water has evaporated or has been lost by downward seepage to the underlying semi-confined aquifer. The shallow perched system beneath the Donohoe parcel has not been recharged by lateral groundwater flow from adjacent irrigated parcels due to the low hydraulic conductivity and low horizontal gradients in the shallow groundwater system.

Groundwater Quality Monitoring

Groundwater samples were taken for the purpose of assessing the baseline groundwater chemistry at the demonstration site. Groundwater samples will be taken quarterly during the first year of monitoring. The first round of groundwater samples were taken during October 1999 by USBR personnel. Groundwater samples were taken from the shallow wells and drain sumps with a peristaltic pump and samples were taken from the deep wells with a two inch stainless steel submersible pump. A total of 20 wells and sumps were sampled to assess groundwater quality. Standard operating procedures for groundwater sampling used by the Mid-Pacific Region of the USBR and those outlined in the Quality Assurance Project Plan (QAPP) (CH2MHill 1999) were employed to obtain groundwater samples.

Groundwater Chemical Analysis

Groundwater samples were analyzed for major ions (calcium, magnesium, potassium, sodium, chloride, sulfate, carbonate), trace elements (selenium, boron, iron, manganese) and isotopes (H-2, O-18 and H-3). Electrical conductivity, pH, temperature and turbidity were measured in the field at the time of sampling. The QAPP for the Land Retirement Demonstration Project describes in detail the analytical procedures and quality assurance measures taken to ensure groundwater data quality (CH2MHill 1999). Flourometric analyses of groundwater samples for selenium were performed by Olsen Biochemistry Laboratories, South Dakota State University. Analyses for isotopes (H-2, O-18) were performed by the USGS Water Resources Division laboratory in Reston, Virginia. Analyses for tritium (H-3) were performed by the USGS Water Resources Division laboratory in Menlo Park, California. All other water analyses were performed by Caltest Analytical Laboratory in Napa, California. The analytical data were not available from the laboratory at the publishing time of this report. The groundwater analytical data from the first full year of monitoring will be analyzed and included in the calender year 2000 annual monitoring report.

Groundwater Salinity

A general indication of the total dissolved ionic constituents in the groundwater can be obtained by determining the capability of a groundwater sample to conduct an applied electrical current. This property is reported as Electrical Conductivity (EC), and is expressed in terms of the conductivity of a cube of water 1 square centimeter on a side. EC is expressed in units of microSiemens/cm (uS/cm). EC data collected during the October 1999 sampling event indicate that the shallow groundwater beneath the Demonstration Project site is highly saline in nature. EC data for the 12 shallow monitor wells sampled in October 1999 are shown in Table 24. The minimum and maximum EC values measured in the shallow wells were 11,520 and 61,100 uS/cm at wells 16B1 and 15F, respectively. The mean EC value for the shallow wells is 36,548 uS/cm. By comparison, seawater typically has an EC of about 50,000 uS/cm. The shallow groundwater EC data shows high spatial variablity with a standard deviation of approximately 15,000 uS/cm.

The groundwater in the underlying semi-confined aquifer is much less saline. The EC values measured in three deep monitor wells at the site (10G3, 15C3, 15M3) range from 5,630 to 17,180 uS/cm. The extreme salinity of the shallow groundwater at the site is a result of the irrigation of saline soils. Naturally occurring salts have been leached from the soil profile under irrigated conditions. Salts have also been transported to the site via the applied irrigation water. Direct evaporation from the shallow water table and transpiration of applied water by crops has concentrated salts in the shallow groundwater, resulting in high concentrations of dissolved solids.

Surface Water Monitoring

No appreciable surface water ponding was noted at the site during 1999. Surface water pools that did form were associated with tailwater spills from ditches that cross the site. The sources of the tailwater are from adjacent irrigated farmland located to the south and west of the site. The surface water pools associated with the tailwater spills were generally small and ephemeral in nature, lasting less than 30 days in duration. Surface water samples were not taken from these ephemeral pools for water quality analysis.

Table 23. Monthly CIMIS Weather Data and Estimated Barley Crop Water Use - Calendar Year 1999. Eto = Reference Evapotranspiration; Est ET Barley = Estimated Barley Crop Water Use; Precip = Measured Precipitation at CIMIS Weather Station.

					AIR TEMPERATURE		
DATE	**ETo**	**Barley Crop**	**Est ET**	**Precip**	**MAX**	**MIN**	**AVG**
	(Inches)	**Coefficient**	**Barley**		**Degrees F**	**Degrees F**	**Degrees F**
Jan-99	0.75	0.3	0.23	1.06	53	35	43
Feb-99	1.62	1.18	1.91	0.5	61	38	49
Mar-99	3.59	1.18	4.24	0.81	64	40	52
Apr-99	6.03	1.18	7.12	1.01	71	44	58
May-99	8.29	0.4	3.32	0.03	81	48	66
Jun-99	8.17	0.2	1.63	0.01	88	55	72
Jul-99	8.19	n/a	0.00	0	91	57	74
Aug-99	7.23	n/a	0.00	0.85	89	58	74
Sep-99	6.09	n/a	0.00	0	90	57	73
Oct-99	4.47	n/a	0.00	0	83	49	65
Nov-99	2.19	n/a	0.00	0.11	69	40	54
Dec-99	1.71	n/a	0.00	0.1	60	31	44
TOTALS AND AVERAGES							
	58.32		18.44	4.5	75	46	60

Table 24. Electrical Conductivity (EC) Data for October 1999 Groundwater Samples

Well/Sump ID	Easting	Northing	Electrical Conductivity (uS/cm)
10G3	739100	4058223	6980
10P1	738819	4057465	32950
15C3	739200	4057365	5630
15M1	738432	4056580	52160
15M3	738432	4056580	17180
15P1	739220	4055992	25960
15F1	738785	4057012	61100
16A1	737908	4056993	39130
16B1	737603	4057341	11520
16B3	737603	4057341	38870
16G1	737629	4056565	29650
16J1	738003	4056193	13310
16Q1	737631	4055758	45300
SUMP 15C2	739199	4057324	46940
SUMP 15F1	739202	4057019	41660

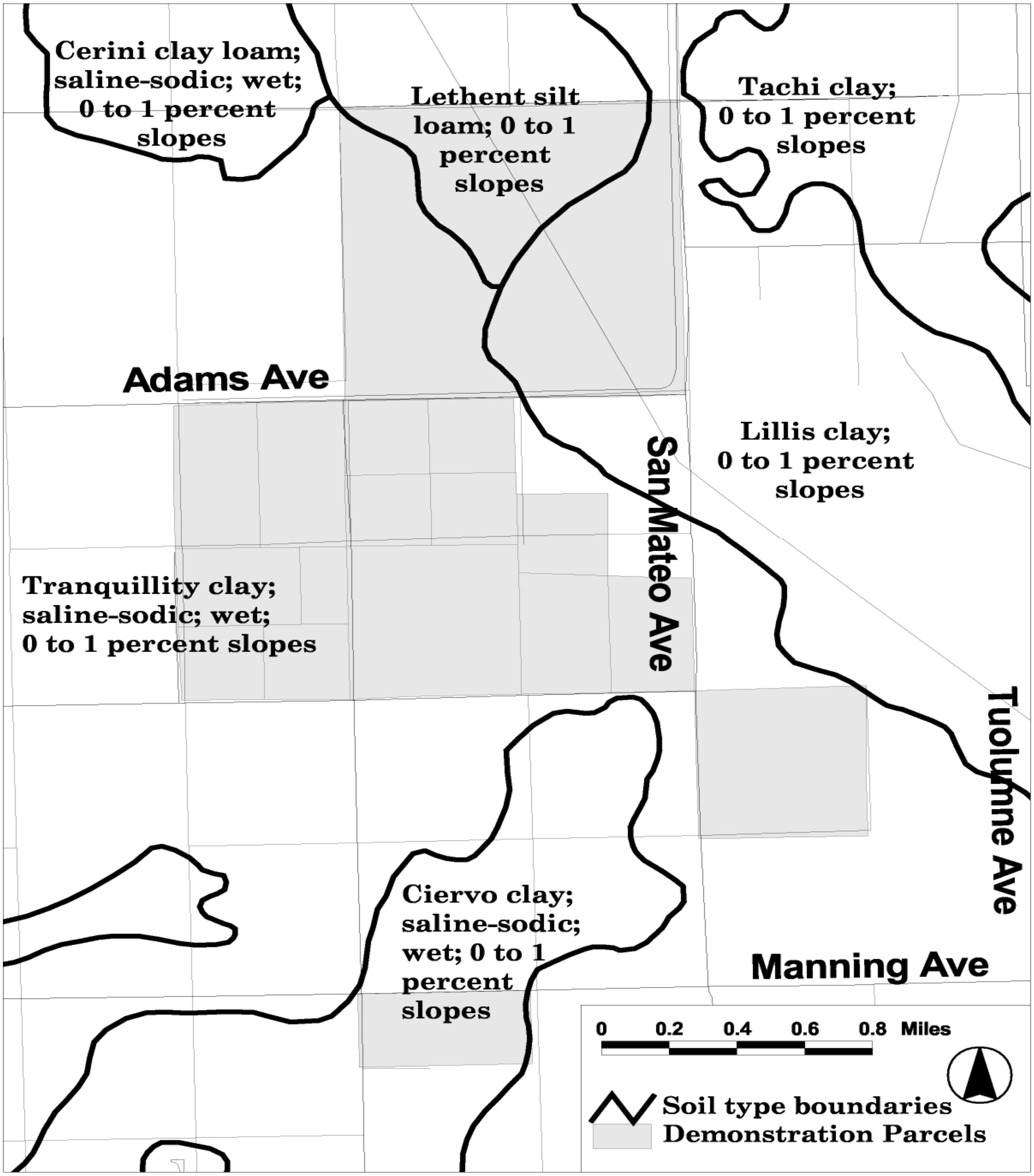


Figure 18. USDA Soil Mapping Units for the Westlands Demonstration Project Site

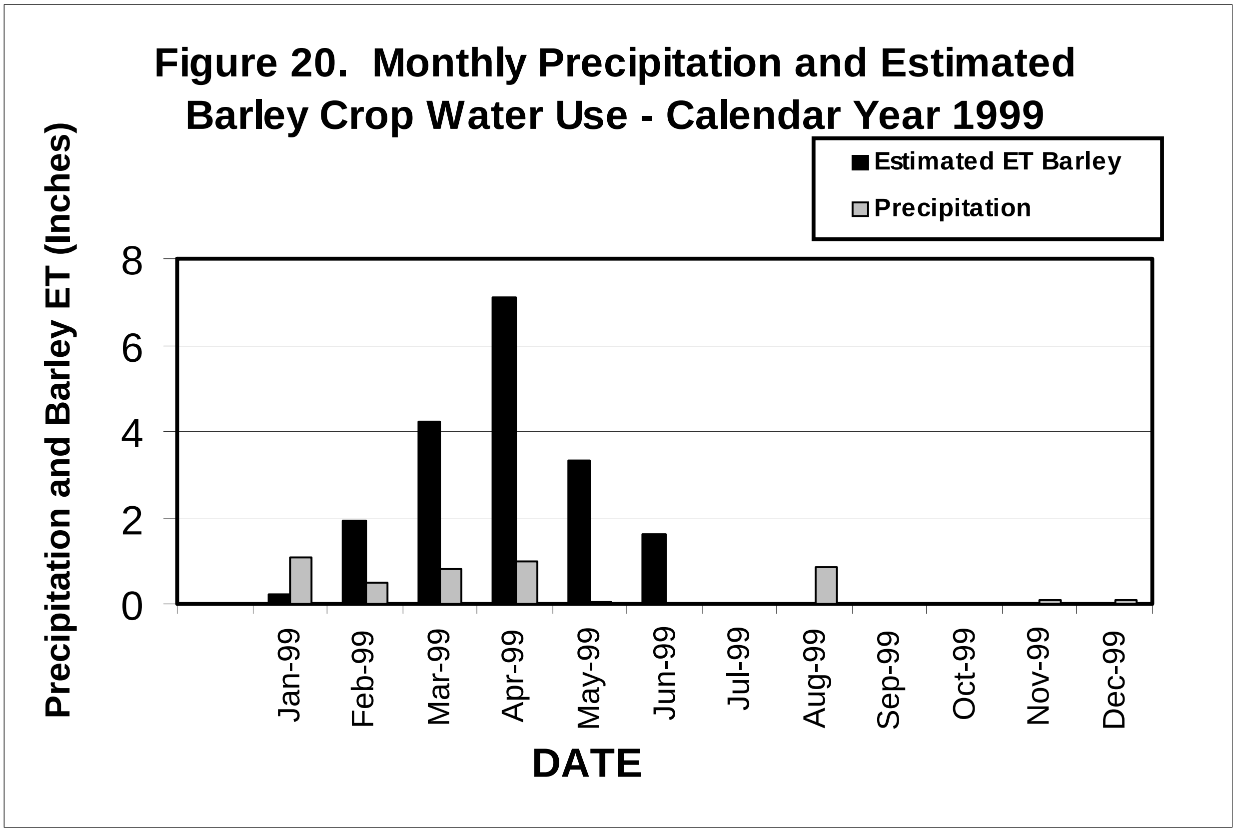


Figure 20. Monthly Precipitation and Estimated Barley Crop Water Use - Calendar Year 1999
Estimated ET Barley
Precipitation
Precipitation and Barley ET (Inches)
0
2
4
6
8
Jan-99
Feb-99
Mar-99
Apr-99
May-99
Jun-99
Jul-99
Aug-99
Sep-99
Oct-99
Nov-99
Dec-99
DATE

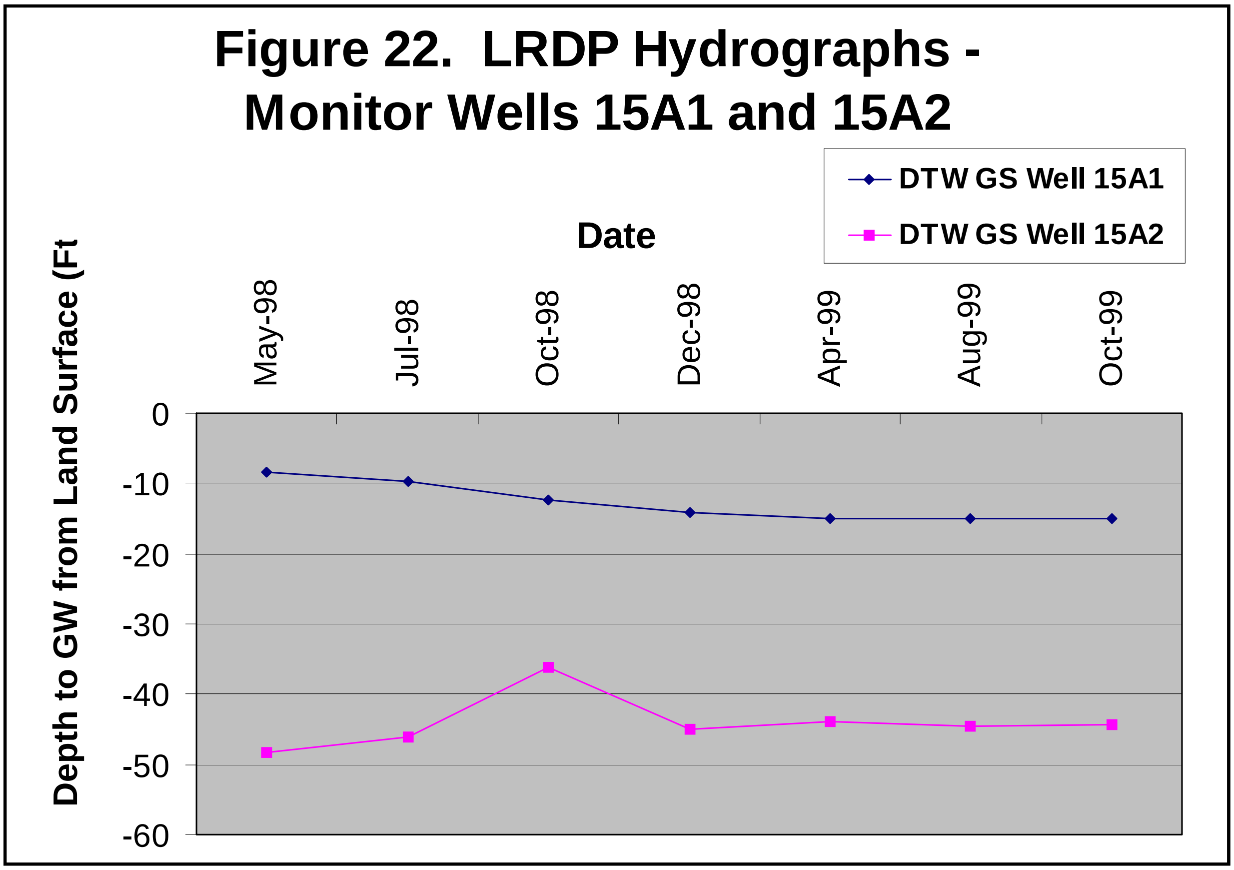
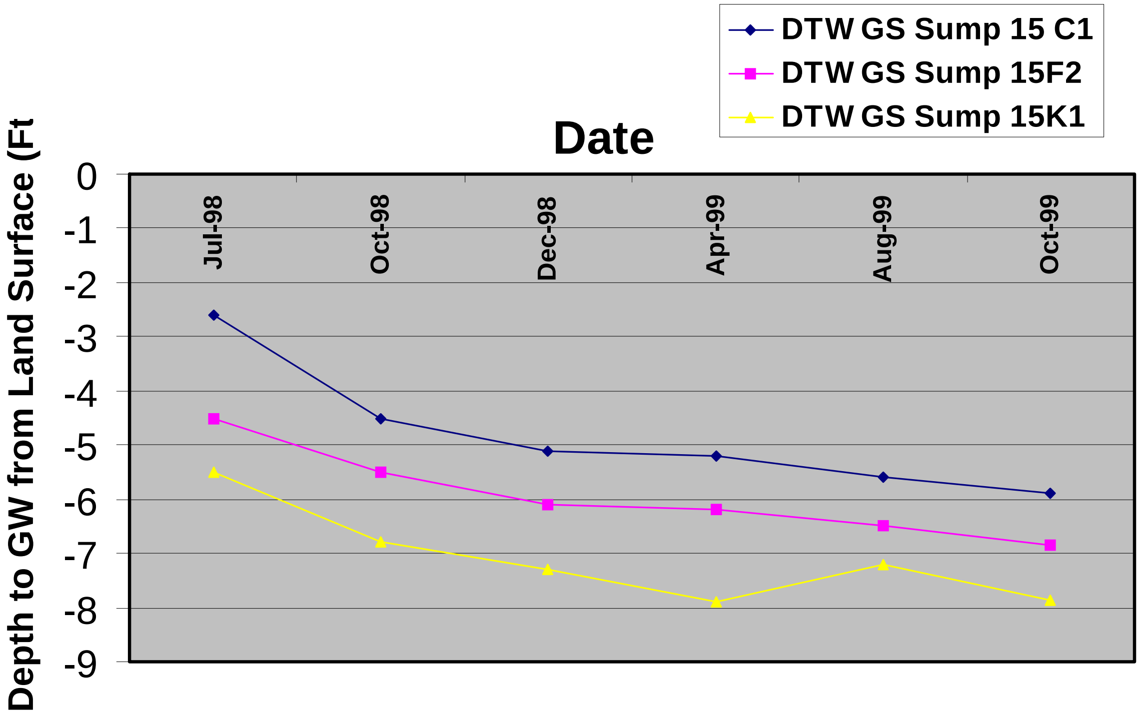


Figure 22. LRDP Hydrographs -
Monitor Wells 15A1 and 15A2
DTW GS Well 15A1
DTW GS Well 15A2
Date
May-98
Jul-98
Oct-98
Dec-98
Apr-99
Aug-99
Oct-99
Depth to GW from Land Surface (Ft
0
-10
-20
-30
-40
-50
-60

Figure 24. Land Retirement Demonstration Project Hydrographs - Drain Sumps 15C1, 15F2 and 15K1



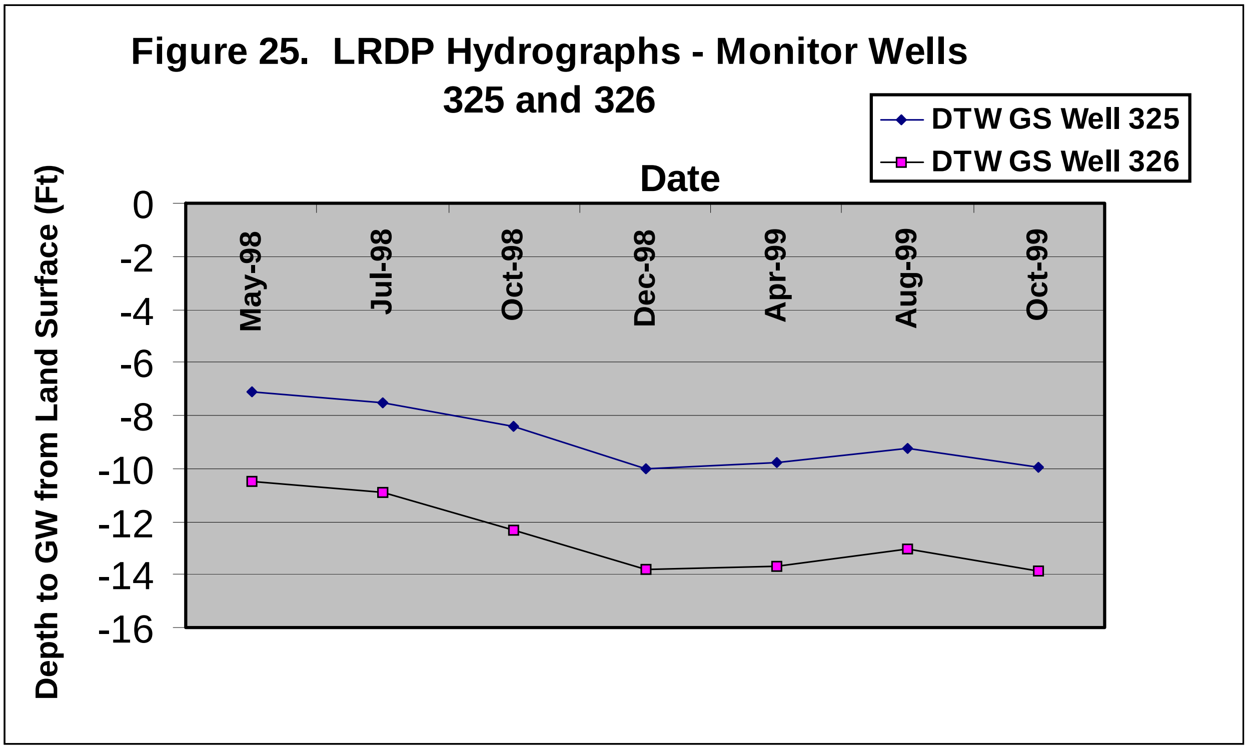


Figure 25. LRDP Hydrographs - Monitor Wells
325 and 326
DTW GS Well 325
DTW GS Well 326
Date
Depth to GW from Land Surface (Ft)
0
-2
-4
-6
-8
-10
-12
-14
-16
May-98
Jul-98
Oct-98
Dec-98
Apr-99
Aug-99
Oct-99

CONCLUSIONS

Biological and physical monitoring data collected thus far on Demonstration Project lands have provided a clear picture of baseline conditions on the site. Some wildlife and native plant species can currently be found on project lands, but numbers and diversity are low compared to natural areas. Simply removing land from intensive agriculture should allow for some additional species to colonize the site. Restoration efforts which increase vegetative community complexity and microtopographic heterogeneity will undoubtably lead to an increase in native plant and wildlife abundance and diversity.

Baseline contaminants collection results indicate that low levels of selenium are present in vegetation, invertebrates and vertebrates inhabiting the Demonstration Project site. However, these levels represent existing baseline conditions for the project site, and are not the result of land retirement activities.

Ongoing monitoring for the HRS and other areas will allow for critical examination of the most cost-effective techniques for facilitating this process on a large scale. Effects from HRS treatment applications may be seen as early as spring 2000, when native seeds that were imprinted on experimental plots begin germinating. The 2000 year annual report for the Demonstration Project will document any such emerging treatment effects.

Physical monitoring data available to date for the Demonstration Project site is encouraging. Declining groundwater levels indicate that the potential for wildlife exposure to selenium via this pathway is unlikely, and that groundwater levels should continue to decline over time. Baseline soil and groundwater chemical analysis data will be presented in the year 2000 annual report for the Demonstration Project.

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APPENDIX A.
1999 SCHEDULE OF ACTIVITIES FOR THE LAND RETIREMENT DEMONSTRATION PROJECT
WESTLANDS SITE

NOT IN ELECTRONIC FORM YET

APPENDIX B.

TARGET PLANT SPECIES FOR THE LAND RETIREMENT DEMONSTRATION PROJECT - WESTLANDS SITE

Appendix B. Target Plant Species for the Land Retirement Demonstration Project - Westlands Site

SPECIES	COMMON NAME	GROWTH FORM
Allenrolfea occidentalis	iodine bush	shrub
Amsinkia menziesii	farmer's fireweed	annual herb
Asclepias fascicularis	Mexican milkweed	perennial herb
Atriplex polycarpa	valley saltbush	shrub
Atriplex spinifera	spiny saltbush	shrub
Bromus carinatus	California brome	perennial/ biennial grass
Castilleja exerta	purple owl's clover	hemiparasitic herb/ forb
Castilleja attenuata	valley tassels	hemiparasitic herb/ forb
Castilleja brevistyla	owl's clover	hemiparasitic herb/ forb
Collinsia bartsiifolia	white chinese houses	annual herb
Dichelostemma capitatum	blue dicks	perennial herb
Distichlis spicata	salt grass	perennial grass
Eremocarpus setigerus	turkey mullein	forb
Frankenia salina	alkali heath	sub-shrub
Heliotropum curassavicum	heliotrope	annual herb
Hemizonia pungens	spikeweed	annual herb
Holocarpha obconica	tarweed	annual herb
Hordeum depressum	alkali barley	annual grass
Isocoma acradenia	goldenbush	shrub
Lasthenia californica	goldfields	annual herb
Lasthenia minor	goldfields	annual herb
Leymus triticoides	creeping wild rye	perennial grass
Linanthus dichotomus	evening snow	annual herb
Linanthus liniflorus	flax-flowered linanthus	annual herb
Malvella leprosa	alkali mallow	annual herb
Myosurus sessilis	mouse tail	annual herb
Nitrophila occidentalis	nitrophila	perennial herb
Plagiobothrys spp.	popcorn flower	annual herb
Sesuvium verrucosum	western sea-purslane	perennial herb
Sporobolus airoides	alkali sacaton	perennial grass
Suaeda moquinii	seep weed	sub-shrub
Trichostema lanceolatum	vinegar weed	annual herb
Trichostema ovatum	San Joaquin blue curls	annual herb
Vulpia microstachys	Nuttall's fescue	annual herb
Wizlenia refracta	jackass clover	annual herb

APPENDIX C.

IMPRINTING DEMONSTRATION OF APRIL 1999

THIS APPENDIX NOT IN ELECTRONIC FORM YET

APPENDIX D.

ALPAUGH PROJECT SITE STUDY PLAN

Study Plan for Experimental Land Retirement Demonstration Project Lands in Kings and Tulare Counties
October 1999
(Revised April 2000)

INTRODUCTION

Land Retirement Demonstration Project

A Land Retirement Demonstration Project (Demonstration Project) has been initiated by the Department of Interior CVPIA Land Retirement Team (LRT) on 1,646 acres in western Fresno county to test various habitat restoration strategies in a scientifically rigorous manner prior to retirement of large acreages of land under the CVPIA Land Retirement Program. The Demonstration Project will expand to 15,000 acres as further land acquisitions are made by the LRT in Fresno, Kings and Tulare counties (USDI 1999).

HRS in Western Fresno County

An 800-acre Habitat Restoration Study (HRS) containing twenty, 10-acre experimental plots has been initiated on the Demonstration Project site in western Fresno county (Westlands site). Plots will be subjected to one of four experimental treatments to identify cost-effective means of reestablishing native communities on retired lands. Five study plots will undergo microtopographic manipulation in which earthen berms are formed in the leveled agricultural fields to recreate habitat heterogeneity. A different set of five plots will be revegetated with native seeds and plugs. Another set of five plots will receive both the microtopographic and revegetation treatments, and a final set of five will serve as controls and receive no treatment.

Study plots at the Westlands site have been established and surveys have begun on the site. Application of the experimental treatments to the study plots is scheduled to begin in November of 1999.

Purpose and Need for this Study

Comparative research is needed on Demonstration Project lands in Tulare and Kings counties (Alpaugh site) to assess the effects of land retirement on the different soil types and local conditions found there. An 800-acre study directly comparable to the HRS would not be feasible due to time and financial constraints. However, a smaller-scale but similarly designed experiment would provide valuable information regarding the possible varying effects of land retirement in different regions of the Central Valley.

STUDY DESIGN

We propose to establish three, 160-acre “research blocks” of study plots at the Alpaugh project site. Plots will be arranged in a randomized block design similar to the HRS. The scale of these blocks will be smaller than the HRS. Rather than 10-acre plots imbedded within 40-acre plots, the research blocks will consist of 2-acre plots centered within 10-acre plots (Figures 1 and 2). Also, the design will consist of four replicates of the experimental treatments rather than five, in order to maintain adequate spacing between plots and still remain within a quarter section of land.

Sixteen, 2-acre plots will be randomly assigned one of the following experimental treatments:

> Revegetation with desired native plant species, which will include seeding and/or planting of plugs (seedlings);
> Microtopographic manipulations such as low mound or berm construction;
> A combination of revegetation and microtopographic manipulation; and,
> No manipulation (control treatment).

METHODS

Vegetation Surveys

A vegetation inventory will be conducted annually on the study plots to measure differences between the experimental treatments. Parameters to be measured on experimental plots include richness, percent cover, species composition, and productivity. Surveys will occur in April or May.

Percent cover, richness, and species composition will be measured by using the modified Daubenmire cover scale (Bonham 1989) with 35 cm by 70 cm rectangular plots (quadrats). For each annual vegetation inventory, ten randomly located quadrats will be examined to estimate species composition and relative cover of native species. Additional quadrats will be sampled as necessary if statistical analysis indicates they are needed to detect change with the desired confidence level.

For each vegetation inventory, productivity will be estimated by clipping all above-ground vegetation falling within ten randomly located quadrats (Bonham 1989). Samples will be sorted into native or non-native species categories and will be dried and weighed in the laboratory.

Mammal Surveys

Small mammal surveys will be conducted to monitor relative abundance of small mammals on study plots to identify differences between the four experimental treatments. Surveys will be conducted quarterly during January, April, July and October for four consecutive nights.

One 125-meter mammal trapping line will be established in each plot. The mammal trapping line will cut diagonally across each plot and will consist of ten Sherman traps spaced 10 meters apart (Jones et al. 1996). Traps will be baited with white proso millet seed and one dry paper towel will be placed in each for shredding material. Baiting of traps will begin approximately one hour before sunset and traps will be checked approximately two hours after sunset. All animals captured will be identified to species, sexed, weighed, ear-tagged or otherwise marked, and reproductive status determined. The information will be recorded on a standardized data sheet.

Bird Surveys

Bird surveys will be conducted quarterly to estimate avian abundance and use of the research blocks. Surveys will occur in January, April, July and October. Two point counts and one transect will be used per 2-acre plot to estimate relative abundance and identify differences between experimental treatments (Dawson 1981, Ryder 1986).

Transects will be walked daily for three consecutive days. Surveys will begin no later than one hour past sunrise. All species identified either visually or by vocalization that fall within plot boundaries will be recorded on standardized data sheets. Data sheets will include information about the date and time of the survey, observer location for each siting, species observed, bird activity at the time of observation, bird distance from the transect, and number of individuals of each species. Start and travel times will be standardized among observers so that equal time is spent on all plots. Avian species abundance will be expressed as the number of individuals observed per 125 meters, the length of the transect.

Herpetological Surveys
Herpetological abundance will be estimated on this site with visual encounter surveys (VES) (Heyer et al. 1994). Surveys will be conducted annually in late spring. Observers will spend twenty minutes systematically searching each study plot. All lizards, snakes and amphibians observed will be noted. For each siting, species, activity, and location information will be recorded on a standardized data sheet. Herpetological species abundance will be expressed as the number seen per time spent searching.

Insect Surveys
Insect surveys will be an important component of biotic monitoring on demonstration project lands. Differences between treatments may be detectable in insect populations before higher trophic levels show a response. Trends in insect populations will also be useful in interpreting results from mammal and bird surveys, since insects are an important food source for both groups and can affect those populations.

Two methods will be used to collect terrestrial invertebrates: pitfall traps and aerial sweeps. One pitfall array will be established in each plot. Each pitfall array will consist of four pitfall traps connected by drift fencing. Pitfall traps will be made with 13-liter (3.5 gallon) buckets and fencing will consist of 6-meter (20 foot) long sections of galvanized steel flashing (Heyer et al. 1994). Traps will be covered with a lid supported by wood stakes which will allow crawling invertebrates to fall in as they encounter the bucket, but prevent unwanted creatures from falling into the pitfall. Traps will be opened on the morning prior to the survey, and remain open for approximately 24 hours before being checked. Invertebrates will be collected at each station on three consecutive mornings every spring during late April/early May. Pitfall traps will be closed and secured after each survey.

Aerial sweeps will be taken to supplement pitfall captures. Aerial sweeps of vegetation to capture flying insects will be conducted at the same time as pitfall sampling. Sweeps will consist of walking a line 25 m long, sweeping with an insect net exactly 50 times along the line in vegetation. Random starting coordinates will be chosen for one line per plot. Insects from the sweeps will be killed in a kill jar and stored in vials containing 70% ethanol, or pinned if appropriate. Insects will be counted and identified to the taxonomic level of order or family in the laboratory.

Photo stations
To document changes over time in vegetative cover and species composition, permanent photo stations will be established at the southern boundary of each study plot. One digital and one 35-mm photo will be taken on a bi-annual basis from this location in each plot. These pictures will be organized by season and by plot. Photographs will be kept in a binder for easy review, and digital photographs will be archived on a compact disc.

Other Surveys
In addition to the intensive surveying that will occur on the research blocks as discussed above, a lower level of surveying will occur on non-experimental Demonstration Project lands at the Alpaugh site. The purpose of these additional surveys will be to document species presence on the larger project area and identify changes that may occur over time as a result of removal of the land from intensive irrigated agriculture. Changes that might occur include an increase or decrease of vertebrate species richness and percent of native species inhabiting the site.

Spotlighting
Spotlighting surveys will occur four times per year for three consecutive nights on Alpaugh Demonstration Project lands. A route will be established which adequately covers the property and allows for detection of nocturnal species using the site. Two researchers using spotlights with 1,000,000 candlepower will slowly drive the route beginning at a standardized time after sunset. If an animal or eyeshine is detected, researchers will stop and identify the animal using binoculars. All species encountered will be recorded on standardized data sheets. Results from the spotlighting surveys may be used to plan additional targeted surveys for small mammals or larger vertebrates such as the kit fox.

Raptor surveys
Raptor surveys will be conducted each winter during November or December to determine species composition and abundance of raptors using the demonstration site. Raptor surveys will be conducted for three consecutive days, beginning one hour after sunrise. The route will be driven slowly by two reseachers using binoculars to identify birds. All raptors observed and corresponding location along the transect will be recorded. The occurrence rate will be calculated as the number of species seen divided by the total number of miles driven.

Targeted surveys
In addition to the spotlighting and raptor surveys which will be conducted on an ongoing basis on the Alpaugh Demonstration Project lands, additional targeted surveys will be conducted as time and funds permit on species of interest. For example, areas with small mammal activity will be noted during the initial biological survey of each parcel, and those with potential kangaroo rats may be trapped at some point to identify the species using the site. Other targeted surveys that may occur in addition to small mammal trapping include track stations, camera stations, pitfall trapping, and bat surveys.

SUMMARY

The research outlined above will provide comparative data to research in Fresno county which will be useful in evaluating the effects of land retirement on Demonstration Project lands in the Tulare and Kings county areas. The research outlined in this document, in addition to the ongoing research in Fresno county, will allow for evaluation of different habitat restoration options useful on retired agricultural lands in the Central Valley.

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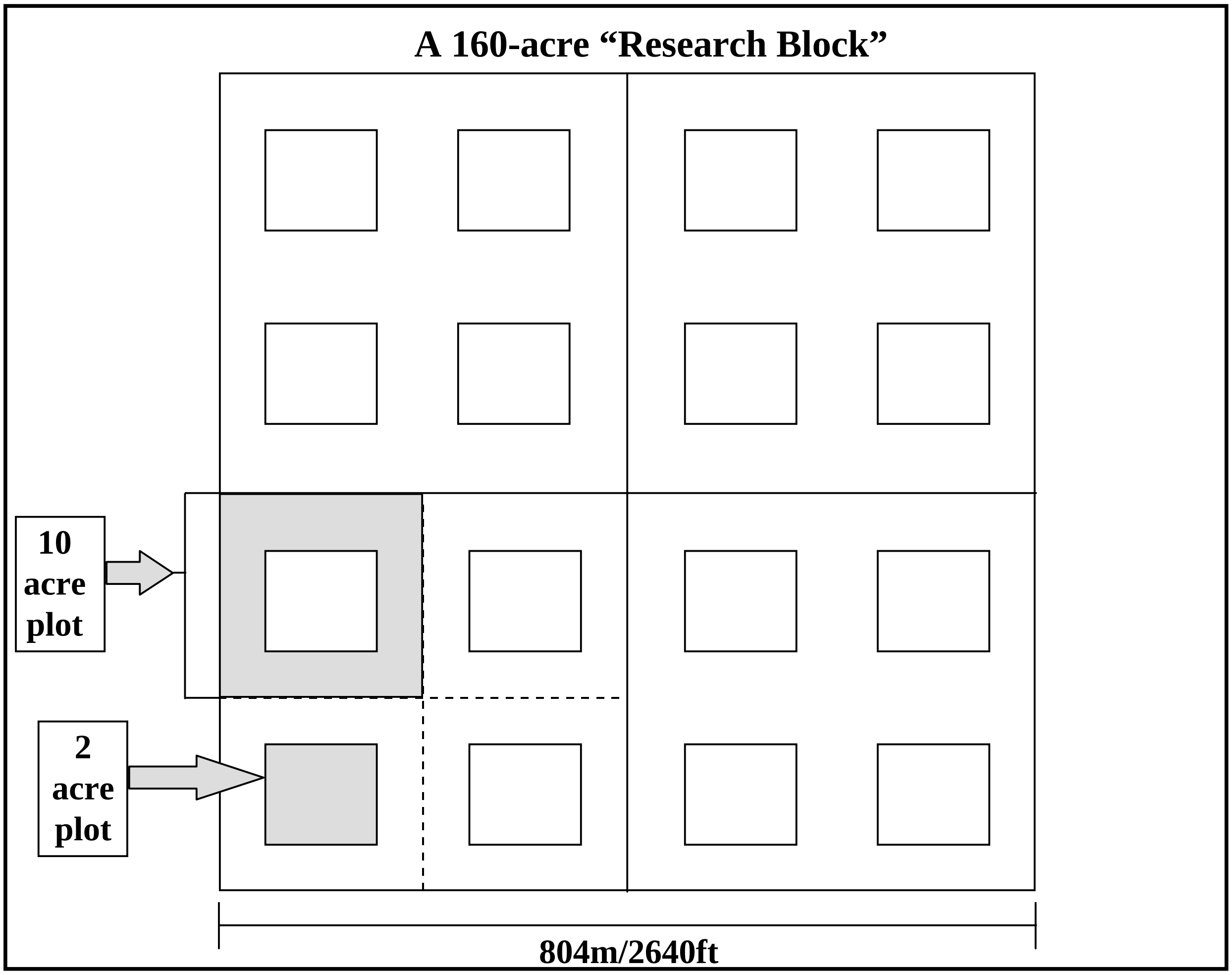

Figure 1. A Proposed 160-acre Research Block for the Alpaugh Land Retirement Demonstration Project Site

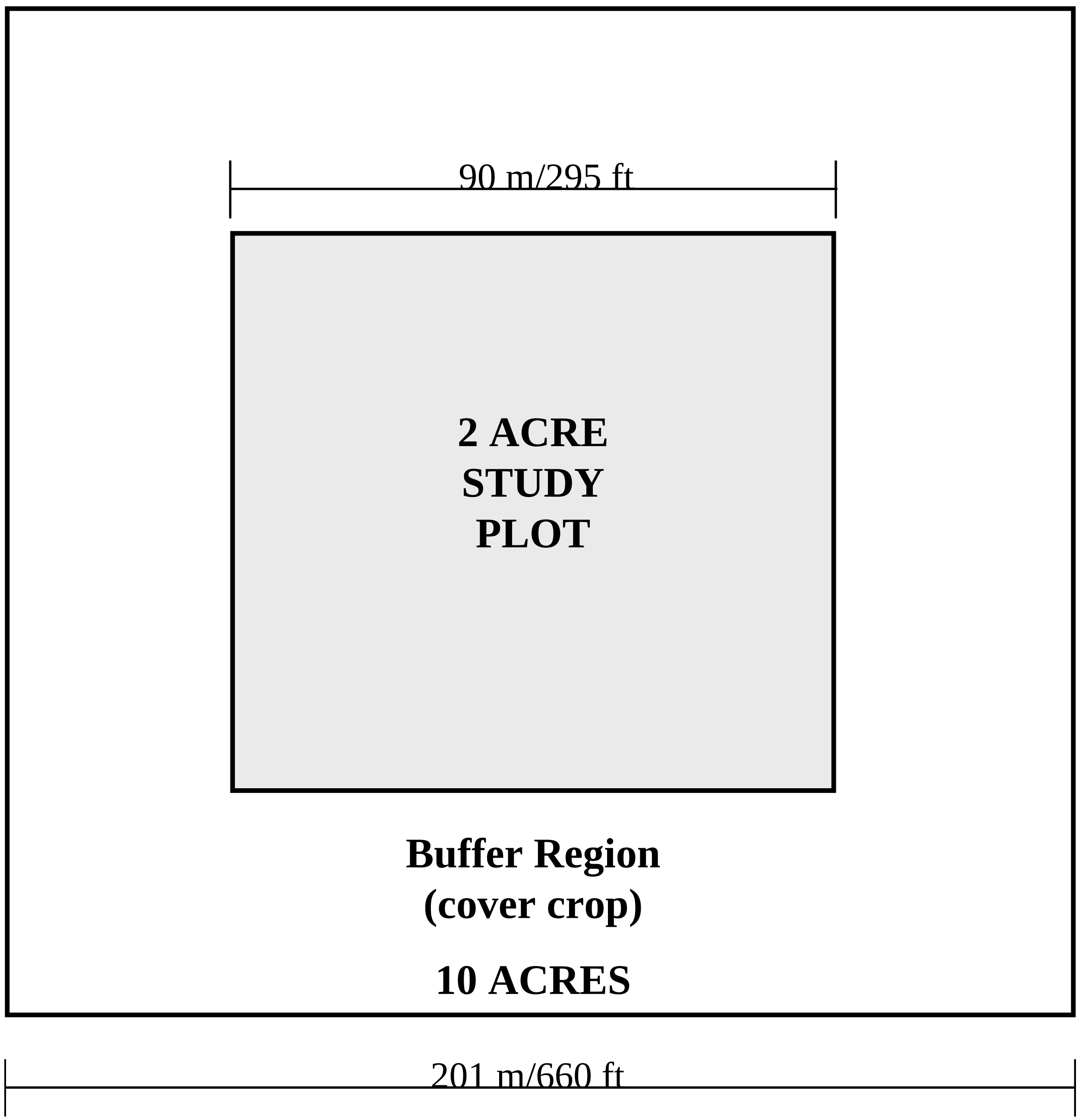

Figure 2. Example of a 2-Acre Study Plot within a 10-Acre Study Plot

APPENDIX E.

CUMULATIVE LIST OF ALL SPECIES OBSERVED ON DEMONSTRATION PROJECT LANDS AT THE WESTLANDS SITE IN 1999

Appendix E. Cumulative List of All Species Observed on the Westlands Demonstration Project Site in 1999

SCIENTIFIC NAME	COMMON NAME
VEGETATION	
Amaranthus spp.	pigweed
Atriplex patula	spear oracle
Avena fatua	wild oats
Beta vulgaris	beet (cultivated)
Bromus hordeaceus	soft chess
Bromus madritensis rubens	red brome
Brassica nigra	black mustard
Capsella bursa-pastoris	shepherd's purse
Carthamnus tinctorius	safflower
Centaurea solstitialis	yellow starthistle
Chenopodium alba	lamb’s quarters
Convolvulus arvensis	bindweed
Conyza canadensis	horseweed
Crypsis schoenoides	swamp pickle grass
Distichlis spicata	saltgrass
Epilobium brachycarpum	annual fireweed
Erodium cicutarium	red-stemmed filaree
Eremalche parryi parryi	Parry's mallow
Helianthus annuus	sunflower
Heliotropium curassavicum	heliotrope
Hirschfeldia incana	short-pod mustard
Hordeum depressum	low barley
Hordeum marinum	mediterranean barley
Hordeum murinum	foxtail barley
Hordeum vulgare	barley (cultivated)
Juncus spp.	rush
Lactuca serriola	prickly lettuce
Leptochloa uninerva	Mexican sprangletop
Malvella leprosa	alkali mallow
Melilotus indica	yellow sweet clover
Phacelia distans	common phacelia
Phalaris minor	dwarf canary grass
Physalis lanceifolia	tomatillo
Ploypogon monspeliensis	rabbit's foot grass
Raphanus sativa	wild radish
Rumex crispus	curly doc
Salsola tragus	Russian thistle

Senecio vulgaris	common ragwort
Sonchus asper	spiny sow thistle
Sonchus oleraceous	common sow thistle
Sysimbrium irio	London rocket
Tamarix ramosissima	salt cedar
Xanthium strumarium	cocklebur
BIRDS	
Corvus brachyrhynchos	American crow
Falco sparverius	American kestrel
Anthus rubescens	American pipit
Tyto alba	barn owl
Hirundo rustica	barn swallow
Euphagus cyanocephalus	Brewer's blackbird
Speotyto cunicularia	burrowing owl
Petrochelidon pyrrhonota	cliff swallow
Casmerodius albus	great egret
Eremophila alpestris	horned lark
Carpodacus mexicanus	house finch
Charadrius vociferus	killdeer
Chondestes grammacus	lark sparrow
Numenius americanus	long-billed curlew
Lanius ludovicanus	loggerhead shrike
Anas platyrhynchos	mallard
Charadrius montanus	mountain plover
Circus cyaneus	northern harrier
Mimus polyglottos	northern mockingbird
Falco mexicanus	prairie falcon
Buteo jamaicensis	red-tailed hawk
Agelaius phoeniceus	red-winged blackbird
Buteo lagopus	rough-legged hawk
Amphispiza belli	sage sparrow
Passerculus sandwichensis	savannah sparrow
Asio flammeus	short-eared owl
Egreta thula	snowy egret
Zonotrichia leucophrys	white-crowned sparrow
Tyrannus verticalis	western kingbird
Sturnella neglecta	western meadowlark
Elanus caeruleus	white-tailed kite
Dendroica coronata	yellow-rumped warbler
MAMMALS	

Lepus californicus	black-tailed jackrabbit
Spermophilus beecheyi	California ground squirrel
Microtus californicus	California vole
Canis latrans	coyote
Peromyscus maniculatus	deer mouse
Canis domesticus	domestic dog
Sylvilagus audubonii	desert cottontail
Dipodomys heermanii	Heerman's kangaroo rat
Mus musculus	house mouse
Thomomys bottae	southwestern pocket gopher
Bufo boreus	western toad

APPENDIX F.

SOIL SAMPLE LOCATION COORDINATES

APPENDIX G.

MONITOR WELL AND SUMP DATA SUMMARY

APPENDIX H.

MONITOR WELL CONSTRUCTION DIAGRAMS AND WELL LOGS