MANAGEMENT PLAN

for

"S" SERIES VERNAL POOLS

on

SAN DIEGO NATIONAL WILDLIFE REFUGE

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Prepared by:

John Martin
Refuge Biologist
San Diego National Wildlife Refuge
13910 Lyons Valley Road, Suite R
Jamul, California 91935

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Introduction

Coastal southern California has been identified as an area supporting high biological diversity (Myers et al. 2000). Among the habitat types contributing to the high diversity of species in southern California are vernal pools. Vernal pools result from an unusual combination of soil, topography, and climate, and are inhabited by a wide variety of plant and animal taxa wholly or partly restricted to such habitats. Vernal pools form in areas with 1) relatively flat topography; 2) impermeable soils such as clay near the surface; and 3) pronounced seasonal variation in rainfall. During the rainy season (November-April in southern California) water pools atop relatively impermeable soils, and remains pooled on the surface for a period of time ranging from days to weeks. During and shortly after this period of inundation, annual plants and invertebrates characteristic of vernal pools grow and reproduce, producing propagules that can withstand a long period of dessication. The pools and underlying soil soon dry up, and the seeds, spores, cysts, and eggs of vernal pool flora and fauna remain dormant in the soil until the next rainy season. The annual period of inundation inhibits growth of upland plants in vernal pool areas, conversely the annual period of dessication precludes the development of a typical community of marsh plants and animals. Therefore a particular group of species tolerant of the pattern of seasonal inundation and dessication has evolved to occupy vernal pools.

Due to the rarity of vernal pools and the low dispersal capability of their characteristic biota, vernal pool animals and plants show a high degree of endemism between groups of pools. Because of this high endemism, and the specialization of vernal pool species for their unusual habitat, vernal pools contribute a disproportionately high number of species to southern California's overall biological diversity, relative to their limited area.

The rapid growth in southern California's human population and concomitant development have greatly reduced the area of vernal pools and the abundance and distribution of their unique taxa. Remaining vernal pools are threatened by development-related impacts such as trash dumping, off-road vehicle travel, and invasion by exotic plant species. Several vernal pool species in southern California are listed as threatened or endangered under the Endangered Species Act. In response to the decline in extent of vernal pools, and impacts to ecological functionality of remaining pools, these habitats have been targeted by southern California conservation efforts.

One such conservation effort has been the acquisition of the Shinohara parcel by the San Diego National Wildlife Refuge. The Shinohara parcel is about 700 meters south of Sweetwater Reservoir in San Diego County, and encompasses a portion of the "S" series vernal pools (Bauder 1986). Bauder described the "S" series as consisting of approximately 12 pools in 4 groups. The appropriate soils and topography to support vernal pools occur on approximately 150 acres in the vicinity of the "S" series pools. Vernal pool species recorded on surveys of this group of pools include including *Navarettia fossalis*, *Psilocarphus brevissimus*, *Juncus bufonius*, and *Crassula aquatica*

(Bauder 1986), San Diego fairy shrimp (*Branchinecta sandiegoensis*), *Pilularia americana*, and *Epilobium pygmaeum* (Scott McMillin pers. comm.).

Though the pools are protected from destruction by development, their probable history of disturbance by agriculture, and their current severe invasion by exotic annual weeds, threatens the ecological functionality of these pools and the persistence of their unique biota. A restoration program such as that described in this plan would increase the likelihood of persistence of the valuable vernal pool community on the site. Currently the lands occupied by the "S" series pools are divided among lands managed by the Sweetwater Authority and lands managed by San Diego National Wildlife Refuge. The Sweetwater Authority's portion of this pool series is adjacent to and broadly contiguous with vernal pool areas on San Diego National Wildlife Refuge. The Sweetwater Authority is currently undertaking the restoration of approximately 23 acres of this adjacent vernal pool habitat. Combined with the proposed restoration of approximately 31 acres on the refuge, a total of approximately 54 acres would be restored. The greater extent of the combined restored areas would make the vernal pool biota on the site less vulnerable to extirpation by edge effects or stochastic and microclimatic variation than either of the restoration sites standing alone.

Failure to undertake exotic vegetation control measures on the San Diego National Wildlife Refuge "S" series vernal pools has the potential to affect the coverage of spreading navarretia under MSCP. Table 3.5 of the MSCP presents "Details of rationale for identifying species as covered". For spreading navarretia, the rationale for coverage stipulates that "Vernal pools incorporated into the National Wildlife Refuge System would be managed for the recovery of this species." Management for recovery entails implementation of Recovery tasks listed in the Recovery Plan (U.S. Fish and Wildlife Service 1998). As noted above, the Recovery Plan for Vernal Pools of Southern California (which specifically addresses spreading navarretia) lists rehabilitation and enhancement of vernal pools as a Recovery Task. Therefore, rehabilitation and enhancement of the vernal pool habitat on San Diego National Wildlife Refuge is necessary to ensure continued coverage of spreading navarretia under the MSCP.

Current conditions

The Shinohara parcel is located approximately 700 m south of Sweetwater Reservoir, in southwestern San Diego County (figure 1). Bauder (1986) considered the "S" series vernal pools to occur on virtually the entire parcel. On 15 June, 2005, I mapped the potential pooling areas on the parcel, based on topography, and distribution of moisture-tolerant grass species such as *Lolium perenne* and *Phalaris aquatica* (figure 2). The potential pooling areas are broadly distributed over approximately 31 acres.

Landscape-scale topography of the site is relatively flat. The aerial photo shows that the mima mound topography characteristic of vernal pool landscapes is less pronounced on the lands managed by San Diego National Wildlife Refuge than on immediately adjacent lands managed by Sweetwater Authority. The transition in topographic relief is abrupt.

This suggests that agricultural activity (e.g., grazing, plowing, brushing...) artificially reduced the topographic relief on the Shinohara side of the fence, and may have reduced depth and duration of inundation of vernal pools on the site.

Vegetation on the site is overwhelmingly dominated by exotic annual weeds, most of them grasses. Weed species include *Avena* sp., *Bromus madritensis* ssp. *rubens*, *Lolium perenne*, *Phalaris* sp., *Aegilops cylindrica*, *Rumex crispus*, and *Foeniculum vulgare*. This infestation of exotic plants is likely to be deleterious to native vernal pool flora in many ways, including competition for light, soil moisture, and nutrients; reduced inundation period, an altered community of soil invertebrates and microbes; enhancement of populations of fossorial rodents, ants, and rabbits (all of which may be deleterious to vernal pool plants); increased risk of deleterious effect to native plants in the event of fire because of increased fuel load; and interference with native pollinators. If exotic annuals continue to dominate the site, eventually some native vernal pool species may disappear from the site, and overall biological diversity is likely to decline. I

In some small areas of the parcel, the native grass *Nassella pulchra* is a co-dominant. Two broad, shallow swales, one in the northeast part of the parcel running northwest-southeast, and one in the large southern part of the parcel running northeast-southwest, support widely scattered individual riparian plants such as *Juncus acutus*, *Salix goodingii*, and *Baccharis salicifolia*. Approximately 15 individual *Tamarix ramosissima* in this area were killed in November, 2005.

The site is separated from the public trail on the adjacent Sweetwater Authority property to the west by an 8-foot cyclone fence. Access from the south is precluded by the SR 125 construction site. Access from the east is limited to a gated private road adjacent to the property. Access from the north is via a little-traveled area of San Diego National Wildlife Refuge, with few or no trails in the immediate vicinity. Therefore, trespass-related impacts to the vernal pools (e.g., trash dumping, off-road vehicles, and horse traffic) are minimal.

Goals

Our overall objective is to re-establish a healthy vernal pool habitat, where existing vernal pool flora and fauna (and re-introduced native flora and fauna, as appropriate) are likely to persist. To that end we have several specific goals:

1. Weed control: Upon project completion, cover of exotic annual weeds should not exceed 10%.
2. Hydrology: In the rainy season, distribution and abundance of pools should be approximately as shown in figure 2, with some augmentation in areas where pools do not currently occur, but where mima mound topography on the adjacent Sweetwater Authority property suggests that they once occurred.

3. Native species: The site should support healthy populations of native vernal pool species, including *Navarretia fossalis*, *Branchinecta sandiegoensis*, and other species appropriate to southern San Diego mesa claypan vernal pools.
4. Quino checkerspot habitat: In addition to vernal pools, the site should support an open grassland/coastal sage scrub plant community including *Plantago erecta*: the primary larval host plant of the federally endangered Quino checkerspot butterfly (*Euphydryas editha quino*).

Restoration strategy

The restoration of ecological functions supporting vernal pool flora and fauna will be accomplished by a multi-faceted approach, with different restoration activities being conducted over a period of approximately 5 years. Therefore only the initial tasks of the overall restoration program would be undertaken in fiscal year 2006.

De-thatching

The site will initially be cleared of living and dead exotic annual weeds. Crews trained in recognition of native southern California plants will use weed-whackers or other hand tools to cut off exotic annual vegetation to a height of approximately 1 centimeter, while avoiding native plants that are still bearing seed. Cut vegetation will be raked, gathered up, and removed from the site. This will serve the restoration effort in several ways:

1. It will remove a substantial amount of exotic annual plant seed from the site, attached to the cut vegetation.
2. It will eliminate the microclimate that favors the germination of exotic annual plants over natives. The layer of thatch retains surface moisture, promoting the germination of exotic annual weeds before the native annuals. With this "head start", the exotics tend to out-compete natives.
3. It will facilitate subsequent weed control efforts, by making subsequent crops of both native and exotic plants more visible. It will be easier to avoid weed control-related impacts to native plants if they are not obscured by thatch. Without the thatch layer, exotic plants can be recognized and controlled sooner. Absence of thatch allows easier access to exotics plants for hand-weeding, and more thorough contact of herbicides with exotic weeds.

Seed collection

Seed will be collected from desirable native plants on site, on adjacent areas of San Diego National Wildlife Refuge, and from other vernal pool areas as determined by the staff biologist at San Diego National Wildlife Refuge. Vernal pool species will be targeted, as will native grassland and coastal sage scrub species that occur in the upland areas between vernal pools. Phenology of plants targeted for seed collection should be monitored to ensure that seed is collected when is has matured sufficiently. Seed should be roughly cleaned, and stored under cool, dry conditions to ensure subsequent viability.

If the project manager determines that inadequate seed of a particular species has been collected to re-seed the project site, seed may be "amplified" by growing the collected seed in captivity, then collecting the seed from the captive-grown plants. Seeds and propagules (e.g., spores, cysts, eggs...) of other taxa may also be collected in soil from vernal pools. The soil and seed will later be used to inoculate vernal pools after weeds have been sufficiently reduced and hydrology is appropriate.

Pool re-contouring

Topography on the site may have been altered by past land use practices. It appears that many of the areas that may once have been seasonally inundated pools are now swales, that may support moist soils for a prolonged period, but may not pool long enough to support a diverse community of vernal pool organisms. Therefore hydrology of the site may be enhanced by slight modifications to some pools, to increase their depth and duration of inundation. A small bulldozer may be used to enhance pool topography. Prior to any topographic modification, specific areas for such modification should be mapped during a period of inundation.

Weed control

Weed control measures are likely to include a variety of techniques, including hand-weeding, cutting, and herbicide application. Where native vernal pool species are present, hand-weeding is the preferred method, to minimize potential for damage to the native plants. Crews trained in recognition and avoidance of desirable native plants will pull weeds by hand, or cut them when they are adjacent to native vernal pool plants, to avoid soil disturbance associated with uprooting weeds. Pulled or cut weeds will be removed from the site. In areas more than 2 meters from desirable native plants, a glyphosate-based herbicide may be used to control exotic weeds. It is expected that an initial cohort of weeds will germinate in response to early winter rains. These should be treated approximately 1-2 weeks after the first substantial rain event in winter of 2006-2007 (weather permitting). Subsequent rain events are expected to stimulate germination and growth of subsequent cohorts of weeds, which will be treated with herbicide on a similar schedule (i.e., after approximately 1-3 weeks growth). Each subsequent rain event is expected to produce a smaller cohort of weeds. Additionally, as the growing season progresses, more and larger desirable native plants are expected to occur on the site, such that as the season progresses, herbicide applicators will need to exercise greater care and selectivity to avoid deleterious effects to native plants. As frequency of seasonal rains diminishes, successive cohorts of exotic weeds are expected to be less numerous and less vigorous; therefore, herbicide applications may occur at longer intervals. It is expected that the site will require several applications of herbicide in a given rainy season. Herbicide will be applied when conditions are optimal for the translocation of glyphosate. Weed seeds dormant in the soil are expected to remain viable for several years, germinating when local conditions are appropriate. While dormant, weed seeds are relatively invulnerable to control, therefore it is likely to be necessary to continue some degree of weed control for several years before the goal of less than 10% annual weed cover is realized.

Riparian weed seed barrier

To reduce the transmission of exotic weed seeds from the unrestored, weed-infested areas to the northeast into project site, native riparian vegetation should be enhanced in the gentle swale that runs northwest-southeast across the northeast portion of the site (Figure 3). Enhancement would entail planting of container stock of native riparian species to augment the riparian natives that currently occur there, and suppression of weeds to reduce competition for soil moisture and nutrients.

Re-seeding

Seed and soil inoculum from vernal pools will be distributed in vernal pools and raked into the soil when weed cover has been reduced and pool hydrology is appropriate. Seed of upland species will be distributed on upland mounds between pools. Seed and inoculum should be distributed in the dry season, shortly before the winter rains begin.

Planting of container stock

In upland areas between pools, native upland plant nursery stock will be planted. Species will be characteristic of valley needlegrass grassland with coastal sage scrub elements (e.g., *Nassella pulchra, Artemisia californica, Deinandra conjugens, Isocoma menziesii, Eriogonum fasciculatum, Astragalus trichopodus*...). Establishment of native upland plants is likely to reduce opportunities for weeds to re-colonize the site.

Monitoring

Randomly located permanent transects should be used to monitor changes in plant cover throughout the site as the restoration progresses. Additionally, transects should be established across pools to specifically estimate cover of native vernal pool species and exotic weeds.

Cost Estimate

See Table 1 for estimated cost of the restoration of this vernal pool complex, for fiscal year 2006. Cost estimates are based on extrapolation from other habitat restoration projects that are currently being undertaken on San Diego National Wildlife Refuge.

Table 1. Estimated costs of Shinohara vernal pool restoration in fiscal year 2006

Activity	**cost**
De-thatching	$60,000
Seed collection	$15,000
Pool re-contouring	$8,000

Herbicide application	$15,000
Map areas for pool re-contouring	$5,000
Establish permanent monitoring transects, initiate monitoring	$5,000
Contingency fund	$10,000
Total	$108,000

Timeline

Rainy season 2005-2006 (November-April):

Reconnaissance surveys for native vernal pool species

Map areas for pool re-contouring

Establish permanent monitoring transects, initiate monitoring

Collect native seed

Dry season 2006 (May-October)

Collect native seed

De-thatch entire parcel

Determine which (if any) southern California vernal pool species are appropriate for introduction into the S series pools

Re-contour pools as needed

Treat weeds with glyphosate as needed. Conditions may or may not be sufficient to support weed growth. If not, no treatment would occur.

Rainy season 2006-2007 (November-April):

Conduct weed control (hand-weeding and/or herbicide, as appropriate)

Plant riparian weed seed barrier in swale across NE corner

Monitor vegetation

Collect native seed

Dry season 2007 (May-October)

Treat weeds with glyphosate as needed. Conditions may or may not be sufficient to support weed growth. If not, no treatment would occur.

Re-seed and inoculate vernal pools with native vernal pool species

Water riparian weed seed barrier plants as needed

Rainy season 2007-2008 (November-April)

Conduct weed control (hand-weeding and/or herbicide, as appropriate)

Monitor vegetation

Plant nursery-grown container stock in uplands between pools

Dry season 2008 (May-October)

Treat weeds with glyphosate as needed. Conditions may or may not be sufficient to support weed growth. If not, no treatment would occur.

Re-seed and inoculate vernal pools with native vernal pool species as needed

Water riparian weed seed barrier plants and other nursery-grown container stock as needed

Rainy season 2008-2009 (November-April)

Control weeds

Monitor vegetation

Weed control (as needed) and monitoring should be continued in the rainy season through 2011.

Literature cited

Bauder, Ellen T. 1986. San Diego Vernal Pools: Recent and projected losses; their condition; and threats to their existence, 1979-1990. California Department of Fish and Game, Sacramento, California. 29 pp and Appendices.

Myers, N., R.A. Mittermeier, C. G. Mittermeier, G.A.B. da Fonseca and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853-858

Figure 1. Location of proposed project.

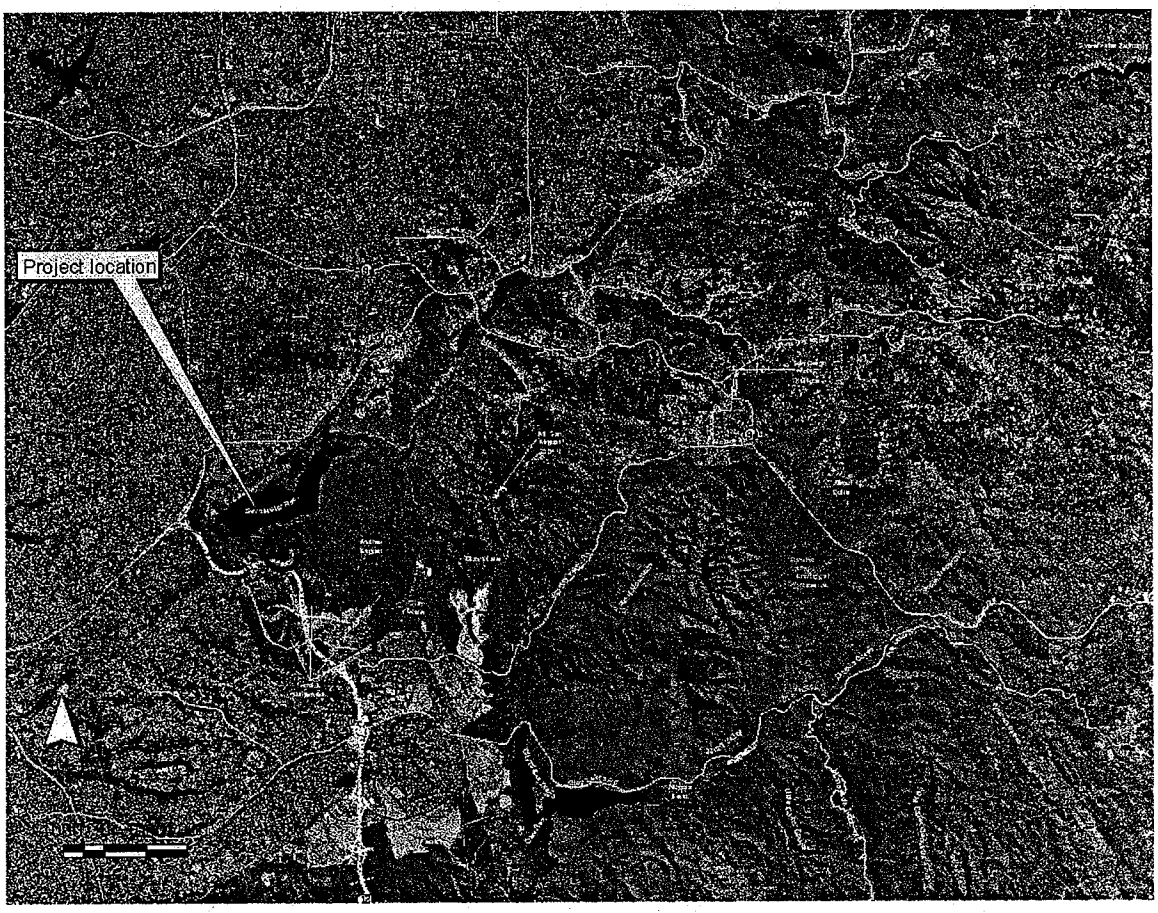

Figure 2. Potential pooling areas mapped on project site on 15 June, 2005

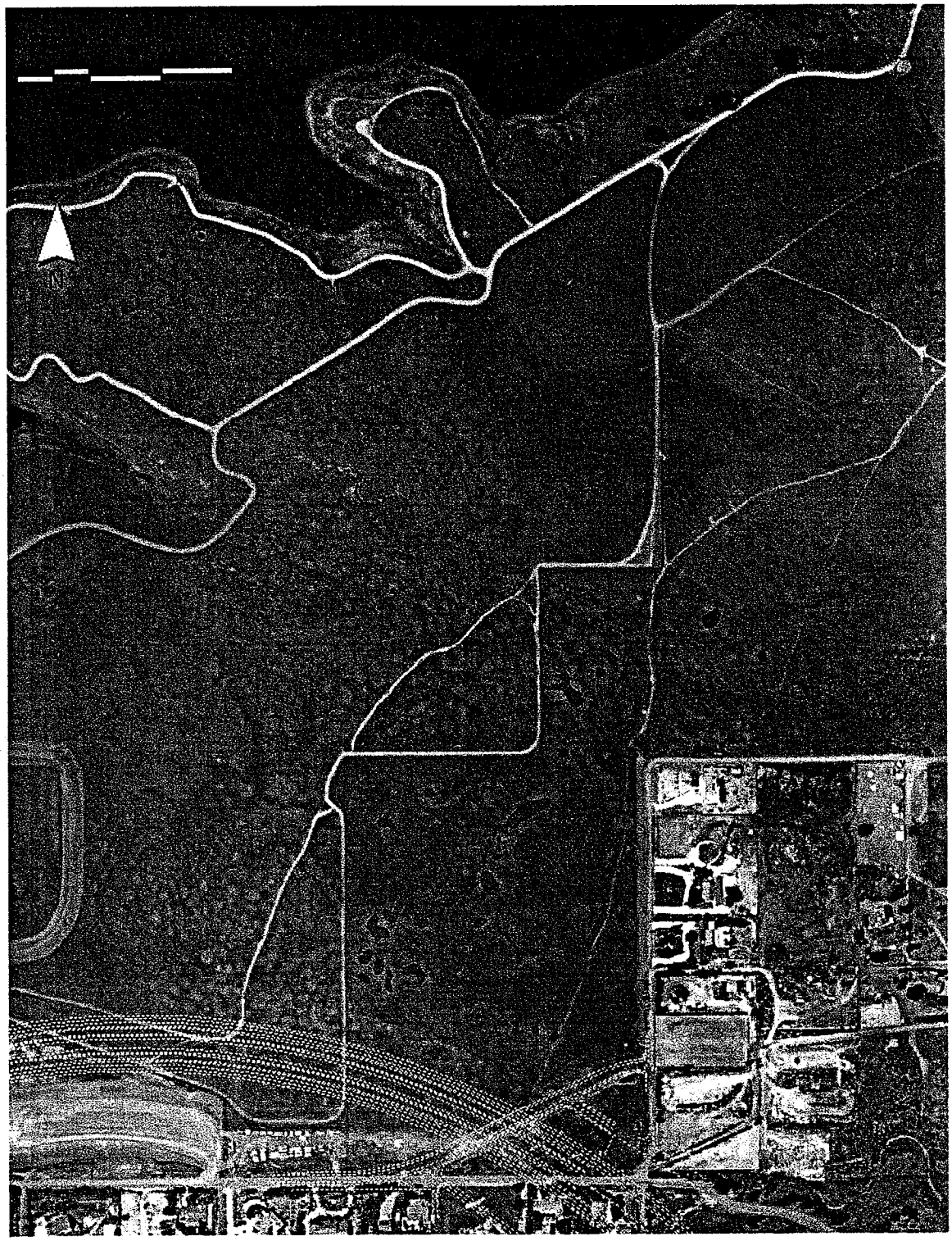

Figure 3. The stippled green area illustrates the location of proposed riparian barrier to weed seeds.