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**DUNE RESTORATION FOR MENZIES' WALLFLOWER, HOWELL'S SPINEFLOWER, AND  
WESTERN SNOWY PLOVER  
MACKERRICHER STATE PARK  
(CONTRACT #P9930012)**

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## INTRODUCTION

The purpose of this project was to reduce the cover of European beach grass (*Ammophila arenaria*) (beach grass) and augment populations of Howell's spineflower (*Chorizanthe howellii*) (spineflower) and Menzies' wallflower (*Erysimum menziesii* ssp. *menziesii*) (wallflower), and increase habitat for the western snowy plover (*Charadrius alexandrinus nivosus*) in the Inglenook Fen – Ten Mile Dunes Natural Preserve (Preserve) within MacKerricher State Park, Mendocino County, California. Seeds of the State- and Federally-listed plants mentioned above and other native plants were collected, propagated, and planted in appropriate areas of the dunes. Emphasis was placed on methods of increasing stands of spineflower on coastal bluffs and openings in dune hollows. Most areas of suitable habitat for spineflower in the Preserve and south to Lake Cleone, MacKerricher State Park were surveyed for presence of spineflower and mapped. All planting was done in the Preserve and some mapping extended beyond the Preserve boundary at Ward Avenue still within MacKerricher State Park.

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## EUROPEAN BEACH GRASS REMOVAL

**LOCATION** Priorities for the removal of beach grass were established based on 1) isolated patches and 2) occupation and proximity to habitat areas of threatened species. The removal area was at the south end of the Preserve north of Ward Avenue where beach grass reaches its southern limit in the foredunes in the Preserve (Fig. 1). These outliers of beach grass have the greatest potential to spread and occupy new areas and so were treated first. Areas in and around archaeological sites were left intact to avoid disturbance and to prevent sand drift onto shell middens.

**METHOD & RESULTS** The method of removal of beach grass was entirely by hand; no herbicides or machinery were used. A crew of 3-5 workers used a pointed-tip hand shovel. Shovels with fiberglass handles were preferred to shovels with wooden handles because they weighed slightly less. A worker would force the shovel into the sand with his or her foot, pry the roots loose, and pull out the clump of grass. Pulling out the clumps by hand without first prying with a shovel sometimes led to roots breaking below ground. This was especially true when the sand was dry. The best time for pulling beach grass was when the sand was damp or wet, although pulling should not be limited to this time only.

Approximately 1500 person-hours were spent in the removal of 1.13 hectares (2.8 acres) of beach grass. The site was pulled 5 times; and from records of person-hours/area it was estimated that each subsequent effort of removal by pulling takes  $\frac{1}{2}$  to  $\frac{3}{4}$  the total time of the previous removal effort. The time between each removal depended on the season. From spring through summer approximately 3 months were allowed to pass, and from autumn through winter approximately 5-6 months were allowed to pass. These times were sufficient for resprouting beach grass to reach a height tall enough to be successfully pulled. Newly resprouting beach grass (one month from last pull during summer) did not have enough biomass to be successfully pulled; most rhizomes were not developed and the plant broke close to the sand surface. Time spent pulling was typically an 8 hour day with travel to the site each way at 0.5-0.75 hours.

**Ammophila arenaria Removal Locations & Revegetation Plots  
Inglenook Fen-Ten Mile Dunes Natural Preserve  
MacKerricher State Park**



**Figure 1. *Ammophila arenaria* Removal Locations and Revegetation Plots, Inglenook Fen-Ten Mile Dunes Natural Preserve.** Black polygons represent areas of European beach grass (*Ammophila arenaria*) removal completed under this Section 6 grant. These are areas of high potential for Menzies' wallflower habitat (*Erysimum menziesii* ssp. *menziesii*). Sites 1-3 were planted with native plants.

A comparison of previously recorded detailed logs of beach grass pulled per hour by Park laborers versus by California Conservation Corps (CCC) crewmembers showed a potential for cost savings. Costs of contracting with the CCC included driving time of two hours per person each day. Because park laborer employees were paid as soon as they arrived on the jobsite, they were chosen to pull the beach grass.

### NATIVE PLANT REVEGETATION

**SEED COLLECTING & PLANTING** Native plant seeds were collected locally in order to establish an assemblage of vegetation that frequently occurs with spineflower and wallflower (Table 1). Seeds were collected in late summer of 2000 and the CCC Nursery in Napa, California began growing approximately 4,000 plants in the spring of 2001. Seeds of *Calystegia soldanella* and *Grindelia stricta* did not germinate, and seeds of *Abronia latifolia* and *Camissonia cheiranthifolia* produced approximately 100 plants each. Seeds of *Ambrosia chamissonis* produced about 1500 plants, *Artemisia pycnocephala* about 2000, and *Poa douglasii* about 300.

Planting occurred in February 2002 in areas where blowouts were caused by people walking down the bluff in a naturally sloping area (Sites 1-3 see Fig. 1, Site 1 see also Fig 2-3.). Repeated foot traffic kept the area from becoming vegetated and sand moved freely across the volunteer trail. Planting also occurred where beach grass had been pulled 5 times (Site 3, Fig. 1). Sites 1, 2, and 3 were approximately 350 m<sup>2</sup>, 150 m<sup>2</sup>, and 75 m<sup>2</sup> respectively. Sites were planted in February 2002 and the California Conservation Corps assisted State Park employees in planting the sites. Site 1 was planted with approximately 2,000 plants and Site 2 with 1,500 plants. Site 3 was planted only with approximately 500 plants because it was determined that planting into the areas where beach grass still needed to be pulled would decrease the chance of the native plants' survival. Sites 1 and 2 were fenced and signed to prevent people from trampling the plants.

Wallflower and spineflower seeds were collected for planting in revegetation sites (See Table 2 for wallflower, Table 3 for spineflower). As part of the contract agreement, ten container plants each of spineflower and wallflower were to be grown for planting in the revegetation sites in March 2002. Spineflower seeds were sown in flats in the greenhouse in fall 2001. When the plants were several inches tall, 125 seedlings were planted in 4" deep containers. This depth provided ample room for the roots. Ten one-gallon wallflower plants were grown in the greenhouse in January 2002. Four seeds per container were planted and 3-4 seeds germinated in approximately 10 days. Out-planting of containers of both listed species occurred during March 2002. Container plants of both species were planted in openings between the other native plants in Site 1. Container plants of the listed species were not planted on the beach grass removal sites because follow-up pulling is still necessary in these areas.

**Table 1. List of Plants Collected for Revegetation**

- Ambrosia chamissonis* - silver bursage, silver beach burr
- Artemisia pycnocephala* - beach sagewort
- Abronia latifolia* - yellow sand verbena
- Poa douglasii* - seashore bluegrass
- Camissonia cheiranthifolia* - beach primrose
- Calystegia soldanella* - beach morning glory
- Eriogonum latifolium* - coast buckwheat
- Grindelia stricta* - beach gumweed

**Table 2. Collection Statistics for *Erysimum menziesii* ssp. *m.*** Numbers are derived from seeds collected and general observations in the field.

total weight of seeds	518 grams
seeds counted/1.6 gram	1026 seeds
approx. total seeds	332,167 seeds
approx. number seeds/gram	641 seeds
approx. plants from which seeds collected	1107 plants
approx. seeds/plant - total	500 seeds
approx. % seeds/plant - collected	0.6 seeds
approx. % seeds/stand - collected	0.5 seeds
approx. % seeds/area - collected	0.15 seeds



**Figure 2. Revegetation Site 1.** California Conservation Corps members and California State Park employees place driftwood on a blowout in the sandy bluff. Native plants are planted on the flat steps between the driftwood.



**Figure 3. Revegetation Site 1, Facing West.** Racks of native plants are laid out before they are planted at approximately 8" centers.

#### WESTERN SNOWY PLOVER MONITORING

Nesting habitat for snowy plovers in the Preserve occurs primarily above high tide on the beach of the preserve, sparsely-vegetated dunes, beaches at creek and river mouths, Ten Mile River sand spit, and secondarily on flat areas like Indian shell middens or deflation plains behind the foredunes. Few plovers have been seen at the south end of the Preserve beach where there is relatively high visitor use. The northern half of the Preserve receives less visitor use and it is where most plovers are seen. However, this half of the Preserve contains more beach grass than the southern half. The invasion of beach grass in coastal dunes is considered to be one of the most significant causes of habitat loss for western snowy plovers (U.S. Fish & Wildlife Service, 2001 pp 35-38).

Monitoring for western snowy plovers occurred along the Ten Mile Beach during the course of this project. No plovers were observed in the beach grass removal areas in this project in the southern part of the Preserve, but they were observed in the northern part of the Preserve where beach grass had been removed in a project funded by State Parks. By removing beach grass from the foredunes, potential habitat for plovers was created in the areas pulled. After the barrier of tall vegetation (European beach grass) was removed, plovers could also potentially occupy a greater area of dune habitat by moving into the backdunes. Some plovers were observed foraging in the foredunes during autumn 2001 where beach grass had been pulled. This area was not far from where plovers have historically nested in the backdunes. Appendix A contains western snowy plover forms completed during the project.

## METHODS FOR INCREASING STANDS OF *CHORIZANTHE HOWELLII*

**BACKGROUND** *Chorizanthe howellii* (spineflower) probably has a hybrid origin with *C. cuspidata* var. *villosa* presumably as one parent, and *C. valida* potentially as the other. This origin or hybridization may have occurred during warm periods 8,000 or 100,000 years ago (Reveal 1989, p. 132). Spineflower is a narrowly restricted endemic species that currently occurs in sand dunes and coastal bluff edges north of Fort Bragg not more than 1.5 km from the coast (See Fig. 10). However, two older California Natural Diversity Database (CNDDDB) records document spineflower further south. One 1962 occurrence (CNDDDB No. 8) was estimated to be on the Georgia Pacific Mill 1 km south of the current southern-most stand near Pudding Creek. A 1958 occurrence (CNDDDB No. 9) was found "in sand on a coastal bluff" 8.5 km south of the same Pudding Creek stand. This location is likely on the northern headland of Jughandle Creek in Jughandle State Reserve. In 2001 an area of suitable spineflower habitat was found that matches the description of CNDDDB No. 9, but no spineflower was found (Maslach, pers. obs.). Exotic perennial grasses and land uses like farming, grazing, and development may have extirpated spineflower from parts of its former range. However, the closely related species *Chorizanthe valida* in Marin County had been thought to be extinct, but has been recently rediscovered (Davis & Sherman 1990).

Half of the CNDDDB occurrences of spineflower mention human volunteer foot trails and horse trails as threats to the observed stands (CNDDDB Nos. 1, 3, 6, 7). However, spineflower may colonize disturbed areas where vegetation cover is low and competition is decreased. In a 1989 revision of the annual species of *Chorizanthe*, Reveal (p. 102) concluded: "Unlike *Eriogonum* species which generally thrive in disturbed habitats, the vast majority of species in *Chorizanthe* do not, and in fact tend to be extirpated in such sites. If our study has done nothing else it has shown us how sensitive species of the genus are to the activities of [humans]." The U.S. Fish & Wildlife Service Recovery Plan (1998 p. 17) has listed recreational activities as one of the reasons for listing the species as federally endangered.

Several people have done studies and made observations on species of *Chorizanthe*. To test for demographic performance of *Chorizanthe pungens* var. *hartwegiana*, Kluse and Doak (1999) transplanted plugs of groups of individuals into a variety of habitats. They showed that density of individuals had a greater effect on mortality than the different habitats into which they were transplanted. McGraw and Levin (1988) examined the effects of soil and shade intolerance on the distribution of the same species. In MacKerricher State Park, the California Department of Parks and Recreation (Flowers, pers. comm.) seeded spineflower in and near an area where *Carpobrotus edulis* had been previously removed. Spineflower seed was collected in 1994 or 1995 and the total amount of seed filled two standard letter-sized envelopes. Eight 10'x10' plots were staked and seed was raked in during the fall of 1996. During the following spring, surveys were made but not all stakes remained and no spineflower was detected. However, spineflower was observed to recruit into some other areas where ice plant had been pulled and where seeds were not sown. After an archaeological excavation, spineflower was observed to recruit into previously disturbed 1 m x 1 m test pits (Barry, pers. comm.). Ferreira (pers. comm.) grew a *Chorizanthe* sp. in flats but the plants produced few seeds. She proposed that possible pollination by insects may have been inhibited by placing the flats on benches.

Spineflower occupies recent coastal dunes and sandy soils of adjacent coastal prairies (USFWS 1998, p.16)

and coastal bluff edges. Locations of spineflower in the Preserve are associated with dune-mat vegetation, introduced grasses, and dune hydrophytic vegetation: 1. The dune mat community consists mainly of beach bursage (*Ambrosia chamissonis*), dune sagebrush (*Artemisia pycnocephala*), and yellow sand verbena (*Abronia latifolia*). 2. The areas of introduced grasses and herbs were dominated by rip-gut brome (*Bromus diandrus*) and burclover (*Medicago polymorpha*) and were located mostly along the haul road and in some old pastures throughout the Preserve. 3. The dune hydrophytic vegetation sites are areas where rushes (*Juncus lesuerii*) and horsetail (*Equisetum* sp.) stabilize parts of the sand sheet and dune swales.

New stands of spineflower were established by direct seeding in suitable habitat where spineflower was expected to grow but was not present. Two densities of seed, one twice the density of the other, were sown in 36 plots among three sites in the Preserve. Spineflower cover at approximately 3 months was measured to determine which density yielded greater cover.

**SPINEFLOWER SEED COLLECTION** Spineflower seed was collected during August of 2001 from the southern half the Preserve. A hair pick was used for collecting the seeds (Fig. 4). If seeds had been collected by hand, they would penetrate skin or become imbedded in gloves. These seeds were placed in paper bags and stored indoors in a cardboard box until March 2001.

Statistics on the number of seeds were derived from the seeds collected (Table 3). Two hundred thirty-three seeds were collected from a 1.1 gram lot of seeds. From this number, the total number of seeds collected was extrapolated. The total amount of seed was collected from approximately 1000 plants, but this number does not correctly address seed collected that had fallen from plants. The numbers of seeds and plants presented in Table 3 are extrapolations and were not counted in the field. Accurate numbers of the total number of seeds per plant would require sampling plants in the field for such characteristics.

**Table 3. Collection Statistics for *Chorizanthe howellii*.** Numbers are derived from seeds collected and general observations in the field.

total weight of seeds collected	837.9 grams
seeds counted/1.1 gram	233 seeds
approx. total seeds collected	177,482 seeds
approx. plants from which seed collected	1109 plants
approx. seeds/plant - total	800 seeds
approx. % seeds/plant - collected	0.2 seeds
approx. % seeds/stand - collected	0.1 seeds
approx. % seeds/area - collected	0.1 seeds



**Figure 4. Hair Pick Used for Collecting *Chorizanthe howellii*.** The use of a hair pick facilitated the collection of spineflower seeds.

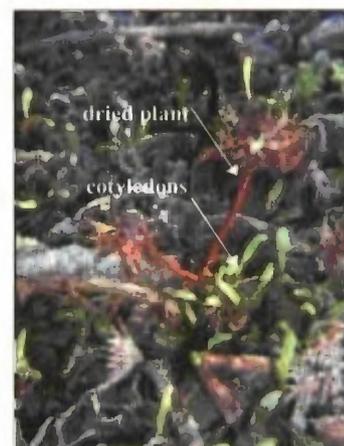
**SPINEFLOWER MAPPING** Most polygons (stands or groups of stands) of spineflower were mapped so that the distance between two or more individuals or groups of individuals was not greater than 2 meters. Areas of suitable habitat were surveyed by walking within areas outlined and labeled "Areas Surveyed" in Fig 10. Suitable habitat was based on the habitat types described in the background section above.

Stands were mapped using a Trimble ProXL GPS between 9/13/2001 and 11/28/2001 (See Fig. 6). Plants were identifiable by the plant stems and leaves, which remained intact, but dried, late into the season. In a few instances (total < 1 m<sup>2</sup>) where spineflower was expected (e.g. at the base of a dune among scattered organic debris and semi-stable sand), the presence of spineflower seed was determined by pressing one's hand on the surface of the sand and organic debris to cause the involucre bract of the seed to attach to the skin, but this potential habitat was not included in the mapping.

The accuracy of most polygons was within one meter. The GPS data was imported into ArcView GIS 8.1.2 and polygons were cleaned for small overlaps. In most cases data was post-processed with differential correction from base station data in Calpella, CA, provided by the Mendocino Redwood Company. The polygons of spineflower (either large stands or groups of small stands) were recorded as groups of stands based on proximity to each other and were documented on CNDDDB survey forms (California Native Species Field Survey Form) (Appendix B). The corrected electronic GIS data of naturally occurring stands and the CNDDDB survey forms will be submitted to the California Department of Fish and Game Natural Diversity Database. Appendix B contains the survey forms with polygons of spineflower stands mapped onto 7.5 minute USGS Quadrangles. These spineflower stands are also illustrated in Figure 10 along with the botanical survey information from EDAW (2001). Figure 10 represents nearly the total extent known distribution of spineflower. A total of 1.24 hectares of spineflower was mapped from this survey and 1.79 hectares of spineflower was mapped in a separate project by EDAW. However, the mapping accuracy of EDAW was not as specific as this survey and probably slightly overestimated the area of spineflower. Combined, both surveys documented a total of 3.03 hectares of spineflower from the Ten Mile River to just south of the Pudding Creek Bridge.

**FIELD OBSERVATIONS** By mid-November 2001, spineflower cotyledons had emerged from the sand in the Preserve. Figure 5 illustrates that some of the plants from spring 2001 were still identifiable in the field as dried plants on December 1, 2001. Cotyledons in the same figure were covered with a light frost in early December but showed no sign of mortality the following day.

Naturally-occurring seedlings were typically distributed as patchy dense clumps (Fig. 6-7), which were mapped as a stand. Stands in dune hummocks usually grew between the ridges, or in the swales where more organic material had collected. These ridges and swales followed the prevailing wind direction of northwest to southeast and, in turn, the spineflower stands followed the same pattern. This pattern was observed near Site 2, and on the dune field south of Ward Avenue and north of the Pinewood Loop campsites in MacKerricher State Park. Some stands near



**Figure 5. Intact *Chorizanthe howelli* in Early December 2001 with New Cotyledons.** New spineflower cotyledons are covered in frost next to a spineflower plant from summer, still with its inflorescence.

the Ten Mile River exhibited a pattern of growing on either side of the road where the sand contained more organic material than several meters away. Near the Pinewood Loop campsites, the volunteer trials had a pattern of



**Figure 6. Spatial Distribution of Natural Patches of *Chorizanthe howellii*.** Spineflower seedlings typically occur in small patches (utility knife for scale).



**Figure 7. Density of *Chorizanthe howellii* Seedlings.** Shown is the typical density of spineflower seedlings within a group as they occur in the field (close-up of patch to the left of utility knife in Fig. 6).

increasing vegetation cover from the center of the trails to beyond the edges. Spineflower was frequently observed growing just beyond the trail edges but absent from the more dense vegetation further from the trail.

While mapping, potential impacts to spineflower stands were recorded by labeling the stands as potentially “threatened” and describing the type of impact in a GPS data logger. Impacts included volunteer trails and exotic plants (*Ammophila arenaria* and *Carpobrotus* sp.). Stands were considered to be threatened by volunteer trails and exotic plants when a trail passed through or lay adjacent to a stand or when an exotic plant grew within or adjacent to a stand. People could leave a trail and trample seedlings and, given enough time, the exotic plants could expand into the spineflower stands. Of the 94 stands mapped, 40 were considered to be threatened. Six were threatened by exotic plants, 27 by volunteer foot trails (2 used by horseback riders), and seven by both volunteer trails and exotic plants. The presence of spineflower in relation to trail disturbance is discussed later.

**DIRECT SEEDING METHODS** To test the establishment new stands of spineflower in the Preserve, three study sites (Sites 1, 2, & 3 in Fig. 10) were established for broadcast seeding in suitable habitat. Of these sites, only Site 2 had spineflower growing in the immediate area. Site 1 (Fig. 11) was on a coastal bluff with moderately developed sandy soil. Ice plant (*Carpobrotus edulis*) had been pulled the previous year and its decomposing leaves contributed to a relatively high organic content in the soil compared to the other sites. Site 2 (Fig. 12) was in a dune swale and Site 3 (Fig. 13) was in an exposed dune area at the edge of a meadow.

Quarter-meter plots were sown at two densities of seeds during the first week of March, 2001. Light densities were sown at 10.94 g seed/0.25 m<sup>2</sup> and heavy densities were sown at 21.89 g seed/0.25 m<sup>2</sup> (see Figs. 14 & 15). At each site, six heavy density 0.25 m<sup>2</sup> plots, six light density 0.25 m<sup>2</sup> plots, and three 0.25 m<sup>2</sup> control plots were randomly chosen and established. Figure 16 is an example of a quarter-meter plot after being sown with spineflower seed. The following procedure was used in establishing plots:

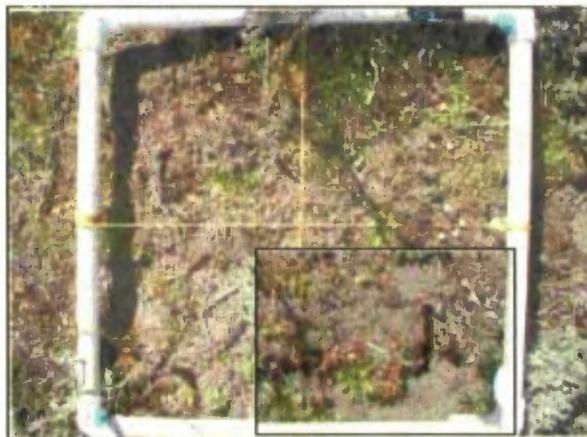
1. randomly place 0.25 m<sup>2</sup> quadrat within site
2. pound in rebar in southwestern and northeastern corners
3. remove organic litter by lightly raking plot with hand and pile it to the side
4. remove exotic weeds, if any
5. remove approximately a 0.5 cm layer of sand from plot with hands and pile it to the side
6. spread out seeds in the plot
7. press in seeds with gloved fist and remove seeds stuck to glove
8. sprinkle piled sand over seeds to cover them approximately 0.5 cm
9. sprinkle piled organic matter over seeds
10. photograph the plot with the camera held parallel to the soil (avoiding oblique photographs), always with the southwestern corner in the upper right hand corner of the photograph
11. temporarily flag the southwestern and northeastern corners of the plot
  - blue – light density
  - red – heavy density
  - red with yellow flagging – control
12. paint plot number and color on the rebar (blue- light density, red- high density, red w/ blue stripe- control)
13. locate each plot with GPS for future reference
14. photograph study site facing southeast

Seeds were not sown into the field plots until March 2001. The germination of the seed had been tested by sowing two 0.18 m<sup>2</sup> by 6.5 cm deep flats with a soil depth of 4.5 cm in a greenhouse at the same low and high densities as above. Most seeds germinated within 8 days in both flats (Fig. 8). At 20 days the plants sown at low density were about 3.50 cm tall and the plants sown at high density were about 2.25 cm. tall and were less robust.

**RESULTS** Plots within each study site were digitally photographed March 1-3, 2002 using the procedure outlined above (see Fig 9). These photographs were georeferenced to the GPS point location of each plot in a GIS. Total coverage of spineflower in each plot was mapped by digitizing on the screen the outline of individual plants, or more often, groups of plants. Coverage of spineflower in each plot was calculated as a percentage of the 0.25m<sup>2</sup> plot (Table 4, p. 16). The control plots (3 at each site) are not included due to lack of significant cover by spineflower. However, one spineflower individual was detected in a control plot at Site 1 and another in a control



**Figure 8. *Chorizanthe howellii* Seedling.** Spineflower at approximately 10 days grown in a greenhouse. Involucral bract on cotyledons (left).



**Figure 9. Typical Monitoring Plot.** A 0.5 m x 0.5 m PVC quadrat was constructed to monitor plots of spineflower broadcast seeding. Photos like this one were taken for each plot and later used for delineating spineflower coverage. The inset photo is a close-up of the lower right-hand corner of the larger photo, and even small spineflower plants are identifiable.

plot at Site 2.

To determine the contribution of the two factors, site and sowing density, a nested analysis of variance (ANOVA) test was applied. Results showed a strong effect of site on cover,  $P < 0.05$ , but there was no statistical difference in cover between the two sowing densities,  $P > 0.05$ . However, the mean cover value at each site ( $N = 6$ ) was greater in plots sown with the lower density of seeds.

**DISCUSSION** It is anticipated that the removal of beach grass from the southern part of the Preserve will increase habitat for wallflower and plovers. However, the high level of recreation in this southern area may keep plovers from nesting on the beach. Seasonal fencing would be necessary to keep people from walking on the upper beach, but with beach grass removed from the foredunes, plovers may use areas in the backdunes not previously used. At the northern end of the Preserve where beach grass is being removed through another State Park project, the reduction of vegetative cover will contribute to favorable nesting habitat for plovers. The unnaturally high profile of sand dunes caused by beach grass roots binding the sand has been observed to decrease over the course of the project in areas where beach grass has been pulled. This lowered topography provides also favorable nesting habitat for plovers, and plovers have been observed foraging in this newly created habitat.

Similarly, the removal of beach grass in the northern part of the Preserve has increased habitat for wallflower. The reduction in beach grass cover has provided open space for colonization by native plants. Most of the species that were planted into the revegetation sites were also observed growing in areas where beach grass had been pulled for this project and the concurrent State Park project. They included dune sage, beach bursage, yellow sand verbena, beach morning glory, and beach primrose. In the middle of the Preserve near Fen Creek, less than a dozen wallflowers were observed growing in an area of pulled beach grass approximately 500 m<sup>2</sup>. After further efforts of pulling resprouts in the same area are completed, wallflower reintroduction through direct seeding or planting young plants would be recommended.

After surveying suitable spineflower habitat, a map was produced that shows spineflower stands from Ten Mile River south to Pudding Creek. Because most plant communities where spineflower occurs were surveyed, this map ably represents the known extant locations of the species, which spans 10 km. The southernmost known occurrence (CNDDDB Occurrence No. 9 from 1958) was searched for and not found. The next southernmost occurrence (CNDDDB Occurrence No. 8 from 1962) was not searched for. The historic range of spineflower is 20 km but the current known range is 10 km.

The largest stands of spineflower were in dune swales away from human activities in relatively pristine areas. Although stand size varied, a third of the stands mapped from Lake Cleone to Ten Mile River were adjacent to recreational activities. Most volunteer foot trails pass through dune swales or low areas, leave portions of the haul road, or follow the coastal bluff edge – all places of habitat preference for spineflower. The presence of spineflower near some trails may be related to the moderate disturbance that occurs adjacent to the trails. Immediately on the trail, trampling from hikers would prevent spineflower development. More than apparently one meter from the edge of the trail, vegetation cover from other species eliminates the relatively open sandy areas where spineflower usually grows. Sand kicked up by hikers on the trails is deposited on the trailsides and creates adequate spineflower habitat. At the north end of the Preserve near the Ten Mile River, spineflower grows in the relatively stable soils along the

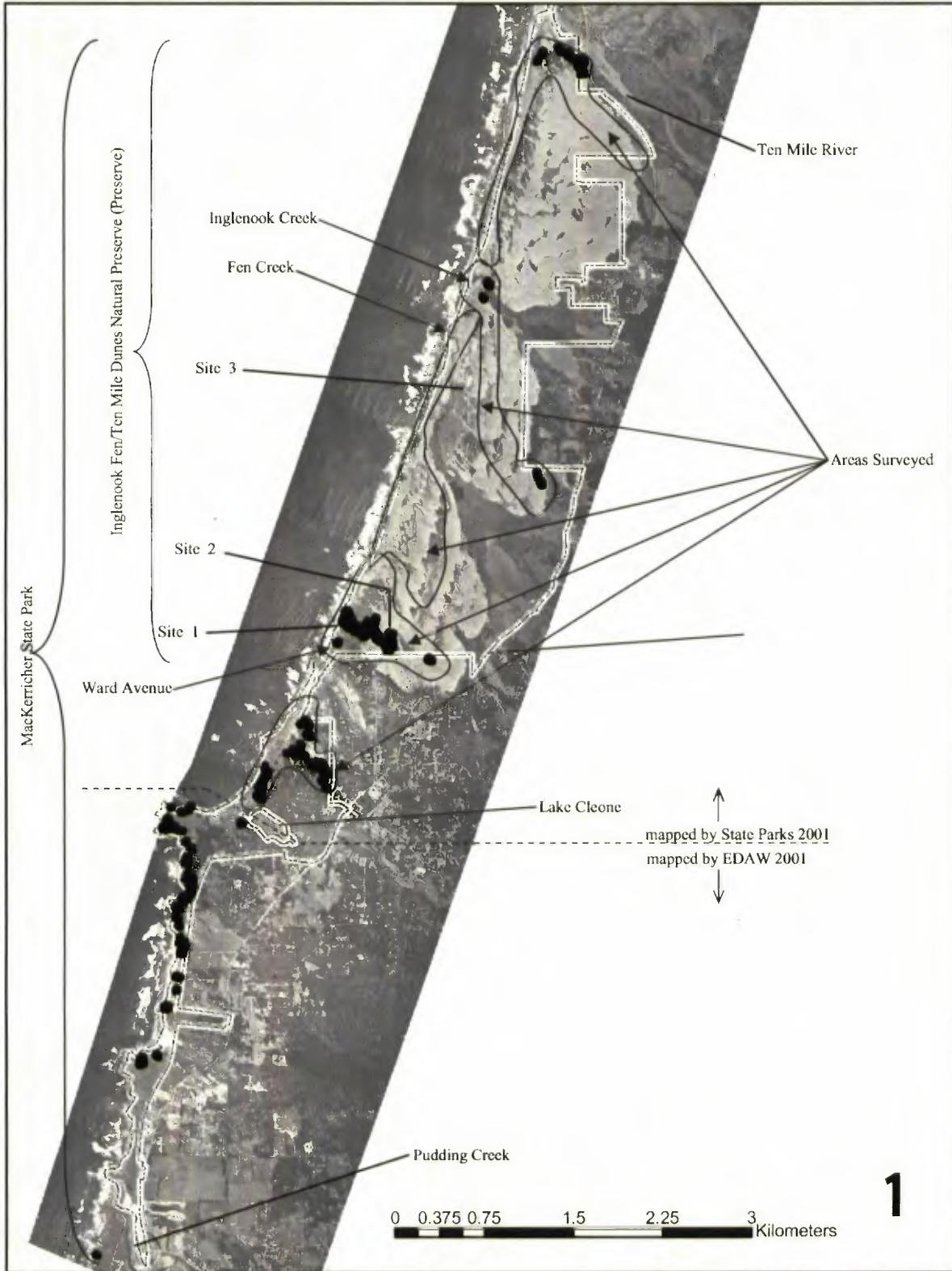
paved haul road. Spineflower also grows along a dirt trail that follows the Laguna Point headland bluff edge and southward, but the bluff edge contains more native plants and is better habitat than the adjacent meadow dominated by exotic perennial grasses. High pedestrian use has kept the vegetation relatively sparse along portions of the bluff edge trail and this disturbance by pedestrians may contribute to the persistence of spineflower in these areas. Although many of the spineflower stands throughout the Preserve have been previously documented in the same general location, the mobile nature of this annual species must be considered when making conclusions about habitat preference.

If exotic plant species are removed from more areas and volunteer trails are managed in MacKerricher State Park it may be possible to attempt to establish new stands of spineflower in areas of suitable habitat. In 1996 a previous effort of seeding a large area (approximately 80 m<sup>2</sup>) with relatively few seeds (2-3 handfuls) did not result in spineflower becoming established. Reasons for this lack of success could include: not all plot stakes were relocated for monitoring, the plot was in a sandy area with little organic matter or cover, or people may have trampled seedlings that may have grown. However, spineflower readily colonized nearby unseeded areas where iceplant was pulled. It is believed that areas where stands of iceplant are removed in the Park will serve as future habitat for spineflower.

In this study, the amount of seed broadcast was increased to approximately one handful per 0.25m<sup>2</sup>, which yielded results that seem to mimic the density of naturally occurring seedlings and the approximate size of a large patch of individuals. Ten months after seeding, mean spineflower cover at each site was greater in plots sown with 10.94 g seed / 0.25m<sup>2</sup> than with 21.89 g seed / 0.25m<sup>2</sup>, although cover difference was not statistically significant. However, greater cover in the low density plots suggests that the lower broadcast seeding density provides sufficient seed for establishing seedlings in the three sites chosen. Effects of intraspecific competition may have contributed to lower cover in the high density plots. These effects may have also contributed to lower height of spineflower seedlings grown in the flat sown with a high density of seeds in the greenhouse. Future monitoring will determine if these seedlings become established as viable stands.

Further studies of spineflower may focus on the multiplicity of environmental factors that create suitable habitat in the Preserve, which may be transient over periods of decades. Stands in pristine areas of the sand dunes appear to follow wind patterns, which may contribute greatly to seed dispersal in these areas. Small mammals may also disperse seeds that become attached to fur. Sand with developed mats of moss may be important in the entrapment of windblown seed. Edaphic characteristics, organic substrates, water-retention in the substrate are areas for further study. Studies of pollination, seed production per plant, seed viability, and seed longevity would also contribute to understanding the ecology of the species. Also, more study is needed on the effects of disturbance by humans and horses. Most importantly, recognizing, maintaining, and restoring the spineflower habitat will ensure that spineflower survives where it is presently growing.

**Figure 10. Locations of Natural Stands of *Chorizanthe howellii* from the Ten Mile River to Pudding Creek & Sites with Planted Spineflower.** This map represents the known extent of *C. howellii* (dark black polygons). A total of 3.03 hectares of occupied habitat was mapped in 2001, 1.24 hectares from this project (Ten Mile River to north of Lake Cleone) and 1.79 hectares from another botanical survey (south of Lake Cleone to Pudding Cr.). Polygons are enlarged to show occurrences.





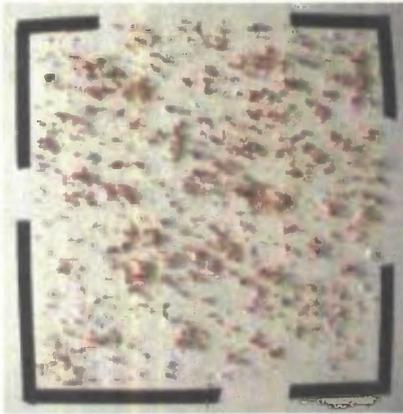
**Figure 11. Site 1, *Chorizanthe howellii* Broadcast Seeding Plots.** The site is located on a sandy coastal bluff (perched dune) just west of the haul road. Photo facing southeast; see Fig. 10 for location.



**Figure 12. Site 2, *Chorizanthe howellii* Broadcast Seeding Plots.** The site is located 250 meters east of the haul road in a dune swale. Photo facing southeast; see Fig. 10 for location.

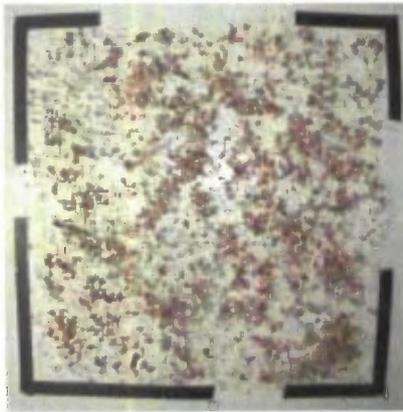


**Figure 13. Site 2, *Chorizanthe howellii* Broadcast Seeding Plots.** The site is located 80 meters east of the haul road in a sparsely vegetated dune meadow. Photo facing southeast; see Fig. 10 for location.



**Figure 14. Example of Light density of *Chorizanthe howellii* seeds, 0.25 m<sup>2</sup>.**

Plots with light density seeding contained 10.94 g of seeds. Seeds were spread evenly throughout the quarter-meter plot.



**Figure 15. Example of Heavy density of *Chorizanthe howellii* seeds, 0.25 m<sup>2</sup>.**

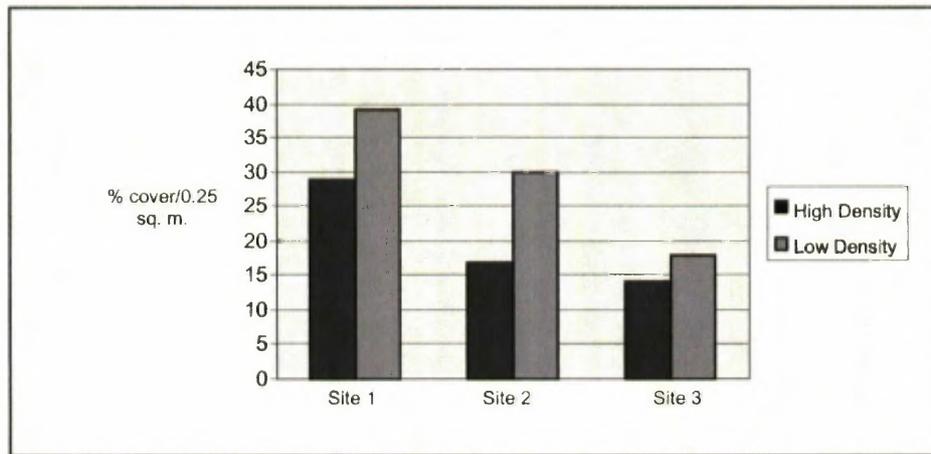
Plots with heavy density seeding contained 21.89 g of seeds. Seeds were spread evenly throughout the quarter-meter plot.



**Figure 16. Example of 0.25 m<sup>2</sup> plot after seeding.** Exotic plants were removed from the plots; sand was scraped; seeds were sown; and sand and duff were placed back over the seeds.

**Table 4. Percent Cover *Chorizanthe howellii* Results for Seeded Plots.**  
Cover was measured for all spineflower individuals in all plots and is reported as a percentage of the 0.25 m<sup>2</sup> plots.

HIGH DENSITY SITE/PLOT	PERCENT COVER OF <i>Chorizanthe howellii</i> PER 0.25 sq. m. PLOT		LOW DENSITY SITE/PLOT
	SEEDING DENSITY		
	HIGH	LOW	
1H1	14%	44 %	1L1
1H2	47%	11%	1L2
1H3	28%	31%	1L3
1H4	29%	54%	1L4
1H5	21%	44%	1L5
1H6	37%	50%	1L6
2H1	20%	29%	2L1
2H2	10%	26%	2L2
2H3	18%	14%	2L3
2H4	25%	22%	2L4
2H5	20%	37%	2L5
2H6	8%	52%	2L6
3H1	16%	27%	3L1
3H2	6%	16%	3L2
3H3	21%	21%	3L3
3H4	15%	7%	3L4
3H5	20%	14%	3L5
3H6	6%	21%	3L6



**Figure 17. Mean Cover of *Chorizanthe howellii* in High & Low Density Sown Plots (6 plots of each density at each site).** Mean percent cover of spineflower from low density plots (10.94 g seeds / 0.25 m<sup>2</sup>) and high density plots (21.89 g seeds / 0.25 m<sup>2</sup>). A nested ANOVA test (factors = site & density) showed a strong effect of site on cover ( $P < 0.05$ ) but weak evidence for an effect of seeding density on cover ( $P > 0.05$ ). Since the cover that resulted from the two seeding densities is not statistically significant, results show that the same cover can be achieved by sowing a lower density of this federally endangered plant.

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APPENDIX A

Summary of Western Snowy Plover Surveys for Russian River/Mendocino District - Year 2000, Permit TE443381-0

Date	Location Surveyed	Time in the Field	Observer(s)	Nests	Plovers Seen	Sex	General location of Plovers, Banded information, and Nesting info if taken	Dogs or Horses Seen? (Y/N)
<b>MARCH SURVEYS</b>								
03/25/2000	Alder Creek Beach	1 hr	CMF	0	2	1M, 1F	200 yds north of Alder Creek valley	Y/horses
	So Coast State Beach							
	rest of Mackerricher							
	Virgin Creek Beach							
03/31/2000	Ten Mile to Ward Ave	6 hrs	JFW	0	8	3F, 2M, 3U	20 the way between Inglebrook Ck. outlet to Ten Mile rivermouth	Y/dogs
<b>APRIL SURVEYS</b>								
	Wendover-Rose Creek Beach, then to Alder Creek then to So Coast State Beach							
04/28/2000	So Coast State Beach	4 hrs	CMF	0	1	1F	200 yds north of Alder Creek valley	no
							runway between Inglebrook Creek and Ten Mile river. 1 unbanded male	
04/28/2000	Ten Mile to Ward Ave	5 hrs	JFW	0	3	2M, 1F	[L: Aqua/Yellow, R: Violet/Orange]	2 dogs off leash
04/28/2000	Virgin Creek Beach	5 hrs	JFW	0	0			4 dogs, 1 off leash
<b>MAY SURVEYS</b>								
	south of Ten Mile outlet enclosure put up		USRWS	1	3	2M, 1F	banded male, unbanded male, and unbanded female, possible scrape	Note: all of the May surveys refer to the same nest. See map of the Ten Mile Beach for nest location.
05/11/2000	to enclosure	?	Mad River	1	1	1M	banded male at nest while enclosure put up	
05/14/2000	to enclosure	1 hr	DT	1	2	1F, 1M	unbanded male and female	
05/15/2000	Ten Mile to nest enclosure	1.00	CMF	1	2	1M, 1F	female incubating, male found 1/4 mi north	
05/18/2000	Ten Mile to nest enclosure	?	JFW	1	1	1F	female incubating	
05/21/2000	to enclosure	?	DT	1	1	1F	female incubating	
05/24/2000	Ten Mile to nest enclosure	1.00	JFW	1	1	1F	female incubating	
05/26/2000	Ten Mile to nest enclosure	0.75 hrs	JFW	1	1	1F	female up and down off nest continuously	
05/29/2000	to enclosure	?	SF	1	1	1F	wind storm, nest abandoned, eggs covered in sand, pair seen north, foraging	
5/30/2000	Ten Mile to Ward Ave	4.00	JFW	0	2	1M, 1F		
5/30/2000	Virgin Creek Beach	0.5 hrs	JFW	0	0			
<b>JUNE SURVEYS</b>								
6/1/2000	Ten Mile to Ward Ave	4.5 hrs	JFW	0	1	1M	unbanded male seen south of Inglebrook Creek, 100 yds from nest, 200 yds from plover's	
6/1/2000	Virgin Creek Beach	0.5 hrs	JFW	0	0		seen on this beach, nest still abandoned	
	Wendover-Rose Creek Beach, then to Alder Creek then to So Coast State Beach							
6/1/2000	Beach	4 hrs	CMF	0	0		Not a single plover sighted, very few shorebirds at all	
6/2/2000	Ten Mile to enclosure	2 hrs	CMF, BM, JFW	0	0		instructed to remove enclosure and collect eggs from abandoned nest, no	3 horses on west sand
6/4/2000	Ten Mile to Inglebrook Creek	2.5 hrs	SF	0	0			3 dogs off leash
6/6/2000	Ten Mile to Ward Ave, including back dune area on return trip	3.75 hrs	JFW	0	0			n
6/6/2000	Virgin Creek Beach	0.5 hrs	JFW	0	0			Y/1 dog on leash
6/15/2000	Ten Mile to Ward Ave	2.75 hrs	JFW	0	0			Y/1 dog off leash
6/20/2000	south of Ten Mile outlet	1.25 hrs	SF	0	0		incomplete survey due to people camping at 10 mile. Obs. Left survey to find	n
6/20/2000	Virgin Creek Beach	0.75	CMF	0	0			Y/1 dog on leash on haul road
6/30/2000	Virgin Creek Beach	0.75	JFW	0	0			Y/1 dog off leash w/ 2 people
6/30/2000	Ten Mile to Ward Ave	3 hrs	JFW	0	0			
<b>JULY SURVEYS</b>								
7/18/2000	Ten Mile to Inglebrook Creek	3.5 hrs	JFW	0	8	3M 2F 3?	nesting in depressions and near seaward side of dune to river mouth. 1 banded SNPL Lt. Yellow, Orange - Rt. Orange, Red	Y/1 dog off leash, 2 horses rode past SNPL, flock
7/30/2000	Virgin Creek Beach	1 hr	JFW	0	0			n
7/30/2000	Ten Mile to Ward Ave	2.75 hrs	JFW	0	16	3M 7F 5?	Roosting in depressions between .25 and .75 Mi. South of 10 Mile river mouth	Y/1 dog off leash just north of Ward Ave
<b>AUGUST SURVEYS</b>								
8/14/2000	Ten Mile to Inglebrook Creek	3 hrs	DT	0	21		Yellow Rt. Violet / Orange 2) Lt. Orange Rt. Yellow / Orange 3) Lt. Nothing Rt. Blue (Juev) 4) Lt. Nothing Rt. Yellow (Juev)	n
<b>SEPTEMBER SURVEYS</b>								
9/14/2000	Ten Mile to Inglebrook Creek	3 hrs	DT	0	30		Yellow Rt. Violet / Orange 2) Lt. Orange Rt. Yellow / Orange 3) Lt. Nothing Rt. Blue (Juev) 4) Lt. Nothing Rt. Yellow (Juev)	Y/2 dogs off leash, 2 horses on dry sand OHV tracks
9/28/2000	Salmon Creek Beach	3.25	JFW, TAK	0	17	5M 6F 6?	Located on north end of beach on wide expanse of sand	Y/2 horses 6+ dogs off leash on beach



Summary of Western Shovier Plover Surveys for Russian River/Mendocino District - Year 2001, Permit TE843381-9

Date	Location Surveyed	Time in the Field	Observer(s)	Nests	No. of Plovers Seen	Sex	General location of Plovers, Banded Information, and Nesting info if taken	Dogs or Horses Seen? (Y/N)
<b>January SURVEYS</b>								
1/12/2001	10-Mile to Ward Ave	4.25	JFW	N	37		West of northern end of haul road. 5 birds banded 1)JL= Y/R R= R/A, 2)JL= NO BAND R=BLUE metal band, 3)JL= R/O R=YO, 4)JL= A/Y R=V/O(Male) 5)JL=NO BAND R= Y	1 Dog off leash
1/20/2001	10-mile to 75 miles north of Inglenook creek	1.5 DT		N	40		200 tracks south of 10-mile river. 5 banded birds 1)JL= Y/R R= R/A, 2)JL= NO BAND R=BLUE metal band, 3)JL= R/O R=YO, 4)JL= A/Y R=V/O(Male) 5)JL=NO BAND R= Y	2 dogs off leash lots of horse sign all over beach
<b>February SURVEYS</b>								
1/30/2001	10-mile to Inglenook creek	2.5	JFW	N	32		Just north of Inglenook creek 3 banded birds 1)JL=NO BAND R= Y 2)JL= NO BAND R=BLUE metal band 3)JL= R/O R=YO 4)JL=NO BAND R= Y	
2/23/2001	10-mile to Inglenook creek	3 DT		N	29		.25 miles south of Ten Mile river 2 banded birds 1)JL= A/Y R=V/O 2)JL= R=Blue Metal band	2 horses down on wet sand.
2/26/2001	10-mile to Inglenook creek	3.5	CMF	N	30		.1 miles south of 10-Mile river mouth Birds seen roosting - 25 miles south of Ten mile river mouth 1 banded bird 1)JL= Y/R R= R/A	
<b>March SURVEYS</b>								
2/28/2001	North of Inglenook creek to Ten Mile river	2	CMF	N	37		4 birds roosting just south of river mouth all unbanded. 32birds 5 miles south of ten mile river. Three banded birds 1)JL= A/Y R=V/O, 2)JL= Y/R R= R/A, 3)JL= NO BAND R=BLUE metal band	
3/5/2001	10-mile to Inglenook creek	3	JFW	N	36		9 birds roosting just south of river mouth all unbanded. 26 birds 3 miles south of ten mile river. Two banded birds, 1)JL= A/Y R=V/O, 2)JL= Y/R R= R/A	
3/6/2001	10-mile to Inglenook creek	2.5	JFW	N	35		4 birds roosting just south of river mouth all unbanded. 32 birds 25 miles south of ten mile river. Two banded birds, 1)JL= A/Y R=V/O, 2)JL= Y/R R= R/A	
3/7/2001	10-mile to Inglenook creek	2.25	JFW	N	36		4 birds seen 25 miles south of 10-mile, 1 banded bird 1)JL= NO BAND R=BLUE metal band, 32 birds seen 125 miles south of 10-mile	N
3/9/2001	10-mile project area survey	2	CMF	N	0		5 miles south of ten-mile river mouth, not checked for bands 1)JL=YO R= R/A	N
3/10/2001	10-mile to Inglenook creek	3	CMF	N	36		Seen in flight thus there is no band/sex data	5 people on beach w/2 on leash dogs. Horse tracks up center of beach 15 feet from wet sand
3/11/2001	10-mile project area survey	CMF, BM		N	30		North of Inglenook creek 2)JL= Y/R R= R/A	1 dog off leash, horse tracks on dry sand
3/12/2001	10-mile to 300 Meters south of project area	1	JFW	N	37		14 birds 1 mile south of ten-mile river mouth 1)JL= A/Y R= V/O, 20 Birds just north of Inglenook creek 2)JL= Y/R R= R/A	2 dogs off leash
3/13/2001	10-mile to 300 Meters south of project area	2	JFW	N	30		23 banded Male SNPL 1)JL= Y/R R= R/A, 2)JL= A/Y R= V/O	
3/14/2001	10-Mile to Ward Ave	3.5	JFW	N	34		23 birds roosting 15 miles south of ten-mile river, 2 birds (Male/Female) roosting in depressions 33 miles south of ten-mile river	
3/15/2001	10-mile to Inglenook creek	3 DT		N	31		7 birds roosting 15 miles south of ten-mile river, 23 birds both roosting and foraging 5 mile south of ten-mile river.	
3/18/2001	10-mile to Inglenook creek	1.5	JFW	N	25		11 birds foraging 10 mile south of ten-mile river 12 birds foraging 33 mile south of ten-mile river.	
3/20/2001	10-mile to 300 Meters south of project area	1	JFW	N	30		22 SNPL detected - 33 mi. South of 10-Mile River birds got up and flew North to - 1 Mi. South of Ten-Mile. 1 lone female detected in area that SNPL left.	
3/21/2001	Ward Ave, Project area survey	1	JFW	N	0		14 SNPL activity foraging - 5 Mile South of 10-Mile River, 7 SNPL foraging, 5 SNPL roosting - 33 Mile South of 10-Mile river	
3/21/2001	10-mile to 5 mile North of Inglenook creek	1	JFW	N	23		3 Male in b SNPL roosting - 33 Mile South of 10-Mile river	
3/26/2001	10-mile to Inglenook creek	2	JFW	N	23			
3/27/2001	Ward Ave, Project area survey	1.5	JFW	N	0			
3/27/2001	10-mile to 5 mile North of Inglenook creek	1	JFW	N	14		2 Males 1 F Roosting 5 Mile South of 10-Mile River	
3/28/2001	10-Mile to Ward Ave	4	JFW	N	26		3 Male in b SNPL roosting - 33 Mile South of 10-Mile river	
3/29/2001	10-mile project area survey	1		N	0			
3/30/2001	10-mile project area survey	1		N	0			
<b>April SURVEYS</b>								
4/2/2001	10-mile to Inglenook creek	2	JFW	N	10		2 SNPL roosting, preening and stretching in depressions near tideline, isolated from the rest of the flock - 4 miles south of 10-Mile river 1)JL= A/Y R=V/O, 8 SNPL foraging - 5 miles South of 10-Mile river, heading North then roosting	OHV tracks down center of beach from 10-mile past Inglenook Creek No people or dogs seen
4/2/2001	Ward Ave to 300 Meters North of Project area	1	CEW	N	0		2 SNPL on North end of beach (.15 miles South of TOMINO) both birds were banded 1)JL= A/Y R= V/O, 2)JL= R=Blue metal band 6 SNPL roosting at tidal line 45 Mile South of (TOMINO)	2 people w/ dog off leash
4/3/2001	10-mile to 5 mile North of Inglenook creek	1.5	JFW	N	8			
4/3/2001	Ward Ave to 350 Meters North of Project area	1	CEW	N	0			
4/4/2001	Ward Ave to 350 Meters North of Project area	1	TSW	N	0			
4/5/2001	Ward Ave to 300 Meters North of Project area	1	TSW, CEW	N	0			
4/9/2001	10-mile to Inglenook creek	1.5	JFW	N	16		16 SNPL roosting in horse tracks @ tidal line - 65 miles South of (TOMINO). Birds did not move while I was there thus No band info.	

Date	Location	Observer	Sex	Age	Count	Notes
4/10/2001	10-mile to 5 mile North of Inglenook creek	JFW	N		16	Foraging and roosting 48 miles south of 10MIND marker. 1 banded bird
4/11/2001	350 Meters North and South of Inglenook Crk	1 TSW	N		0	
4/12/2001	Inglenook Creek to 300 Meters North of Fridge	1 CEW	N		0	1) = ANY = V/O
4/13/2001	10-Mile to Ward Ave	5 CMF	N		11	Foraging and roosting 48 miles south of 10MIND marker. 1) = ANY = V/O
4/18/2001	Mixing Table to 350 Meters North and South	1 TSW, CEV	N		0	11 SNPL seen - 5 Miles South of 10-Mile River 2 banded birds 1) = ANY = V/O
4/18/2001	Mixing Table to 350 Meters North and South	1 TSW, CEV	N		0	2) = - = Blue metal band
4/23/2001	10-mile to Inglenook creek	1.5 JFW	N		6	3 sets of Horse tracks down center of beach
4/24/2001	10-mile to 5 mile North of Inglenook creek	1.25 JFW	N		5	Horse Tracks on Dry sand - .8 Miles South of Fen Creek
4/25/2001	10-Mile to Ward Ave	3.5 JFW	N		4	
May SURVEYS						

Cliff - Christina (Thru) Fabris, JFW - Justin Ward, Bill - Bill Matulich, TAW - Tanna Kraus, DT - Dorothy Tobbin, SF - Sarah Flowers

APPENDIX B

