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Staff Report:	September 17, 2009
Hearing Date:	October 7, 2009
Commission Action:	

STAFF REPORT: REGULAR CALENDAR

APPLICATION NO.:	**1-09-026**
APPLICANT:	**CALIFORNIA DEPARTMENT OF PARKS & RECREATION**
PROJECT LOCATION:	Little River State Beach, near Highway 101 & Crannel Avenue, McKinleyville area, Humboldt County (APNs 513-161-01 & 513-171-08)
PROJECT DESCRIPTION:	Restoration of approximately 81 acres of dune habitats through the removal of invasive exotic plant species and the restoration of natural dune topography using heavy equipment, flaming, and manual removal techniques.
GENERAL PLAN DESIGNATION:	Public Recreation (PR) as designated in the McKinleyville Area Plan
ZONING DESIGNATION:	Public Recreation with Coastal Wetland, Design Review, and Beach and Dune Area Combining Zones (PR-W/D/B)
LOCAL APPROVALS RECEIVED:	None Required

OTHER APPROVALS RECEIVED:	U. S. Fish & Wildlife Service Technical Assistance
OTHER APPROVALS REQUIRED:	None
SUBSTANTIVE FILE DOCUMENTS:	1) CDP File No. 1-04-071 (CDPR) 2) Little River State Beach Restoration and Enhancement Plan, prepared by North Coast Redwoods District, California State Parks, February 2009 3) Humboldt County Local Coastal Program

SUMMARY OF STAFF RECOMMENDATION:

Staff recommends that the Commission approve with conditions the coastal development permit for the proposed dune restoration project at Little River State Beach south of Trinidad in Humboldt County. Staff believes that the project, as conditioned, is consistent with Section 30240 of the Coastal Act, as the project is for a use dependent on the resources of the environmentally sensitive dune habitat in which it is located, as the project is a restoration project, and the project will protect the habitat against significant disruption of its habitat values. To ensure that the dune habitat restoration envisioned by the project that enables the Commission to characterize the development as a resource dependent use pursuant to Section 30240 is achieved, staff recommends Special Condition No. 1. Special Condition No. 1 would require the applicant to submit a final monitoring plan to outline a method for measuring and documenting the improvements in habitat value at the site over the course of five years following project completion. Furthermore, Special Condition No. 1 would require the monitoring plan to include provisions for remediation to ensure that the goals and objectives of the restoration project are achieved.

Overall, the project would restore and enhance dune habitat values and would produce generally beneficial environmental effects. However, depending on the manner in which the proposed project is conducted, significant adverse impacts could result. Thus, staff is recommending Special Condition No. 2 to ensure that the project is implemented in a manner that protects sensitive species and habitats. In addition, with the requirements of Special Condition No. 3 to monitor for archaeological resources during construction, the project will be conducted in a manner that will avoid significant disturbance of archaeological resources. Furthermore, public access will be maintained at Little River State Beach during the extent of the project, and the project will have only insignificant impacts on public access use. Therefore, as conditioned, staff believes the proposed development is fully consistent with the ESHA protection, archaeological resource protection, public access, and all other applicable policies of Chapter 3 of the Coastal Act.

The Motion to adopt the Staff Recommendation of Approval with Conditions is found below on pages 3-4.

STAFF NOTES:

1. Standard of Review

The proposed project area is bisected by the boundary between the retained coastal development permit jurisdiction of the Commission and the coastal development permit jurisdiction delegated to Humboldt County by the Commission through the County's certified Local Coastal Program. The boundary lies somewhere in the back dunes near the frontage road that runs parallel to and west of Highway 101, with the Commission's jurisdiction lying westward of the line and the County's lying eastward of the line. It appears that the majority, if not all, of the proposed restoration work lies within the Commission's jurisdiction, with a portion of the proposed access road lying within the County's jurisdiction.

The Coastal Act was amended by Senate Bill 1843 in 2006, effective January 1, 2007. The amendment added Section 30601.3 to the Coastal Act. Section 30601.3 authorizes the Commission to process a consolidated coastal development permit application when requested by the local government and the applicant and approved by the Executive Director for projects that would otherwise require coastal development permits from both the Commission and from a local government with a certified LCP. In this case, the Humboldt County Board of Supervisors adopted a resolution and both the applicants and the County submitted letters requesting consolidated processing of the coastal development permit application by the Commission for the subject project, which was approved by the Executive Director.

The policies of Chapter 3 of the Coastal Act provide the legal standard of review for a consolidated coastal development permit application submitted pursuant to Section 30601.3. The local government's certified LCP may be used as guidance.

I. MOTION, STAFF RECOMMENDATION AND RESOLUTION:

The staff recommends that the Commission adopt the following resolution:

MOTION:

> *I move that the Commission approve Coastal Development Permit No. 1-09-026 pursuant to the staff recommendation.*

STAFF RECOMMENDATION OF APPROVAL:

Staff recommends a **YES** vote. Passage of this motion will result in approval of the permit as conditioned and adoption of the following resolution and findings. The motion passes only by affirmative vote of a majority of the Commissioners present.

RESOLUTION TO APPROVE THE PERMIT:

The Commission hereby approves a coastal development permit for the proposed development and adopts the findings set forth below on grounds that the development as conditioned will be in conformity with the policies of Chapter 3 of the Coastal Act. Approval of the permit complies with the California Environmental Quality Act because feasible mitigation measures and/or alternatives have been incorporated to substantially lessen any significant adverse effects of the development on the environment.

II. STANDARD CONDITIONS: See Attachment A.

III. SPECIAL CONDITIONS:

1. Final Restoration Monitoring Program

(A) **PRIOR TO ISSUANCE OF COASTAL DEVELOPMENT PERMIT NO. 1-09-026**, the applicant shall submit for review and approval of the Executive Director, a final detailed restoration monitoring program designed by a qualified biologist for monitoring of the dune restoration site. The monitoring program shall at a minimum include the following:

1. Performance standards that will assure achievement of the restoration goals and objectives set forth in Coastal Development Permit Application No. 1-09-026 as summarized in the Findings IV.C, "Project Description," including, but not limited to, (a) reduction of the invasive European beachgrass and yellow bush lupine in the foredune and dune hummock areas to a total area cover of less than 5 percent (b) reduction of the invasive species in the dune swales and wetland areas to a total area cover of les than 25 percent, (c) restoration of native nearshore dune species of the Sand-verbena-Beach bursage series and/or Native dunegrass series in the foredune and dune hummock areas to a total area cover of greater than 10 percent, and (d) restoration of native wetland species of the Hooker willow series, Sedge series, and/or Red alder series in dune swales and wetland areas to a total area cover of greater than 25 percent.

2. Provisions for monitoring invasive species cover and increases in native species cover.

3. Provisions for submittal within 30 days of completion of the initial restoration work of (a) "as built" plans demonstrating that the initial restoration work has been completed in accordance with the approved restoration program, and (b) an assessment of the initial biological and ecological status of the "as built" enhancements. The assessment shall

include an analysis of the attributes that will be monitored pursuant to the program, with a description of the methods for making that evaluation.

4. Provisions to ensure that the restoration site will be remediated within one year of a determination by the permittee or the Executive Director that monitoring results indicate that the site does not achieve the goals, objectives, and performance standards identified in the approved restoration program and in the approved final monitoring program.

5. Provisions for monitoring and remediation of the restoration site in accordance with the approved final restoration program and the approved final monitoring program for a period of five (5) years.

6. Provisions for submittal of annual reports of monitoring results to the Executive Director by August 31 each year for the duration of the required monitoring period, beginning the first year after submission of the "as-built" assessment. Each report shall include copies of all previous reports as appendices. Each report shall also include a "Performance Evaluation" section where information and results from the monitoring program are used to evaluate the status of the stream restoration project in relation to the performance standards.

7. Provisions for submittal of a final monitoring report to the Executive Director at the end of the 5-year reporting period. The final report must be prepared in conjunction with a qualified biologist. The report must evaluate whether the restoration site conforms with the goals, objectives, and performance standards set forth in the approved final restoration program. The report must address all of the monitoring data collected over the 5-year period.

(B) If the final report indicates that the restoration project has been unsuccessful, in part, or in whole, based on the approved goals and objectives set forth in CDP Application No. 1-09-026 as summarized in Findings IV.C "Project Description," the applicant shall submit a revised or supplemental restoration program to compensate for those portions of the original program which did not meet the approved goals and objectives set forth in CDP Application No. 1-09-026 as summarized in Finding IV.C "Project Description." The revised restoration program shall be processed as an amendment to this coastal development permit, unless the Executive Director determines that no amendment is legally required.

(C) The permittee shall monitor and remediate the restoration site in accordance with the approved final monitoring program. Any proposed changes to the approved monitoring program shall be reported to the Executive Director. No changes to the approved monitoring program shall occur without a Commission amendment to this coastal development permit, unless the Executive Director determines no amendment is legally required.

2. Protection of Sensitive Species & Habitats

The permittee shall comply with all proposed measures to protect sensitive species and habitats, as listed in Exhibit No. 5, as well as the following construction-related requirements:

(A) No construction materials, debris, or waste shall be placed or stored where it may be subject to wave erosion and dispersion; any debris discharged into coastal waters shall be recovered immediately and disposed of properly;

(B) Any and all debris resulting from construction activities shall be removed from the project site and disposed of at an authorized disposal location within 10 days of project completion;

(C) Heavy equipment shall enter and exit the project area through the existing trail from the Clam Beach frontage road to the foredunes;

(D) Western snowy plover protection measures shall be implemented as proposed in Exhibit No. 5;

(E) Sensitive plant protection measures shall be implemented as proposed in Exhibit No. 5;

(F) Any fueling and maintenance of construction equipment shall occur within upland areas outside of environmentally sensitive habitat areas or within designated staging areas; and

(G) Fuels, lubricants, and solvents shall not be allowed to enter the coastal waters or wetlands. Hazardous materials management equipment shall be available immediately on-hand at the project site, and a registered first-response, professional hazardous materials clean-up/remediation service shall be locally available on call. Any accidental spill shall be rapidly contained and cleaned up.

3. Area of Archaeological Significance

(A) If an area of cultural deposits is discovered during the course of the project all construction shall cease and shall not recommence except as provided in subsection (B) hereof; and a qualified cultural resource specialist shall analyze the significance of the find.

(B) A permittee seeking to recommence construction following discovery of the cultural deposits shall submit a supplementary archaeological plan for the review and approval of the Executive Director.

1. If the Executive Director approves the Supplementary Archaeological Plan and determines that the Supplementary Archaeological Plan's recommended changes to the proposed development or mitigation measures are *de minimis* in nature and scope, construction may recommence after this determination is made by the Executive Director.

2. If the Executive Director approves the Supplementary Archaeological Plan but determines that the changes therein are not de minimis, construction may not recommence until after an amendment to this permit is approved by the Commission.

IV. FINDINGS & DECLARATIONS

The Commission hereby finds and declares as follows:

A. Background

The proposed development involves the restoration of approximately 81 acres of dune habitats through the removal of invasive exotic plant species and the restoration of natural dune topography using heavy equipment, flaming, and manual removal techniques.

Little River State Beach (LRSB) currently provides habitat for and/or has historically provided habitat for several California and federal special-status species including the western snowy plover (*Charadrius alexandrinus*), beach layia (*Layia carnosa*), and pink-sand verbena (*Abronia umbellata* ssp. *breviflora*). These species often occur in the Sand verbena-Beach bursage and Native dunegrass vegetation communities, which are considered rare and worthy of special consideration by the California Department of Fish and Game (CDFG 2003). Since the 1930's, European beachgrass (*Ammophila arenaria*) has steadily displaced these communities at LRSB, contributing to the decrease, and in some cases extirpation, of native beach and dune species entirely. Currently, pink sand verbena (remnant occurrences) and snowy plovers are the only known special-status species to occur at LRSB.

The desire for a large-scale coastal dune restoration plan at LRSB emerged from management goals put forward in the North Coast Redwoods District Beach and Dunes Management Plan (Transou *et al*. 2004). This plan was the result of the Department's stewardship efforts to protect the western snowy plover and the ensuing acknowledgement that something more comprehensive than single species management was needed to sustain the natural resources of the North Coast Redwoods District (NCRD). In February of 2009, the NCRD completed the Little River State Beach Restoration and Enhancement Plan to further outline details on restoration activities as well as opportunities to enhance visitor education and interpretation, recreation, Native American traditional uses of the LRSB, among other goals and objectives. Implementation of the plans' recommendations are currently underway by the District's Natural Resource Program.

In northern California, coastal dune ecosystems have been severely altered by the invasion of exotic species, primarily yellow bush lupine (*Lupinus arboreus*) and European beachgrass (Pickart et al. 1998). Consequently, dune management efforts have largely focused on restoration. Beach and dune restoration projects of varying scope have been implemented throughout the North Coast and the coast of Oregon. Many of these projects have employed manual removal, and to a lesser extent mechanical removal methods (grading with a dozer), to remove invasive species. Until recently, however, the efficacy and cost efficiency of these efforts had not been rigorously analyzed, and little data existed regarding European beachgrass removal efforts.

Given that existing information on mechanical removal is largely site specific, and experimentally tested methods are lacking, the NCRD developed the Little River State Beach Pilot Habitat Restoration Project in 2004. This pilot project was designed to experimentally evaluate and determine the most successful mechanical removal technique for a large-scale European beachgrass removal project as it relates to sand movement patterns, removal efficacy, and cost effectiveness.

In December of 2004, the Commission granted CDP No. 1-04-71 to the California Department of Parks and Recreation (CDPR) to experimentally treat approximately nine acres of European beachgrass-infested dunes at LRSB. The project was designed to determine the most successful mechanical removal technique as it relates to sand movement patterns, removal efficacy, and cost effectiveness. The total project area included roughly 40 acres along the primary foredune, dune hollows, and stabilized back dunes. Four treatments, consisting of three mechanical removal methods and one control (no treatment) were replicated once and randomly assigned to initially treat eight 1.48-acre plots. In addition, three techniques were analyzed to determine the most effective disposal method. Heavy equipment operation occurred between December 27 and February 4, 2004, with follow-up hand removal treatments occurring through March 15 (which is the start of the western snowy plover nesting season).

The results of the authorized pilot project (see Exhibit No. 4) indicate that mechanical grading was the most successful method to restore dune function altered by European beachgrass for LRSB beaches. The method was determined to be (1) effective at reducing European beachgrass cover; (2) the most efficient removal technique in terms of requiring the least amount of retreatment hours; and (3) resulting in the least amount of resprouting of invasive plants after treatment. The mechanical grading method involved using a D8 or D850 Dozer to excavate sand and invasive weeds to a depth of approximately 3 meters, and then burying the contaminated spoils in the excavated dunes (in the middle of the treatment area) via a dozer to a minimum depth of 2 meters. The surrounding freshly exposed sand (free of *Ammophila*) was used to cap buried spoils.

Because of the success of the 2005 pilot project and the receipt of grant funding to support additional restoration work at LRSB, the applicant is proposing to expand dune restoration efforts across approximately 80 acres of dune habitat, as described below in Finding IV-C.

B. <u>Site Description</u>

The proposed project site is located 13 miles north of Eureka and five miles south of Trinidad at Little River State Beach off of Crannel Avenue in Humboldt County (see Exhibit Nos. 1-2). Little River State Beach (LRSB), which was acquired by the Department of Parks and Recreation in 1931 and was designated a state beach in 1963, extends approximately two miles and is located adjacent to Highway 101 between

Moonstone County Park to the north and Clam Beach County Park to the south, with a small stretch of private property adjacent to the north. Little River State Beach and the surrounding area are characterized by an extensive stretch of coastal dunes and an expansive, flat, sandy beach. The park is comprised of approximately 148 acres of beach and dunes. Little River flows across the northern end of the state beach toward Moonstone beach where it empties into the Pacific Ocean.

Little River State Beach is characterized by a dune system comprised of beach strand, foredunes, dune ridges, deflation plains, stabilized back dunes, and a small dune forest. Little River flows through the dune system, creating a small island of stabilized dunes on the north side of the river adjacent to Highway 101. The project area is relatively flat, at elevations ranging from sea level to approximately 40 feet.

Habitat types at LRSB include dune systems, wetlands, and coastal scrub. These habitat types currently support four vegetation communities that are separated into units based on dominant vegetation: the European beachgrass series, the Yellow bush lupine series, the Coyote brush series, and the Sedge series (Pickart & Sawyer 1998, Sawyer & Keeler-Wolf 1995). Of these four series, two are largely comprised of invasive, non-native plant species: European beachgrass (*Ammophila arenaria*) and yellow bush lupine (*Lupinus arboreus*).

Little River State Beach provides habitat for sensitive animal and plant species. The western snowy plover (*Charadrius alexandrinus*) has been observed nesting at LRSB since the early 1990's. The species has been listed as "threatened" under the federal Endangered Species Act since 1993, and at the State level, the western snowy plover has been classified by the Department of Fish and Game (DFG) as a "species of special concern" throughout all of California since 1978. At LRSB, the species nests in the Sand verbena-Beach bursage and Native dunegrass communities. These communities, considered rare and worthy of special consideration by the DFG, have been steadily displaced since the 1930's by the European beachgrass vegetation community. This displacement has contributed to the decrease, and in some cases extirpation, of native beach and dune species entirely, including snowy plovers. The proposed removal of invasive species from the stabilized dunes is expected to increase western snowy plover habitat in the LRSB.

In addition to the western snowy plover, LRSB also supports habitat for the sensitive pink sand verbena (*Abronia umbellata* ssp. *breviflora*). The species is on the California Native Plant Society's (CNPS) List 1B plant list (which includes species that are considered rare, threatened, or endangered in California and elsewhere) and is classified by CNPS and the DFG's Natural Diversity Data Base (NDDB) as "endangered" in California and "rare" outside of California. Pink sand verbena typically grows in the Sand verbena-Beach bursage vegetation community, which has been steadily displaced by invasive European beachgrass and yellow bush lupine over the decades, as discussed above. The proposed invasive plant removal is expected to increase pink sand verbena habitat at the LRSB.

C. Project Description

The applicant proposes to restore approximately 81 acres of dune habitats through the removal of invasive exotic plant species and the restoration of natural dune topography using heavy equipment, flaming, and manual removal techniques (see Exhibit No 3).

The upland dune restoration areas span approximately 69 acres of LRSB and include the foredune and hummocks of the nearshore dunes (see Exhibit No. 3). The elevation of the foredunes is believed to be unnaturally high due to the invasion and dune stabilization properties of European beachgrass. The European beachgrass series is the dominant vegetation type in this area, with little species diversity. The restoration goals for the foredune and dune hummock areas are to reduce the invasive European beachgrass and yellow bush lupine to a total area cover of less than five percent and to restore native nearshore dune species of the Sand-verbena-Beach bursage series and Native dunegrass series (from Sawyer & Keeler-Wolf 1995) to a total area cover of greater than 10 percent.

The wetland dune restoration areas span approximately 12 acres and include herbaceous dune swales (see Exhibit No. 3). Historic photos and reports indicate that prior to the construction of Highway 101, dune swales were more abundant at the LRSB. The reduction of dune swales in the area has been attributed to invasive plant species, dune stabilization, and the construction of Highway 101. The restoration goals for the dune swales and wetland areas are to reduce the invasive species to a total area cover of less than 25 percent and to restore native wetland species of the Hooker willow series, Sedge series, and Red alder series (from Sawyer & Keeler-Wolf 1995) to a total area cover of greater than 25 percent.

Initially, the upland dune restoration areas would employ a combination of invasive plant removal methods including the use of a bulldozer, excavator, manual removal, and flaming. Initial treatment in the wetland restoration areas would employ only manual removal techniques. The various proposed invasive plant removal techniques are described below (and see Exhibit No. 3):

- <u>Mechanical Removal Techniques</u>: Heavy equipment is proposed to be used for the initial treatment of the upland dune restoration areas. Two different methods are proposed (described below), and each involves the movement of sand and vegetation resulting in cutting and filling to reduce the foredune and to grade the area. The area would be reshaped to resemble the natural foredune, but no sand would be added or removed from the project area.
    - *Dozer Grade Technique:* This technique is similar to that used in the LRSB Pilot Habitat Restoration Project (see CDP No. 1-04-071) and by Bureau of Land Management (BLM) at the South Spit of Humboldt Bay (USDI 2002). A D8 or equivalent dozer would be used to remove the European beachgrass and any other nonnative plants to a depth below the rhizomes (approximately 3 meters). The invasive plants removed from the ridges would be moved behind the foredune prior to grading the foredune. The foredune would then be graded to a 1.5-2.5 percent slope, depending

on seasonal sand deposition. The invasive plant spoils would be buried beneath the reduced, graded foredune to a depth of approximately 2 meters. The highest point of the graded slope would be less than 4 meters.

- *Excavator Technique*: This technique, which also was used in the LRSB Pilot Habitat Restoration Project (see CDP No. 1-04-071) would be employed throughout the nearshore dunes, as necessary (i.e., where the dozer technique cannot be utilized). Rhizomes would be excavated to a depth of 2 meters, and the existing topography would be retained as much as possible. The excavator would stage the removed mixture in piles for disposal.

- Manual Removal Techniques: Manual removal would occur throughout the entire project area. In the upland dune areas, manual removal techniques would be used in and around all sensitive areas and species. Manual removal techniques would involve using hand tools (e.g., shovels) to dig up invasive species to a depth of approximately 0.6 meters. Care would be taken to not disturb any sensitive species or habitats.

- Flaming Technique: Flaming would be used to treat small, nonnative plants after the larger plants have been manually removed. This technique has been found to be effective on a variety of invasive plant species without causing ground disturbance. Two types of flaming are proposed to be used. Green flaming involves using a small torch that is applied just long enough to wilt the plant. Although the targeted plant does not brown or look dead until the next day, the heat is enough to kill many invasive plant species. Black flaming utilizes the same equipment, but the torch is left on the plant long enough to actually cause incineration. Flaming would be employed during the wet season only.

All restoration areas would be retreated on a regular basis (once every three months, or as funding allows), until the nonnative plants are controlled or eradicated and success criteria are met. Only manual removal techniques would be utilized for retreatment efforts in the wetland dune habitats. Both flaming and manual removal techniques would be utilized for retreatment efforts in the upland dune habitats.

As discussed above, spoils resulting from the mechanical removal techniques would be removed and deposited on the leeward side of the foredune prior to dune grading. When the foredune is subsequently graded, the deposited spoils would be buried to a depth of 2 meters below the newly reduced foredune. The pilot project conducted in 2005 discussed above (permitted under CDP No. 1-04-071; see Exhibit No. 4) found this proposed burial depth to effectively prevent resprouting of invasive plant spoils. Spoils from manual treatment efforts would be bagged and hauled offsite to Patrick's Point State Park (approximately eight miles to the north) to be burned later and/or composted at a local facility. Invasive species receiving the flaming treatment would be left in place to decompose.

Finally, upland dune treatment areas would be manually revegetated with native dune vegetation. The restored wetland habitats are not proposed to be revegetated, but revegetation is expected to occur naturally. Symbolic fencing and signage would be used around the revegetated areas to protect the restoration efforts. Symbolic fencing would be placed such that access corridors would remain between fenced areas to ensure that public access to the waveslope, interior dunes, and river is maintained.

The applicant proposes to conduct all project activities outside of the snowy plover breeding season (i.e., project activities would be implemented between September 15 and March 1 only). The applicant anticipates that initial treatment and revegetation of most areas can be accomplished in two to four phases.

The applicant proposes to monitor vegetation and use adaptive management to direct overall project success. The applicant also proposes to produce an annual summary report throughout the implementation phases of the project.

The following measures, among others, have been proposed by the applicant to minimize potential impacts to coastal resources (see Exhibit Nos. 3 and 5 for all proposed minimization measures):

- Prior to operations, botanical surveys would be conducted by a qualified botanist, with the botanical results to be submitted to the Department of Fish and Game for review;
- A 5-meter heavy equipment exclusion zone (EEZ) would be established around all sensitive resources including sensitive plants, wetlands, and cultural resources. Restoration activities within the EEZ would be restricted to manual removal techniques;
- Heavy equipment would enter the project area through an existing trail from the Clam Beach frontage road to the foredunes, where it would be stored at the interface of European beachgrass and Coyote brush plant series. Heavy equipment would remain onsite until the completion of each year's implementation phase, at which time equipment would exit in the same route as it entered;
- Heavy equipment would be fueled at the start of every day at a predetermined location. Fuel would be delivered via a fuel dispenser held in the bed of a 4 X 4 truck that would enter the beach from the Clam Beach County Park vehicle entrance. A snowy plover monitor would walk in front of the vehicle from the waveslope to/from the western ¼ of the treatment area to fuel the equipment;
- Western snowy plover mitigation measures would be applied whenever operations are occurring in the nearshore dune habitat.

Little River State Beach was surveyed in July of 2004 for prehistoric and historic cultural resources by a State Park Archeologist. A confidential report was prepared, and two cultural significant sites were located, along with six new findings that could be of some historical significance (Gruver 2004). The two cultural significant sites known to be of importance date back to prehistoric and historical times. Although prehistoric and historic cultural sites have been documented within LRSB, the sites are not within the project area. Regardless, the applicant proposes that a cultural monitor would be on site during the treatment phase to ensure the protection of any new findings or unknown cultural artifacts that may become unearthed. If an artifact were to become exposed, heavy equipment use in that area would stop, and consultation with the monitor, local tribes, and the State Park Archeologist would begin to determine the appropriate course of action (see Exhibit No. 5 for specific proposed archaeological resources protection measures).

D. Environmentally Sensitive Habitat Area (ESHA)

1. Summary of Applicable Coastal Act Policies

Coastal Act Section 30107.5 defines "environmentally sensitive habitat area" as:

> *…any area in which plant or animal life or their habitats are either rare or especially valuable because of their special nature or role in an ecosystem and which could be easily disturbed or degraded by human activities and developments.*

Coastal Act Section 30240 states in part that:

> *(a) Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on such resources shall be allowed within such areas.*
>
> *(b) Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.*

2. Consistency Analysis

The dune habitats at Little River State Beach, which contain snowy plover nesting habitat, pink sand verbena habitat, and wetland habitat, constitute ESHA, as they are rare or especially valuable habitats that are easily disturbed or degraded by human activities or developments. The upland dunes themselves, in the absence of sensitive plant or animal species, also constitute ESHA, as the County's certified Land Use Plan for the area (the McKinleyville Area Plan) recognizes, in general, "Vegetated dunes at Clam Beach, Little River Beach, and the banks of the Mad River" as a type of ESHA (Section 3.41A.1.c) subject to the ESHA protection provisions of Coastal Act Section 30240. Furthermore, coastal dunes are easily disturbed and degraded by human activities and developments and have in fact been destroyed by development over large areas of the state. Coastal dunes once were widespread all along the west coast, but through the combined impacts of development, off-highway vehicles, and the invasion of nonnative species, only relatively small, fragmented patches of intact coastal dune habitat remain today. Compared to its natural distribution and abundance, coastal dunes are in decline, and their decline is due to destruction by human activities. As discussed above, historic photos and reports indicate that prior to the construction of Highway 101, dune swales were more abundant at the LRSB. The reduction of dune swales in the area has been attributed to invasive plant species, dune stabilization, and the construction of Highway 101. Unfortunately for the habitat type, coastal dunes occupy a narrow strip of land adjacent to the ocean, areas that are prized for development. California's dunes were formed over thousands of years, yet today, dune erosion is outstripping sand deposition as dams trap river sediments, depleting the sand supply, and coastal protective structures, such as seawalls, disrupt the natural recycling of sand from sandbar to beach. Coastal development has disturbed dunes at many points along the coast. Off-road vehicles, foot traffic, and horses can damage dune plants, loosening the sands and leaving the dunes vulnerable to wind erosion and blowouts. Coastal dunes provide important ecological functions, as discussed above. Even disturbed or degraded coastal dunes may provide essential habitat for breeding birds and other animals, they may contribute to the local diversity of vegetation, and they may themselves be a rare habitat type inherently deserving of protection wherever they are found. Therefore, the Commission finds that the coastal dune habitat in which the restoration activities are proposed constitutes ESHA as defined by Section 30107.5 of the Coastal Act.

Section 30240(a) of the Coastal Act limits activities within environmentally sensitive habitat areas (ESHAs) to only uses that are dependent on the resources of the ESHA. In addition, ESHA must be protected against any significant disruption of habitat values.

The purpose of the proposed project is to restore native vegetation and natural topography and function to the coastal dune habitats at LRSB. Thus, as the project is inherently a restoration project, the Commission finds that the proposed development activities within the environmentally sensitive dune habitats are for a use dependent on the resources of the ESHA.

As discussed above, this finding that the proposed project constitutes "a use dependent on the resources of the ESHA" is based, in part, on the assumption that the proposed project will be successful in eliminating invasive species from the site and restoring native dune habitat values. Should the project be unsuccessful, or worse, if the proposed grading and excavation impacts of the project actually result in long term degradation of the habitat, the proposed development would not be for "restoration purposes." To ensure that the proposed project achieves the objectives for which it is intended (*i.e.*, for the restoration of native dune habitat values), the Commission attaches **Special Condition No. 1**. Special Condition No. 1 requires the applicant to submit a final monitoring plan for review and approval by the Executive Director prior to the issuance of the permit. The monitoring plan is required to outline a method for measuring and documenting the improvements in habitat value at the site over the course of five years following project completion. Furthermore, Special Condition No. 1 requires the monitoring plan to include provisions for remediation to ensure that the goals and objectives of the dune restoration project are achieved.

The proposed project includes various measures designed to prevent any significant disruption of habitat values of the dunes, including limitations on areas where heavy equipment can operate within the dune system, restrictions on fueling and operation of heavy equipment, and measures to avoid disturbance of sensitive plants and the threatened snowy plover. To ensure that the applicant implements the project in a manner that protects ESHA and is compatible with the continuance of environmentally sensitive habitats at LRSB, the Commission attaches **Special Condition No. 2**. This condition requires adherence to various construction responsibilities including responsibilities that (A) no construction materials, debris, or waste shall be placed or stored where it may be subject to wave erosion and dispersion; (B) any and all debris resulting from construction activities shall be removed from the project site and disposed of at an authorized disposal location within 10 days of project completion; (C) heavy equipment shall enter and exit the project area through the existing trail from the Clam Beach frontage road to the foredunes; (D) western snowy plover protection measures shall be implemented as proposed in Exhibit No. 5; (E) sensitive plant protection measures shall be implemented as proposed in Exhibit No. 5; (F) any fueling and maintenance of construction equipment shall occur within upland areas outside of environmentally sensitive habitat areas or within designated staging areas; and (G) fuels, lubricants, and solvents shall not be allowed to enter the coastal waters or wetlands; hazardous materials management equipment shall be available immediately on-hand at the project site, and a registered first-response, professional hazardous materials clean-up/remediation service shall be locally available on call; any accidental spill shall be rapidly contained and cleaned up.

Therefore, the Commission finds that the proposed project, as conditioned, is consistent with Section 30240 of the Coastal Act, as the project is for a use dependent on the resources of the environmentally sensitive dune habitats and will not result in a significant disruption to ESHA.

E. Archaeological Resources

Coastal Act Section 30244 provides for protection of archaeological and paleontological resources and requires reasonable mitigation where development would adversely impact such resources.

Little River was the natural feature that separated two prehistoric Native American tribes: the Yurok and Wiyot. The Yurok had over 50 named villages clustered along the Klamath River and coastal lagoons and creeks, including 17 villages on the coast. The Wiyot lived along the coast around Humboldt Bay, extending 35 miles from Little River to the Eel River.

Both the Yurok and Wiyot have historically utilized both the north and south sides of Little River. As noted previously, Little River State Beach was surveyed in July of 2004 for prehistoric and historic cultural resources by a State Park Archeologist. A confidential report was prepared, and two cultural significant sites were located, along with six new findings that could be of some historical significance (Gruver 2004). The two cultural significant sites known to be of importance date back to prehistoric and historical times. Although prehistoric and historic cultural sites have been documented within LRSB, the sites are not within the project area.

The applicant indicates that a cultural monitor will be on site during the treatment phase to ensure the protection of any new findings or unknown cultural artifacts that may become unearthed. If an artifact were to become exposed, heavy equipment use in that area would stop, and consultation with the monitor, local tribes, and the State Park Archeologist would begin to determine the appropriate course of action.

To ensure protection of any cultural resources that may be discovered at the site during construction of the proposed project, and to implement the recommendation of the archaeologist, the Commission attaches **Special Condition No. 3**. This condition requires that requires that if an area of cultural deposits is discovered during the course of the project, all construction must cease, and a qualified cultural resource specialist must analyze the significance of the find. To recommence construction following discovery of cultural deposits, the applicant is required to submit a supplementary archaeological plan for the review and approval of the Executive Director to determine whether the changes are *de minimis* in nature and scope, or whether an amendment to this permit is required.

Therefore, the Commission finds that the proposed project, as conditioned, is consistent with Coastal Act Section 30244, as the development will not adversely impact archaeological resources.

F. <u>Public Access</u>

Coastal Act Sections 30210, 30211, and 30212 require the provision of maximum public access opportunities, with limited exceptions. Coastal Act Section 30210 requires, in applicable part, that maximum public access and recreational opportunities be provided when consistent with public safety, private property rights, and natural resource protection. Section 30211 requires, in applicable part, that development not interfere with the public's right of access to the sea where acquired through use (i.e., potential prescriptive rights or rights of implied dedication). Section 30212 requires, in applicable part, that public access from the nearest public roadway to the shoreline and along the coast be provided in new development projects, except in certain instances, such as when adequate access exists nearby or when the provision of public access would be inconsistent with public safety. In applying Sections 30211 and 30212, the Commission is limited by the need to show that any denial of a permit application based on these sections, or any decision to grant a permit subject to special conditions requiring public access, is necessary to avoid or offset a project's adverse impact on existing or potential public access.

Little River State Beach does not have a designated trail system. However, there are many access points along the frontage road and from the Clam Beach County Park, and the park is used by many for public access. Although the symbolic fencing and the experimental project in general would temporarily preclude public access within certain areas, the impact on public access use is not significant. Access would be allowed to continue along the waveslope and around the fenced restoration areas throughout the duration of the project, except for brief periods when heavy equipment is operating in the area of work for safety reasons. Furthermore, access from the frontage road and adjacent

Clam Beach County Park parking lot to the beach would not be affected during this project.

Therefore, the Commission finds that the proposed project will not have a significant adverse effect on public access, and that the project as proposed without new public access is consistent with the requirements of Coastal Act Sections 30210, 30211, and 30212.

G. California Environmental Quality Act

The California Department of Parks and Recreation served as the lead agency for the project for CEQA purposes. The CDPR completed a final mitigated negative declaration for the project in June of 2009 (SCH No. 2009042121).

Section 13906 of the California Code of Regulation requires Coastal Commission approval of a coastal development permit application to be supported by findings showing that the application, as modified by any conditions of approval, is consistent with any applicable requirements of the California Environmental Quality Act (CEQA). Public Resources Code Section 21080.5(d)(2)(A) of CEQA prohibits a proposed development from being approved if there are feasible alternatives or feasible mitigation measures available, which would significantly lessen any significant effect that the activity may have on the environment.

The Commission incorporates its findings on conformity with Coastal Act policies at this point as if set forth in full. These findings address and respond to all public comments regarding potential significant adverse environmental effects of the project that were received prior to preparation of the staff report. As discussed herein in the findings addressing the consistency of the proposed project with the Coastal Act, the proposed project has been conditioned in order to be found consistent with the policies of the Coastal Act. As specifically discussed in these above findings which are hereby incorporated by reference, mitigation measures which will minimize all adverse environmental impact have been required. These required mitigation measures include requirements that limit extraction to avoid environmentally sensitive habitat areas, rare and endangered species, migratory fish, and extractions that could lead to changes in river morphology. As conditioned, there are no feasible alternatives or feasible mitigation measures available, beyond those required, which would substantially lessen any significant adverse impact that the activity would have on the environment. Therefore, the Commission finds that the proposed project, as conditioned to mitigate the identified impacts, can be found consistent with the requirements of the Coastal Act and to conform to CEQA.

V. EXHIBITS:

1. Regional Location Map
2. Vicinity Map
3. Proposed Site Plan Map & Project Plans
4. Pilot Restoration Project Results
5. Measures Proposed to Protect Sensitive Species and Cultural Resources

APPENDIX A

STANDARD CONDITIONS

1. Notice of Receipt and Acknowledgment. The permit is not valid and development shall not commence until a copy of the permit, signed by the permittee or authorized agent, acknowledging receipt of the permit and acceptance of the terms and conditions, is returned to the Commission office.

2. Expiration. If development has not commenced, the permit will expire two years from the date on which the Commission voted on the application. Development shall be pursued in a diligent manner and completed in a reasonable period of time. Application for extension of the permit must be made prior to the expiration date.

3. Interpretation. Any questions of intent of interpretation of any condition will be resolved by the Executive Director or the Commission.

4. Assignment. The permit may be assigned to any qualified person, provided assignee files with the Commission an affidavit accepting all terms and conditions of the permit.

5. Terms and Conditions Run with the Land. These terms and conditions shall be perpetual, and it is the intention of the Commission and the permittee to bind all future owners and possessors of the subject property to the terms and conditions.

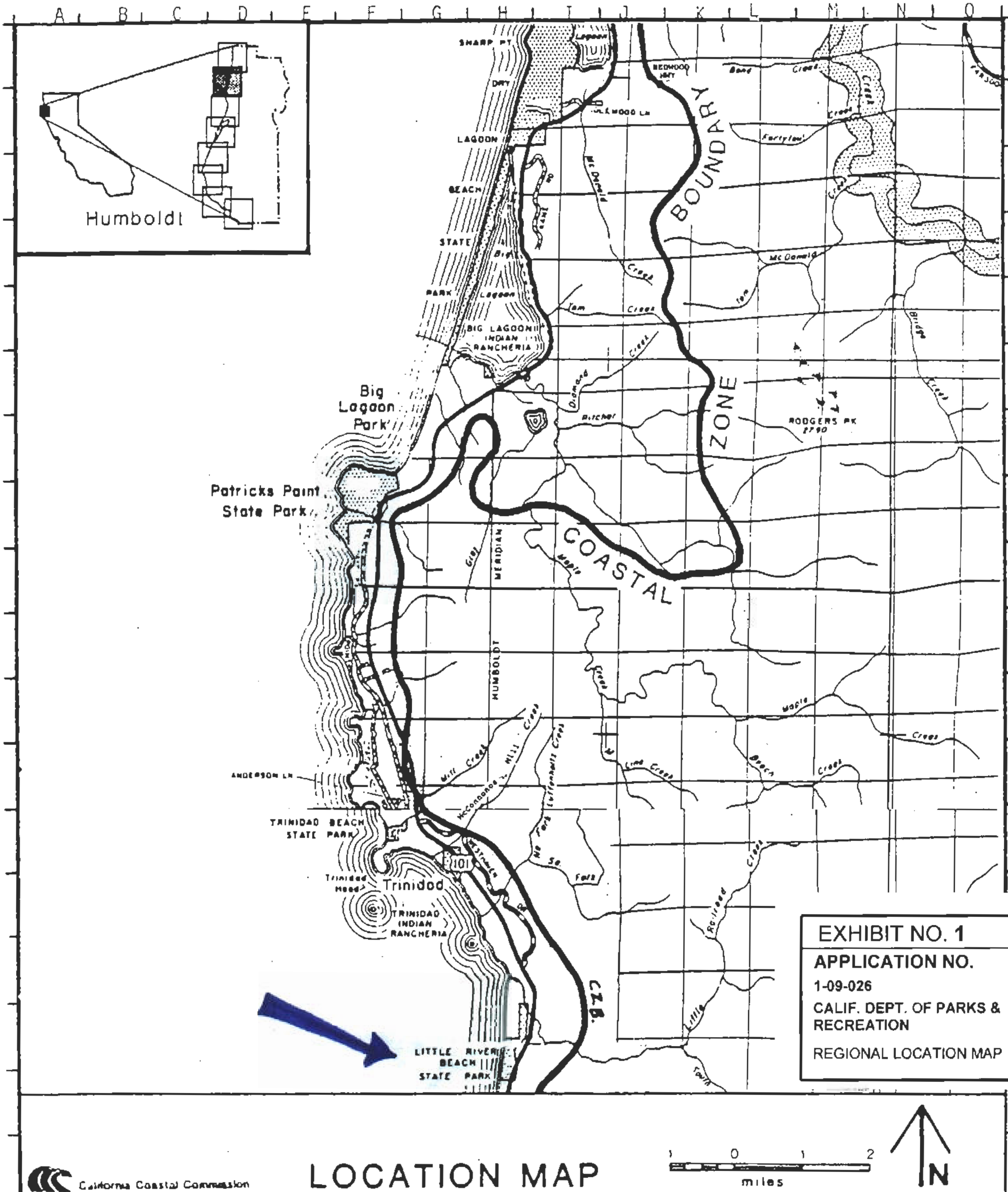


EXHIBIT NO. 1

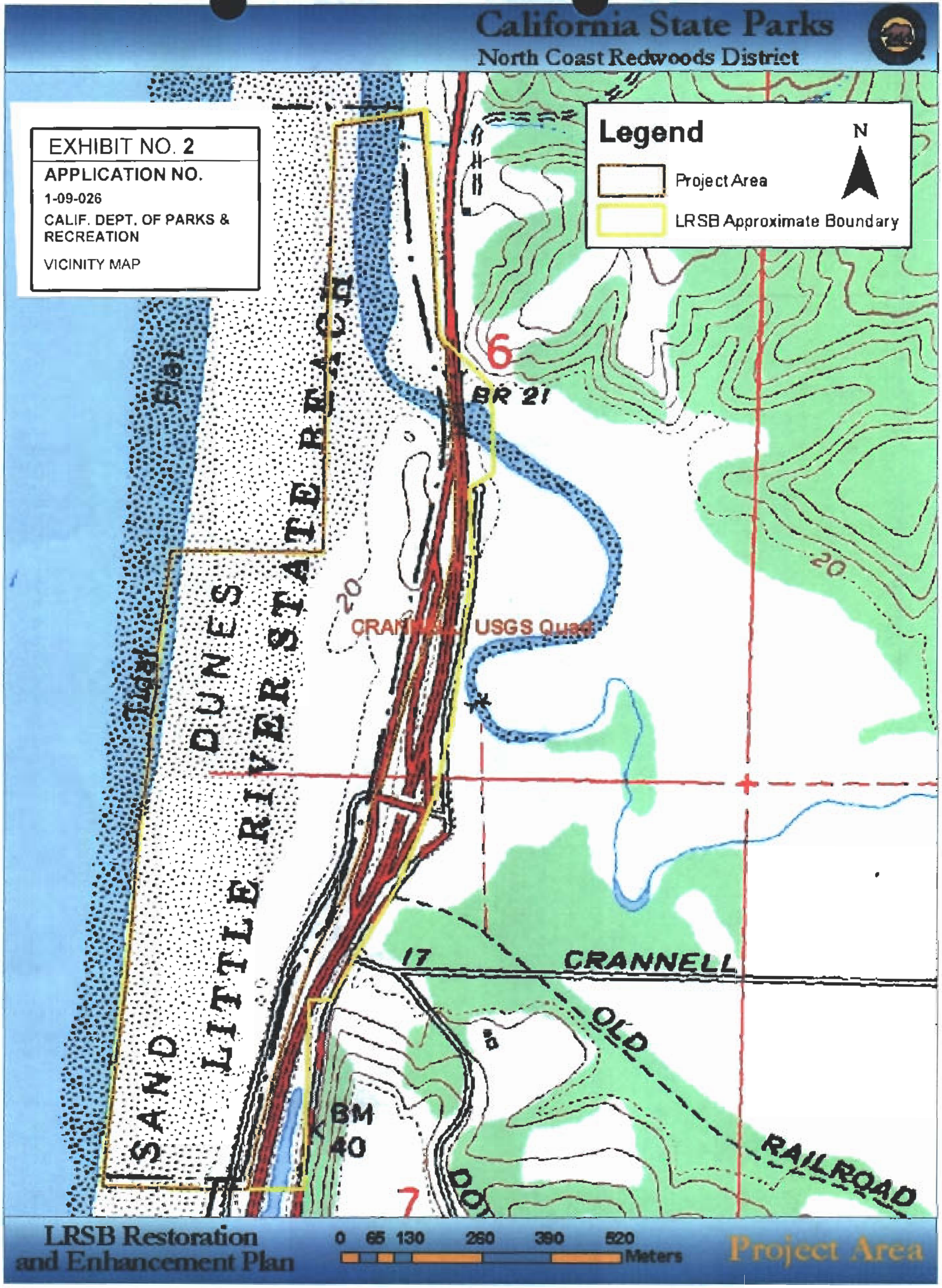
APPLICATION NO.

1-09-026

CALIF. DEPT. OF PARKS & RECREATION

REGIONAL LOCATION MAP

County of Humboldt


California State Parks
North Coast Redwoods District
EXHIBIT NO. 2
APPLICATION NO.
1-09-026
CALIF. DEPT. OF PARKS & RECREATION
VICINITY MAP
Legend
Project Area
LRSB Approximate Boundary
N
SAND DUNES
LITTLE RIVER STATE BEACH
Tidal Flat
BR 21
6
20
CRANNELL USGS Quad
17
CRANNELL
OLD
RAILROAD
BM 40
7
LRSB Restoration and Enhancement Plan
0 65 130 260 390 520
Meters
Project Area

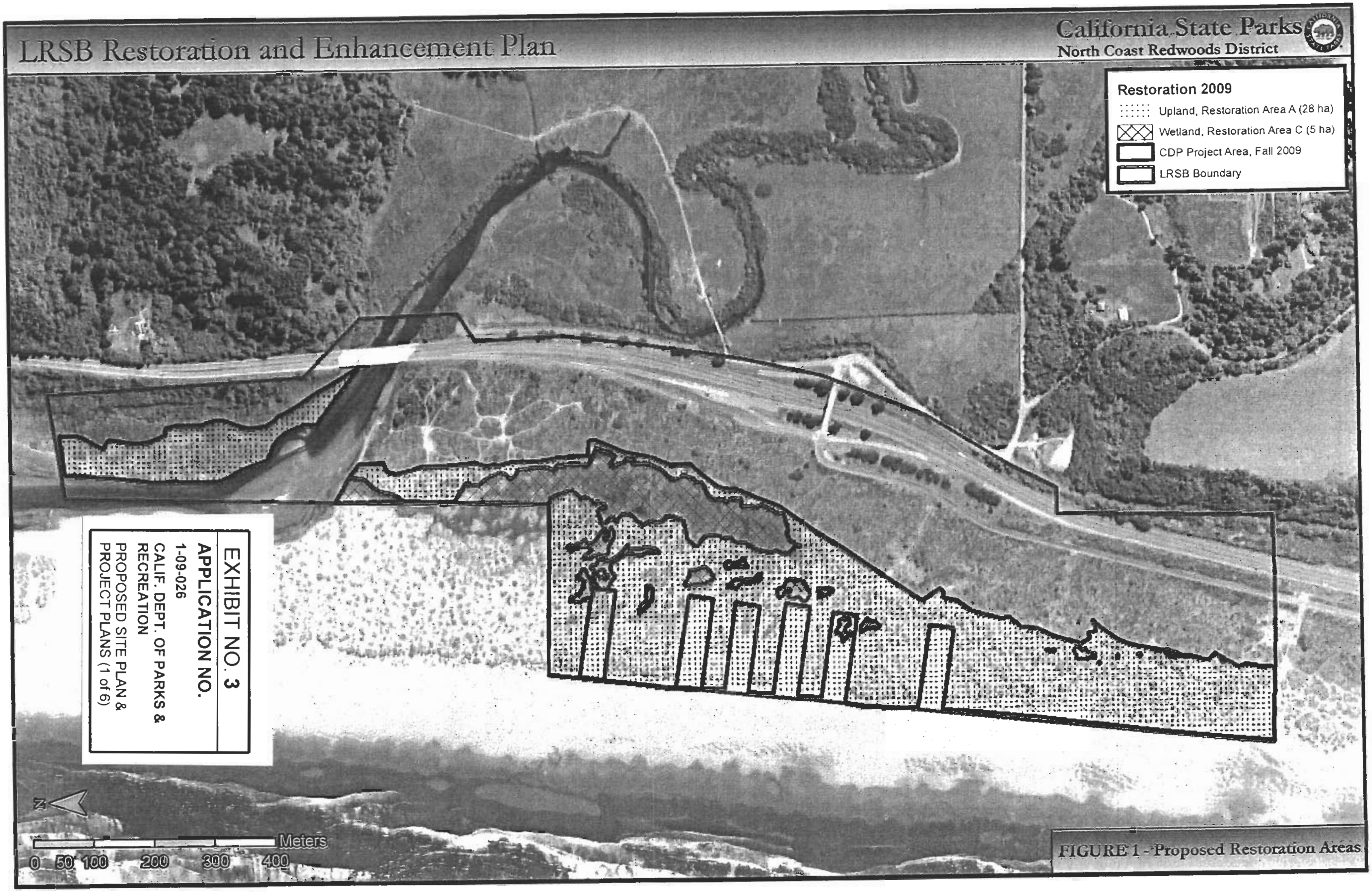


FIGURE 1 - Proposed Restoration Areas

EXHIBIT NO. 3

APPLICATION NO.

1-09-026

CALIF. DEPT. OF PARKS & RECREATION

PROPOSED SITE PLAN & PROJECT PLANS (1 of 6)

State of California • The Resources Agency
Arnold Schwarzenegger, *Governor*
DEPARTMENT OF PARKS AND RECREATION
Ruth G. Coleman, *Director*
NORTH COAST REDWOODS DISTRICT
P.O. Box 2006
Eureka, CA 95502-2006
(707) 445-6547 Ex19; Fax (707) 441-5737
Email: jharris@parks.ca.gov

September 09, 2009

RECEIVED
SEP 0 9 2009
CALIFORNIA
COASTAL COMMISSION

Melissa B. Kraemer
CA Coastal Commission
710 E Street, Suite 200
Eureka, CA 95501

Regarding: Coastal Development Permit Application No. 1-09-026, Little River State Beach Restoration and Enhancement Plan, Project Scope Change.

Dear Ms. Kraemer,

The North Coast Redwoods District is submitting a revised project scope for the Little River State Beach Restoration and Enhancement Plan Coastal Development Permit application. Currently funding is available to implement the nearshore dune restoration (33 ha) component, whereas funding for the additional components of the restoration and enhancement plan is lacking. To facilitate the timely implementation of the funded component, we request a change in project scope to include only those activities associated with the nearshore dune restoration (Figure 1). Restoration activities associated with the nearshore dunes remain identical to those discussed in the LRSB Restoration and Enhancement Plan CDP application submitted 06/03/09 (No. 1-09-026).

We propose to restore 28 hectares of upland habitat (Area A - foredune and dune hummocks) and 5 hectares of wetland habitat (Area C - herbaceous dune swales and northern riparian of the nearshore dunes). The restoration will involve the removal of invasive exotic plant species and the restoration of natural dune process and topography. After the initial treatment of exotic plant species, upland areas will be revegetated with native dune vegetation. Proposed exotic removal techniques include the use of dozers and excavators (foredune and hummocks), flaming (foredune and hummocks), and manual removal (all areas). Exotic plant material will be disposed of on-site through burial or off-site by burning or composting at an appropriate facility. Please see the Little River State Beach Restoration and Enhancement Plan (submitted June 3, 2009) for further detail. Appendix A, presents excerpts from the restoration and enhancement plan as they pertain to this CDP application and the truncated project scope.

The following measures have been included in the restoration plan and/or the CEQA documentation, to minimize potential impacts to coastal resources:

- Prior to operations, botanical surveys will be conducted by a qualified botanist within the project boundaries (all areas of proposed operations and adjacent areas that could be impacted where sensitive plant habitat is present). Surveys will be conducted in conformance with the DFG "Guidelines for Assessing the Effects of

- Proposed Projects on Rare, Threatened, and Endangered Plants and Natural Communities". Results of the survey effort will be submitted to the Senior Environmental Scientist and the DFG at least 10 business days prior to commencing operations to allow sufficient time for review of the survey effort.
- A 5 m (16.5 ft) heavy equipment exclusion zone (EEZ) will be placed around all sensitive natural (wetlands and sensitive plants) and cultural resources. No heavy equipment operation will be allowed within this zone. Restoration activities within the EEZ will be restricted to hand pulling.
- Heavy equipment will enter the project area through an existing trail from the Clam Beach frontage road to the foredunes, where it will be stored at the interface of European beachgrass and Coyote brush plant series. Heavy equipment will remain onsite until the completion of each year's implementation phase, at which time equipment will exit from where it came. Once heavy equipment moves through, objects to obstruct the entrance will be placed at the trailhead.
- Heavy equipment will be fueled at the start of every day at a predetermined location (western ¼ of each treatment area). Fuel will be delivered via a 4x4 truck at the start of each workday, and be administered by a fuel dispenser held in the bed of the truck. The truck carrying the fuel dispenser will enter the beach at the Clam Beach County Park vehicle entrance. A snowy plover monitor will walk in front of the vehicle from the waveslope to/from the western ¼ of the treatment area, where heavy equipment will be fueled.
- Western snowy plover mitigation measures will be applied whenever operations are occurring in the nearshore dune habitat.
- Permitted snowy plover monitors will survey areas that work will be conducted in each day prior to operation. Snowy plover monitors will be onsite for the entire duration of operational hours to ensure that there are no snowy plovers present within the established spatial buffer zone and that they have not moved on site. If snowy plovers are observed within the spatial buffer zone of project activities, an alternative area where snowy plovers are not present will be picked.
- All staff and activities will remain in delineated project area in which presence/absence surveys will be conducted.
- Heavy equipment operations will be conducted outside of the WSP breeding season between September 15th and March 1st. All operations will occur during daylight hours.
- During the non-breeding season, a 50 meter (164 feet) spatial buffer zone will be maintained between WSP and restoration/enhancement operations. If the WSP monitor determines that operations are resulting in a behavioral disturbance to WSP then operations will be moved far enough away so as to eliminate the disturbance to the plovers.
- During the breeding season, a 100 meter (330 feet) spatial buffer zone will be maintained between WSP and restoration/enhancement operations. If the WSP monitor determines that operations are resulting in a behavioral disturbance to WSP then operations will be moved far enough away so as to eliminate the disturbance to the plovers.

- All operations will occur during daylight hours.
- Vehicles driven on the beach will be limited to 10 mph, or the minimal speed required to prevent getting stuck in sand. Vehicles will remain on the wet sand until reaching the treatment area. All vehicles will be escorted by a permitted snowy plover biologist. A snowy plover monitor will walk in front of vehicles to and from the waveslope. This will be repeated in the afternoon when work is completed for the day. There will be no night driving or driving during periods of diminished visibility.
- Trash will be contained in predator-proof containers and transported off site at the end of each workday.
- Lunch and breaks will be taken at the work site to prevent workers from disturbing plovers.
- No dogs or other pets will accompany workers to the work site.
- Prior to operating in area(s) identified as potentially culturally sensitive in the confidential 5024 document, the project manager will contact the North Coast District Archaeologist at least two weeks prior to operations. The Archaeologist (or his designee) shall determine the boundaries of the sensitive area(s) and flag with black and yellow candy-stripe flagging. The Archaeologist will determine if a tribal monitor needs to be present during operations within these area(s). No heavy equipment will be allowed within designated culturally sensitive area(s).
- Should treatment require digging in the ground within 20 m (60 ft) of the two known cultural sites, a cultural monitor will be on site for that portion of the project. The cultural monitor will be there to help ensure the protection of any new findings or unknown cultural artifacts that may become unearthed. If an artifact were to become exposed, treatment efforts in that area would stop and consultation with the monitor, local tribes, and a State Park Archeologist would begin to determine the appropriate course of action.

If you have any questions or require additional information please feel free to contact me.

Sincerely,

John E. Harris
Senior Environmental Scientist

Acronyms Used:

LRSB, Little River State Beach

CDP, Coastal Development Permit

Ec: Jeff Bomke
Michelle Forys
Amber Transou

Appendix A
2009 LRSB Restoration and Enhancement Project
Restoration Methods and Techniques

Mechanical Removal Techniques: Heavy equipment will be used for the initial treatment of Area A. Two different methods, primarily the Dozer-Grade and secondarily the Excavator technique will be employed in Area A. Each heavy equipment method will involve the movement of sand and vegetation resulting in cutting and filling to reduce the foredune and to grade the area. Area A will be reshaped to resemble the natural foredune, but no sand will be added or removed from the project area. *A 5 m (16.5 ft) heavy equipment exclusion zone will be placed around all sensitive natural and cultural resources.* Initial treatment methods using heavy equipment are described below.

Dozer-Grade Technique:

This technique is similar to that used in the LRSB Pilot Habitat Restoration Project (Transou et al. 2007) and by the Bureau of Land Management (BLM) at the South Spit of Humboldt Bay (USDI 2002). A D8 or equivalent dozer will be used to remove the European beachgrass and any other non-native plants to a depth below the rhizomes (3 m, 9.9 ft). The European beachgrass removed from the ridges will be moved behind the foredune prior to grading the foredune. The foredune will then be graded to a 1.0-2.5 percent slope depending on seasonal sand deposition. The exotic plants will be buried beneath the reduced graded foredune, approximately 2 m (6.6 ft) deep. The highest point of the graded slope will be less than 4 m (13.2 ft).

Excavator Technique:

This technique, used in the LRSB Pilot Habitat Restoration Project (Transou et al. 2007), will be employed throughout the nearshore dunes, where needed. Rhizomes will be dug to a depth of 2 m (6.6 ft) and the existing topography will be retained as much as possible. The excavator will stage the removed mixture in piles for disposal. This method will be employed where the dozer techniques cannot be utilized.

Flaming Technique: Flaming will be used for follow-up treatments of Area A. Two types of flaming are commonly used: green and black. Green flaming sometime called wilting or blanching utilizes a small torch that is applied just long enough to wilt the plant. Although the plants do not brown and look dead until the next day, this is enough heat to actually kill many species of plants. Black flaming utilizes the same equipment, but the torch is left on the plant long enough to actually cause it to incinerate. Both techniques will be utilized to treat small non-native plants after the larger woody shrubs have been manually removed. Flaming will be conducted during the wet season. The NCRD's fire specialist conducted a risk and complexity analysis and determined that this technique does not pose a fire danger at LRSB (Underwood pers. com. 2007). Any necessary permits will be obtained prior to employing this treatment method.

Manual Removal Technique: Manual removal will occur throughout the entire project area. In Area A, manual removal techniques will be used in and around all sensitive areas and species. Manual removal is the sole removal method for wetlands, Area C. Manual removal techniques will be performed using hand tools such as shovels to dig up European beachgrass and any other non-native plant species. The non-native plant species will be dug to a depth of 0.6 meters (2 ft) (Bossard et. al. 2000). Care will be taken to not disturb any sensitive resources.

Retreatment Methods: All restoration areas will be retreated on a regular basis (once every 3 months or as funding allows), until the non-native plants are controlled or eradicated and success criteria is met. Timely retreatment of European beachgrass and other invasive, non-native plants is essential for their control and eradication. Flaming and manual removal techniques will be employed for all retreatment efforts in the upland dune habitats (Areas A). Only manual removal techniques will be utilized for retreatment efforts in the wetland habitats (Areas C).

Disposal Methods: The majority of the removed vegetation will be removed and disposed of by mechanical means. During heavy equipment removal the non-native vegetation will be removed and deposited on the leeward side of the foredune prior to grading. When the foredune is graded, the deposited vegetation will be buried up to 2 m (6.6 ft) below the new reduced foredune. The sand moved by grading will bury the vegetation deep enough to prevent re-sprouting (Transou et al. 2007). Non-native vegetation generated during manual retreatment efforts will be bagged and hauled offsite to Patrick's Point State Park (PPSP) to be burned later and/or composted at a local facility. Vegetation left after flaming treatments will be left in place.

Revegetation Methods: Due to the level of habitat degradation, few native plant species are left to naturally re-colonize the proposed restoration areas. The upland dune treatment area (Areas A) will be manually revegetated with native dune vegetation. The wetland habitats will not be actively revegetated. Once treated for exotic plant species, the native wetland plants species will be allowed to re-colonize Area C naturally. Revegetation should occur within one growing season after each area has been initially treated. Additional revegetation efforts may occur in following years depending on initial success.

Monitoring Methods: Project monitoring is an important component to help direct adaptive management and overall project success. Vegetation monitoring will be conducted pre and post treatment efforts to determine restoration success. Simple stratified random sampling will be employed. Diversity and abundance (via % cover) of vegetation will be estimated by placing 1 m2 quadrats at randomly generated distances (length to be determined) from base points. Visual estimates of native and non-native plant cover within 1 m2 quadrats will be collected by the same observers over time to minimize sampling error. Pre-treatment and immediate post-treatment data will be collected to assess the degree of change that is attributed to restoration activities as opposed to natural variation or external influences. Additional post-treatment data will be collected twice a year or as funding and time allows, helping determine long term success and trends.

Reporting Methods: A summary report will be produced on a yearly basis throughout the implementation phases of the project. This report will summarize the project tasks completed, the methods used, and the outcome of the associated monitoring activities.

Abstract

At Little River State Beach, European beachgrass (*Ammophila arenaria*) has replaced native vegetation, reduced species diversity and has altered the beach and dunes system by creating an artificially steep slope that impedes sand movement into the back dunes. During the late winter of 2004-2005 the California Department of Parks and Recreation North Coast Redwoods District initiated a pilot project to compare three different heavy-equipment *Ammophila* removal methods. The three treatment methods were compared as they related to 1) *Ammophila* removal efficacy, 2) potential and actual sand movement patterns and 3) cost-effectiveness. Percent reduction in Ammophila did not vary significantly between treatments; however we surmise that these results are largely a product of inadequate sampling design. Re-treatment hours proved to be significantly different among treatments, with the dozer-grade method requiring 30 percent less follow-up treatment and the dozer-rake treatment requiring 10 percent less follow-up compared to excavator treatments. The sand flux rates revealed loss of sand in the control areas, roughly equivalent gains in dozer treatments, and more than double the gain of dozer treatments within excavator treatment areas. We calculated costs significantly lower than many published figures at $7,331/hectare ($2,967/ acre) for dozer-rake treatments, $8,883/hectare ($3,595/ acre) for dozer-grade treatments and $9,686/ hectare ($3,920/ acre) for excavator treatments. In light of site specific factors and with consideration to efficacy, cost and resultant topography we determined mechanical grading to be the most successful method to restore dune function altered by Ammophila for beaches within the Humboldt Bay Dunes System, specifically Little River State Beach and Clam Beach County Park.

EXHIBIT NO. 4
APPLICATION NO.
1-09-026 - CALIF. DEPT. OF PARKS & REC.
PILOT RESTORATION PROJECT RESULTS
(1 of 33)

Introduction

In northern California coastal dune ecosystems have been severely altered by the invasion of exotic species, primarily the invasive European beachgrass (*Ammophila arenaria*) (Barbour and Johnson 1977, Pickart and Sawyer 1998). Ammophila is a prolific, rhizomatous grass that is recognized for its ability to stabilize sand. Since its introduction in the late 1800's, *Ammophila* has come to dominate many areas along the Pacific coast resulting in static communities where native dune species have been displaced, species diversity has been reduced, and significant alterations in dune morphology have occurred (Buell et al. 1995).

Coastal dunes have long been noted for the dynamic connection between vegetation and the physical environment (Parker 1974). Prior to the introduction of *Ammophila*, dunes along the Pacific coast were in a continuing process of colonization, stabilization and erosion (Parker 1974). In northern California, *Ammophila* has changed the morphology of the foredune community from gentle sloped hummocks, to a steep almost vertical, continuous wall that impedes sand movement from beach to interior dunes (Barbour and Johnson 1977, LaBanca 1993). This continuous foredune has greatly reduced sand supplies to interior dunes, altering dune morphology and affecting function of entire beach and dune ecosystems.

The spread of *Ammophila* and its subsequent dominance throughout beach and dune areas has resulted in an increased emphasis on the removal and control of this invasive species. Successful control has been demonstrated using manual, mechanical, and chemical methods (Van Hook 1983, Pickart et al. 1990, Berger 1993, Miller 1994b, 1996, Hyland and Holloran 2005, Rodgers 2006), but relative success of such methods has often been based on removal efficacy or costs alone. As *Ammophila* has the potential to severely alter dune morphology and as relic rhizomes of removed *Ammophila* have the potential to continue to stabilize sand; we suggest, for ecosystem restoration, one should also consider the resultant topography. Projects employing manual and/or chemical control alternatives have often relied on natural processes to restore dune morphology; these dune altering processes, however, can take considerable time especially if the dunes have been extensively built up with *Ammophila*. Lacking intervention, these sites may not readily develop species composition and dune morphology representative of the region's pre-*Ammophila* dune system for some time.

Because coastal areas are complex and extremely dynamic, highly tailored and site-specific techniques are often needed for successful coastal restoration. In addition to ecological factors presented above, one must also consider site-specific factors such as site accessibility, degree of alteration, potential impacts to sensitive species, disposal opportunities, and potential hazardous conditions when selecting appropriate removal methods. In an attempt to address these complexities and to restore ecosystem function over the short-term, California Department of Parks and Recreation (DPR) initiated the Little River State Beach Pilot Habitat Restoration Project. The decision to implement a pilot project, rather than a large scale restoration plan, emerged from the desire to evaluate and determine the most successful mechanical removal technique, as it relates to 1) removal efficacy, 2) cost-effectiveness and 3) topographic restoration for future large-scale Ammophila removal projects. This project was developed within the constraints of existing society; therefore topographic restoration was accomplished to the extent feasible, minimizing exposure of the nearby infrastructure to sand movement and oceanic hazards. We analyzed the short-term (1 year) results of three Ammophila mechanical removal techniques by comparing 1) % reduction in Ammophila to address removal efficacy, 2) initial and follow-up implementation costs to address cost-effectiveness, and 3) sand movement patterns to address physical changes (potential and actual) between three mechanical removal treatments.

Study Area

Little River State Beach occurs in the northern portion of the Humboldt Bay dunes system, which extends from Trinidad Head south to Centerville Beach (Figure 1). The park spans from the Pacific Ocean to HWY 101 and is approximately 60 hectares (148 acres) in size. Clam Beach County Park delineates the southern boundary and in most years the Little River delineates the northern extent. The area is relatively flat, at elevations ranging from 0.00 m (mean low, low water (MLLW) to approximately 12 m (40 ft). The total project area includes roughly 16 ha (40 ac) of nearshore dunes, dune hollows and stabilized back dunes

Given the extensive infestation on State Park lands, Little River State Beach was selected based on the ease of access, greater interpretive value as a demonstration project, increasing dominance of *Ammophila* in the surrounding area, recent impacts to the beach and dunes system from oil spills (Stuyvesant) and evidence of dwindling native and sensitive species (western snowy plover (*Charadrius alexandrinus nivosus*), pink sand verbena (*Abronia umbellata breviflora*), and beach layia (*Layia carnosa*)).

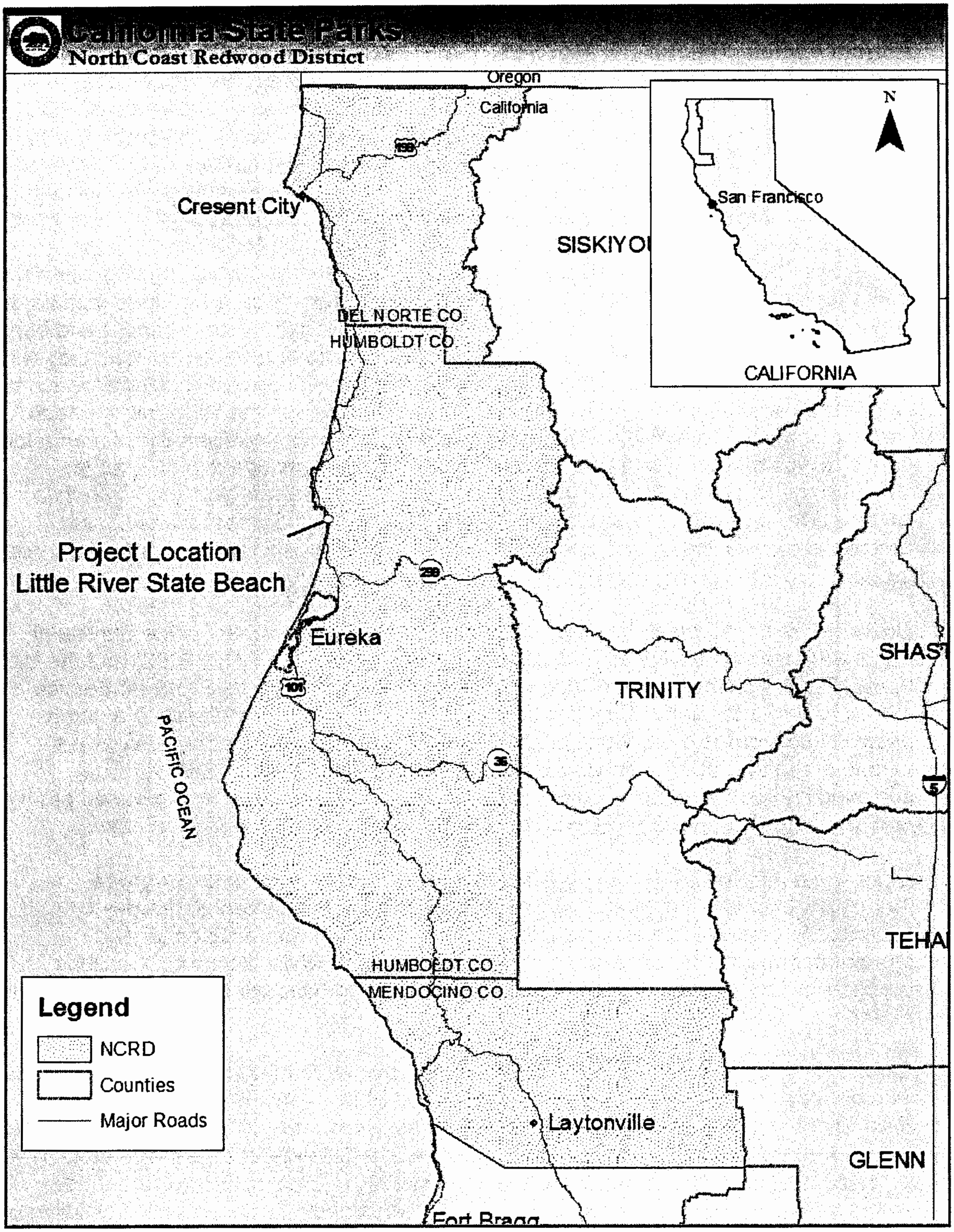

California State Parks
North Coast Redwood District
Oregon
California
Cresent City
SISKIYOU
DEL NORTE CO
HUMBOLDT CO
San Francisco
CALIFORNIA
N
Project Location
Little River State Beach
Eureka
SHASTA
TRINITY
PACIFIC OCEAN
TEHAMA
HUMBOLDT CO
MENDOCINO CO
Legend
NCRD
Counties
Major Roads
Laytonville
GLENN
Fort Bragg

Figure 1

Methods

Project Implementation

We initiated a pilot project to compare three different heavy-equipment removal methods during the late winter of 2004-2005. Two replications of three mechanical removal treatments and one control (no treatment), were randomly assigned to eight 0.6-hectare (1.48-acre) treatment areas (Figure 2). Treatment areas 40 X 150 m (131 X 492 ft) were oriented so that their long axes (east-west) were roughly perpendicular to the surf and oblique to the prevailing wind direction (approximately N44W). Designed to evaluate openings in the primary foredune, blowouts intended to reestablish sand transportation from the beach into the dunes were created by 'breaching' the foredune with a dozer for all treatments. The dozer-grade treatment was designed to completely flatten existing topography to a 1-3% grade (as to mimic natural disturbance) and bury exotic material within the treatment area. The dozer-rake and excavator methods, with the exception of the foredune breaching, were used to remove *Ammophila* while to the greatest extent possible maintain existing dune hummocks. The latter two methods were selected in the event that wave and sand run-up became a concern. As an added bonus, it was thought that these two methods might also provide a jump-start in successional development. Two on-site disposal pits were selected for *Ammophila* extracted from dozer-rake and excavator treatment areas. Symbolic fencing was erected around all treatment areas to reduce potential impacts from human and vehicle traffic.

Dozer-grade mechanical removal – This technique has been used by the Bureau of Land Management (BLM) at the South Spit of Humboldt Bay (USDI 2002) and the U.S. Forest Service at the Oregon Dunes National Recreation Area (U.S. Forest Service 1994). Using a D8 or D850 Dozer, we excavated sand and *Ammophila* to a depth below live rhizomes (3 m, 9.9 ft). The contaminated product was buried near the middle of the treatment area via a dozer to at least a depth of 2 m (6.6 ft). The surrounding freshly exposed sand (void of *Ammophila*) was used to cap buried product and smoothed landward at a 1-3% slope until the sand supply was exhausted.

Dozer-rake mechanical removal – This method, adapted from the dozer-grade technique, utilized a dozer equipped with a brush rake attachment to remove *Ammophila*. Ammophila was plucked from the substrate with a D8 dozer and attachment to a depth below the rhizomes (2 m, 6.6 ft), while maintaining existing topography to the extent possible. A D8 or D850 dozer was used to push contaminated material to off-area disposal sites.

Excavator mechanical removal – This method is similar to methods using an excavator with an attachment to remove exotics around the BLM, Coos Bay District Habitat Restoration Area as well as Point Reyes National Seashore (Citation…). An excavator was employed to pluck beachgrass from dunes to a depth below the rhizomes (2 m, 6.6 ft), while maintaining existing topography not directly altered by Ammophila (to the extent possible). The excavator attachment was designed to maximize the handling of *Ammophila* while filtering excess sand. Ammophila was piled and then pushed by a dozer to off-area disposal sites.

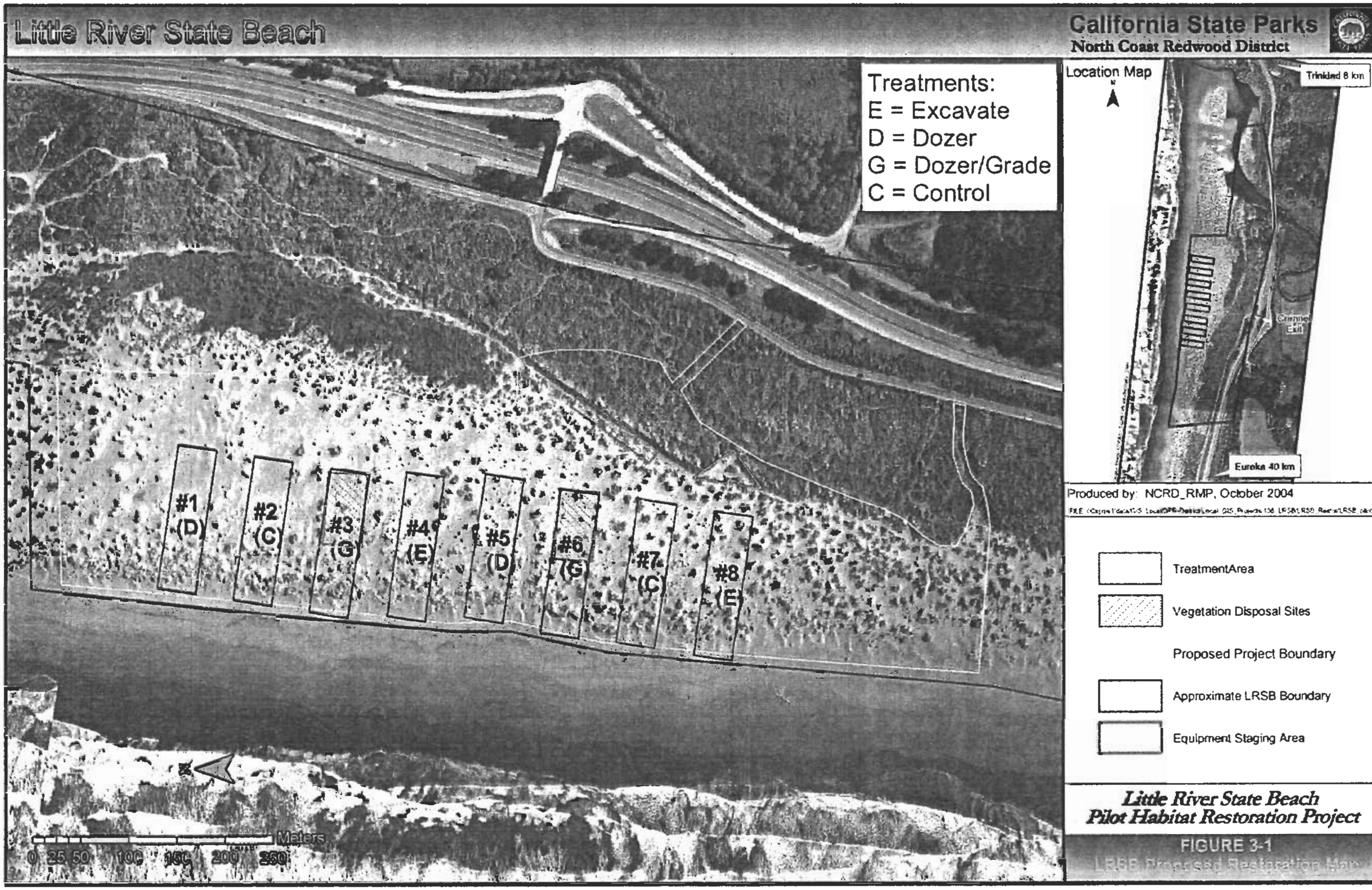

Little River State Beach
California State Parks
North Coast Redwood District
Treatments:
E = Excavate
D = Dozer
G = Dozer/Grade
C = Control
#1 (D)
#2 (C)
#3 (G)
#4 (E)
#5 (D)
#6 (G)
#7 (C)
#8 (E)
Location Map
Trinidad 8 km
Eureka 40 km
Produced by: NCRD_RMP, October 2004
TreatmentArea
Vegetation Disposal Sites
Proposed Project Boundary
Approximate LRSB Boundary
Equipment Staging Area
Little River State Beach
Pilot Habitat Restoration Project
FIGURE 3-1
0 25 50 100 150 200 250
Meters

Figure 2

The dozer-blowout mechanical technique – This method was used in dozer-rake and excavator treatment areas to reestablish sand transport to the back dunes. Once *Ammophila* was removed a D8 or D850 was used to push slots or create overwashes through the immediate foredune. Blowouts were leveled to approximately 1 m (3.3 ft.) above mean sea level and were approximately 10 meters wide.

Resprout Manual Removal - Shovels were used to dig up the re-sprouting Ammophila to a depth of 0.6 m (2 ft.). Pulled material was placed in large plastic bags to be transported off-site and burned at a later date. All treatment plots were re-treated using manual removal techniques during May 2005, September 2005 and February 2006.

Removal efficacy

Stratified random sampling was employed, using a 150 m (495 ft) base transect at 5 m intervals through the center of each treatment area. Diversity and abundance (via % cover) of vegetation was estimated by placing 2 m^2 quadrats at randomly generated distances (1-19 m) from base points. Visual estimates of cover and species composition within 2 m^2 quadrats was collected by the same observers over time to minimize sampling error. Pre-treatment, 3-month post and 6-month post treatment data were collected from treatment and control areas to assess the degree of change that is attributed to restoration activities as opposed to natural variation or external influences (Pickart and Sawyer 1998).

Removal costs

Initial and follow-up costs were recorded for each treatment area on production logs that were later entered into an excel worksheet for analysis.

Sand movement

Aeolian Effects (Total Station) - We used a TOPCON GTS-212 electronic total station to measure elevation data across the eight plots over three topographic survey periods. The first survey occurred as soon as practicable after the heavy equipment treatments (late winter of 2004-2005) to provide baseline data. The second survey, in the fall of 2005, captured changes following the dominant period for prevailing northwesterly winds and before winter storms might affect the sand balance in the plots. The third survey, in the late winter and early spring of 2005-2006, provided data for an annual comparison. In general, staff measured visually significant breaks-in-slope that exceeded 0.3 to 0.6 m (1 to 2 ft) along distinguishable dune forms. Sufficient data was collected at interdune areas to demonstrate the general character of the landform and to demonstrate that these areas had been considered in the mapping effort. We collected data from the entire plot and generally in a perimeter about 10 m (~30 ft) outside of the plot, as we expected some change outside of the plots as sand escaped in response to the vegetation removal. All data were referenced to known temporary benchmarks on the Clam Beach Frontage Road and tied into a permanent benchmark on the HWY 101 Bridge across Little River.

The data from each period of survey were modeled using a TIN model and kriging to capture the topographic forms and to extrapolate the data to areas with comparatively less coverage. The elevations between various periods of survey were compared to demonstrate areas of change over the period in question. The tolerance for the comparisons was set at 0.25 m (0.82 ft), indicating that areas with less than this amount of change would display no change, which is reasonable given the tolerance on the data collection.

Aeolian Effects (aerial photo interpretation) - We compared rectified aerial photography of the project area from 1941, 1974, 1988, 1993, 2000 and 2005.

Surf Effects - We estimated wave run-up into the plots over the project period by examining the extent of logs, sticks and other beach debris that clearly had an oceanic origin and that were deposited over the initially debris limited plots. We visited the site shortly after a known period of wave run-up challenged the plots to observe the extent of continuous soil moisture within the plots that could only be attributed to wave run-up. We also visually monitored the plots during one of the major winter storms of 2005-2006.

Results and Discussion

Project Implementation

We removed Ammophila from 3.6 hectares (8.9 acres) of infested dunes at Little River State Beach between January 2005 and February 2006 (Figure 3). Initial mechanical removal occurred over a ten day period, for an average of 0.36 hectare/day (.9 acre/day). All three methods presented challenges; most notably the disposal methods for the excavator and dozer-rake treatments were modified. These treatments called for on-site disposal in backdune areas to a depth of at least two meters. Due to an elevated water table sufficient depth could not be obtained in the disposal pit. In addition, the transport of the extracted material proved to be problematic. Similar to results reported by Pickart and Sawyer (1998) we found the extracted material to be significantly masticated and intermixed with sand prior to reaching disposal areas. An alternative method was employed where the extracted *Ammophila* was pushed through the back (east end) of the plots by a dozer and integrated into existing dune ridges outside of the plots. This disposal method poses risks of new satellite populations as well as inherent problems if implementing a large scale project, and as such this is not a recommended disposal option. It is worth note; however, that these masticated piles had little resprouts 1 year later. In addition this mixed pile visually appeared to have little change in topographic form over the monitoring period. From this, and its generally downwind location, we conclude that the organic matter acted as a mulch to help arrest this potential sand source and thus it did not have a significant impact on sand movement in adjacent plots. The grade method, designed to smooth sand landward at a 1-3 % slope until the sand supplies were exhausted, was successful in the removal and burial phases, but resulted in a shore parallel break-in-slope just past the middle of the plot. This abrupt break-in-slope may be modified in future work by creating more variation in the troughs (vs. a set 1-3% slope) or lowering the overall slope so that sand supplies can feather into back dune areas.


Little River State Beach
California State Parks
North Coast Redwood District
Treatments:
E = Excavate
D = Dozer
G = Dozer/Grade
C = Control
#1 (D)
#2 (C)
#3 (G)
#4 (E)
#5 (D)
#6 (G)
#7 (C)
#8 (E)
Trinidad 8 km
Eureka 40 km
Meters
0 25 50 100 150 200 250
Equipment Staging Area
TreatmentArea
Approximate LRSB Boundary
Vegetation Disposal Sites
Little River State Beach
Pilot Habitat Restoration Project

Figure 3

Removal efficacy

As demonstrated in previous studies, we found all three mechanical treatments to be effective at reducing Ammophila cover, (Fig. 4). Four hundred and forty-eight quadrats were sampled for each sample period: 1) pre-treatment sample , 2) three months post treatment sample and 3) six months post treatment sample period. We found no significant differences in removal efficacy among treatments or through time.

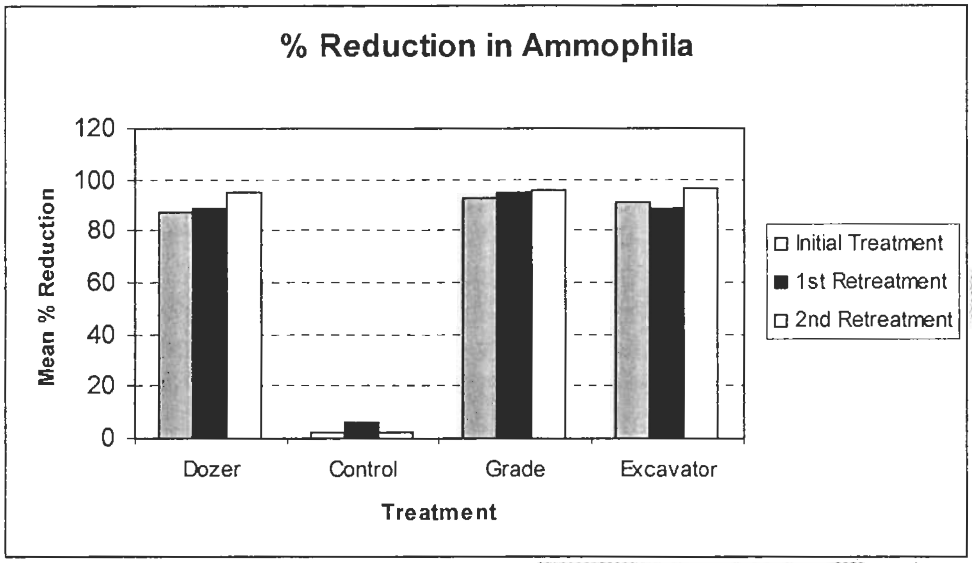


Figure 4 – Mean percent reduction in Ammophila determined by 116 1m2 quadrats in each of the 4 treatments (Dozer, Control, Grade, Excavator).

Though we found no significant difference in removal efficacy among treatments, if you consider re-treatment hours (Fig. 5) as an index to removal efficacy, the Grade method was the most effective treatment to reduce *Ammophila* cover at LRSB. In addition, subsequent observations indicate that re-sprouts in Grade treatment areas are occasional and sparse compared to other treatment areas.

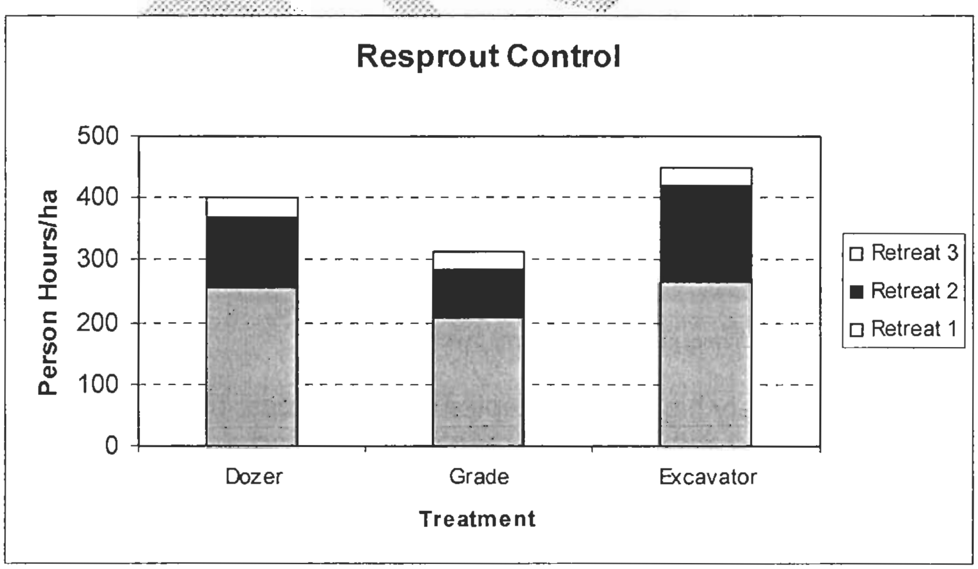


Figure 5 – Mean person hours to pull Ammophila resprouts for three different treatments (Dozer, Control, Grade, Excavator).

These results could be in part a result of inadequate sampling design as there were only two replications of each treatment. Large treatment areas were needed to address sand movement differences among treatment types, and as such the study area could only physically support two replications of each treatment. Percent reduction presented here is likely an under estimate, as percent cover less than one percent was not recorded and as such, the less than one percent cover value was lumped into the 1 percent category. Finally, removal efficacy increased with the second replication indicating that efficacy is likely to improve over time as naive laborers become experienced.

Removal costs
Compared to manual removal cost, mechanical treatment methods have, in most cases, proven to be substantially cheaper $36,600-86,703/hectare and 13,246/ha-$38,769/ hectare respectively (Hyland and Holloran 2005). To assist with future beach and dunes restoration efforts we compared treatment costs between mechanical removal methods. The dozer-rake method ($7,331/hectare) was the least costly followed by the dozer-grade method ($8,883/hectare) and the excavator method ($9,686/ hectare). The dozer-rake figure, however, does not represent costs associated with recommended disposal techniques as previously noted. Due to a high water table and transport challenges of extracted material, contaminated material was piled and left adjacent to treatment areas. As disposal presents a significant cost (Pickart and Sawyer 1998), one may expect that any alternative disposal methods considered for this site would generate costs similar to or in excess of the grade method.

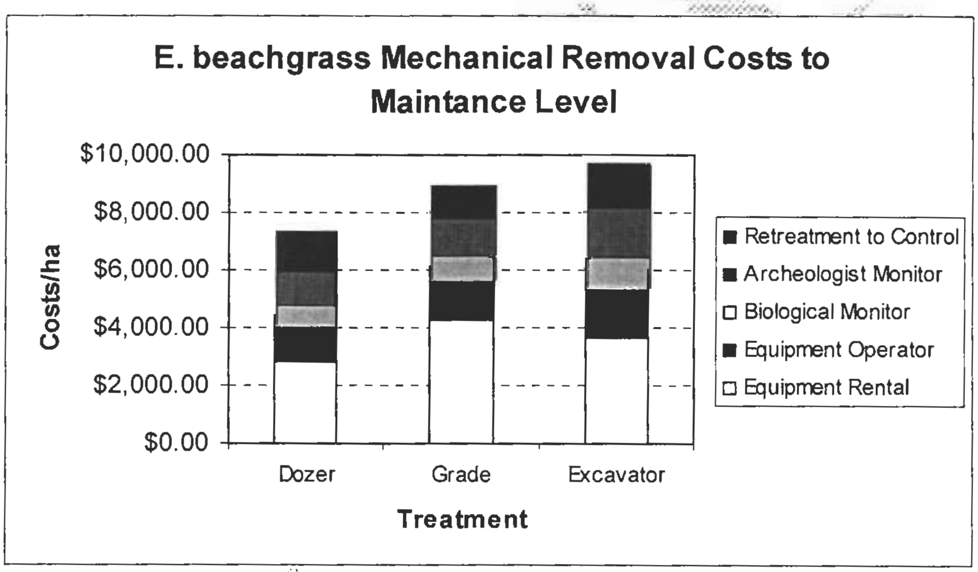


Figure 6 – Per Hectare costs associated with three different mechanical removal treatments.

Actual costs presented here are likely higher than implementation costs of a large scale project due to challenges associated with the experimental design and an inexperienced workforce. Future efforts employing one or two removal methods at Little River State Beach and surrounding area should achieve costs in the $7000/hectare range.

Sand movement
Because there were considerable concerns surrounding the physical aspects of the project, this component of the study received disproportionate attention and as such a

separate report (Vaughan and Fiori 2007) addressing sand movement issues resultant from the pilot project was generated. In addition, prior to project implementation the area was surveyed and a geological assessment of LRSB was prepared (Vaughan and Fiori 2004).

Aeolian Effects (Total Station) -The volumetric changes for each of the four plots revealed some mildly surprising results (Table 1). For example, the control plot actually had a decrease in sand volume over the approximately one year monitoring period (-0.03 m^3/m^2/year [m^3/m^2/yr]). The dozer-grade plot (0.04 m^3/m^2/yr) and dozer-rake (0.05 m^3/m^2/yr) plots had similar flux, while the excavator plot, which retained the most topography, had more than double the flux rate of the other plots (0.11 m^3/m^2/yr). We used fill storage areas estimated from central and southernmost profiles (Vaughan and Fiori 2006), in combination with the flux rate from the three treatments and a travel distance from the source areas to their targets, to estimate how long it would take to fill the potential storage areas. Our calculations reveal the following durations will be needed to fill the central storage area (by treatment technique): dozer - 105 to 110 years; grade - 120 to 125 years; and excavator - 60 to 65 years. The southern storage area results show: dozer – 25 to 50 years; grade 25 to 55 years; and excavator - 15 to 30 years. Final results for all calculations were rounded to the nearest 5 years

Table 1. Sand movement treatment method calculations.

Treatment style/plot #	Measured flux (m^3/m^2/yr)	Adjusted flux [1] (A) (m^2/m/yr)	Target storage compartment (central or south) area [2] (B) (m^2/m)	Time to fill one target compartment at flux rate - (B/A=C)) (yrs)	# of plot boxes (D) (fore dune to target)	Profile volume source - time to fill (CxD=E) (yrs)	Source volume adjustment [3] (Target area to north/target area) (F)	Prevailing wind volume source - time to fill (ExF =G) (yrs)	Range for filling (E to G)(yrs) Rounded to nearest 5 yrs
Dozer-rake (1)	0.05	0.08	Central 1.95	24.4	4.5	109.8	.96	105.4	105-110
Dozer–rake (1)	0.05	0.08	South 0.94	11.8	2	23.6	2.07	48.9	25-50
Dozer-grade (3)	0.04	0.07	Central 1.95	27.9	4.5	125.6	.96	120.6	120-125
Dozer-grade (3)	0.04	0.07	South 0.94	13.4	2	26.8	2.07	55.5	25-55
Excavator (4)	0.11	0.14	Central 1.95	13.9	4.5	62.6	.96	60.1	60-65
Excavator (4)	0.11	0.14	South 0.94	6.7	2	13.4	2.07	27.7	15-30

Aeolian Effects (aerial photo interpretation) - We examined rectified aerial photography from 1941 – 2005 (Figure 7). Comparison of the 1974 and 1988 photography showed that the Ammophila dunes (which developed after the 1941 photo) extended about 100 m (328 ft) farther seaward in 1974, indicating that this vegetation was eroded by surf

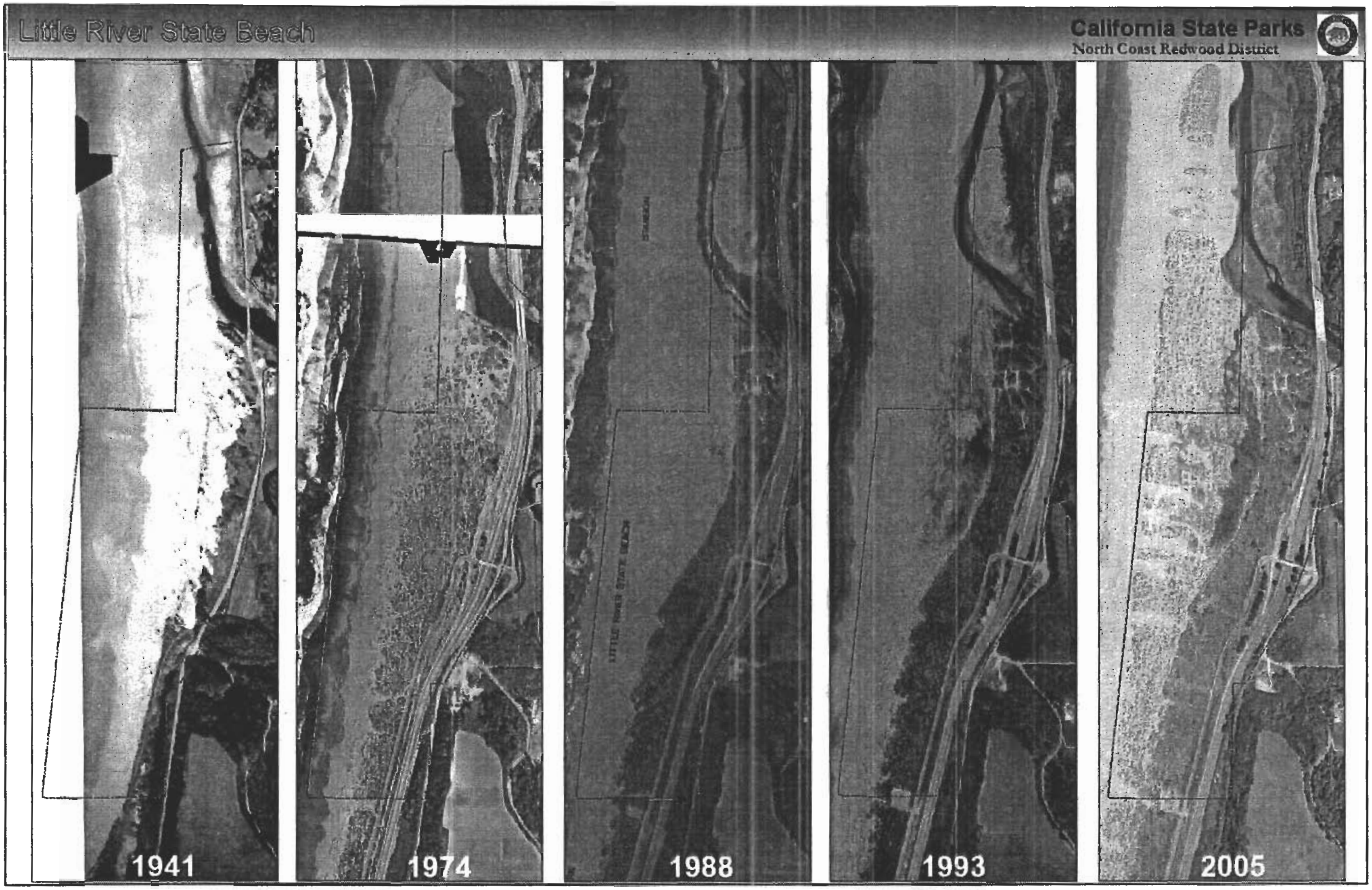

Little River State Beach
California State Parks
North Coast Redwood District
1941
1974
1988
1993
2005

Figure 7

attack and/or consumed or buried by a pulse of sand during this period. The 2000 photography revealed that Ammophila dominated the embryo dunes observed in 1988, a distinct backdune ridge had developed, as well as the major wetland fronting the backdune ridge. A foredune had also developed about 275 m (~900 ft) seaward from the west edge of the major wetland. As the 1988 air photo revealed no pronounced foredune; we estimate the maximum age of the current foredune to be (19-22) years (1988-2007, plus 3 years for incipient accumulation). We estimate that the beach/dune complex prograded westward (widened) about 120 m (~395 ft) between 1974 and 1988 (8.6 m [~28 ft] per year) and approximately 65 m (~215 ft) between 1988 and 2000 (5.4 m [~18 ft] per year). Between 1974 and 2000 the total progradation was about 185 m (~607 ft), yielding a rate of about 7.1 m (~23.3 ft) per year.

Surf Effects -The largest run-up reported during the project observation period occurred on March 9, 2005. This event was not associated with any particular storm observed on the coast, though off-shore storms and a relatively high tide (7.5 ft in Trinidad) may have accentuated the run-up. Run-up did not extend significantly past the eastern edge of the cuts in the foredune in any of the plots, except for plot four (excavator treatment), where the run-up extended nearly through the entire plot (about 115 m [~375 ft] past the foredune). This site is in the middle of the treatment area and thus had an average distance from the wave slope (in comparison with the closer southern plots and the more removed northern plots). We surmise that the retention of differentially lower topography east from the foredune likely encouraged surf that crossed the foredune to retain momentum and travel farther into the plot, potentially posing a greater risk to infrastructure.

Conclusions

Highly tailored and site-specific techniques are often needed for successful coastal restoration. Sites that are accessible by heavy equipment, moderately to highly degraded by *Ammophila*, conducive to disposal opportunities by burial, and those that have few to no sensitive species present when work is to be accomplished are well suited for the dozer-grade mechanical removal method to restore dune function altered by Ammophila. As this method has the potential to quickly alter Ammophila influenced dune topography, sites employing this method may readily develop species composition and richness (both flora and fauna) representative of the region's pre-*Ammophila* dune system. We believe future efforts employing this *Ammophila* removal method will improve in removal efficacy, minimize mechanical removal sand and wave run-up concerns, and may achieve costs in the $7000/hectare range. The North Coast Redwoods District will continue adaptive management for large-scale mechanical removal efforts, further improving removal techniques with hopes to demonstrate the feasibility of large-scale removal efforts.

**Pilot Project for Assessment of Sand Movement
Following Vegetation Removal
Little River State Beach,
Humboldt County California**

Prepared for California State Parks
North Coast Redwoods District

By

Patrick R. Vaughan, Engineering Geologist and Rocco A. Fiori, Engineering Geologist

October 2007

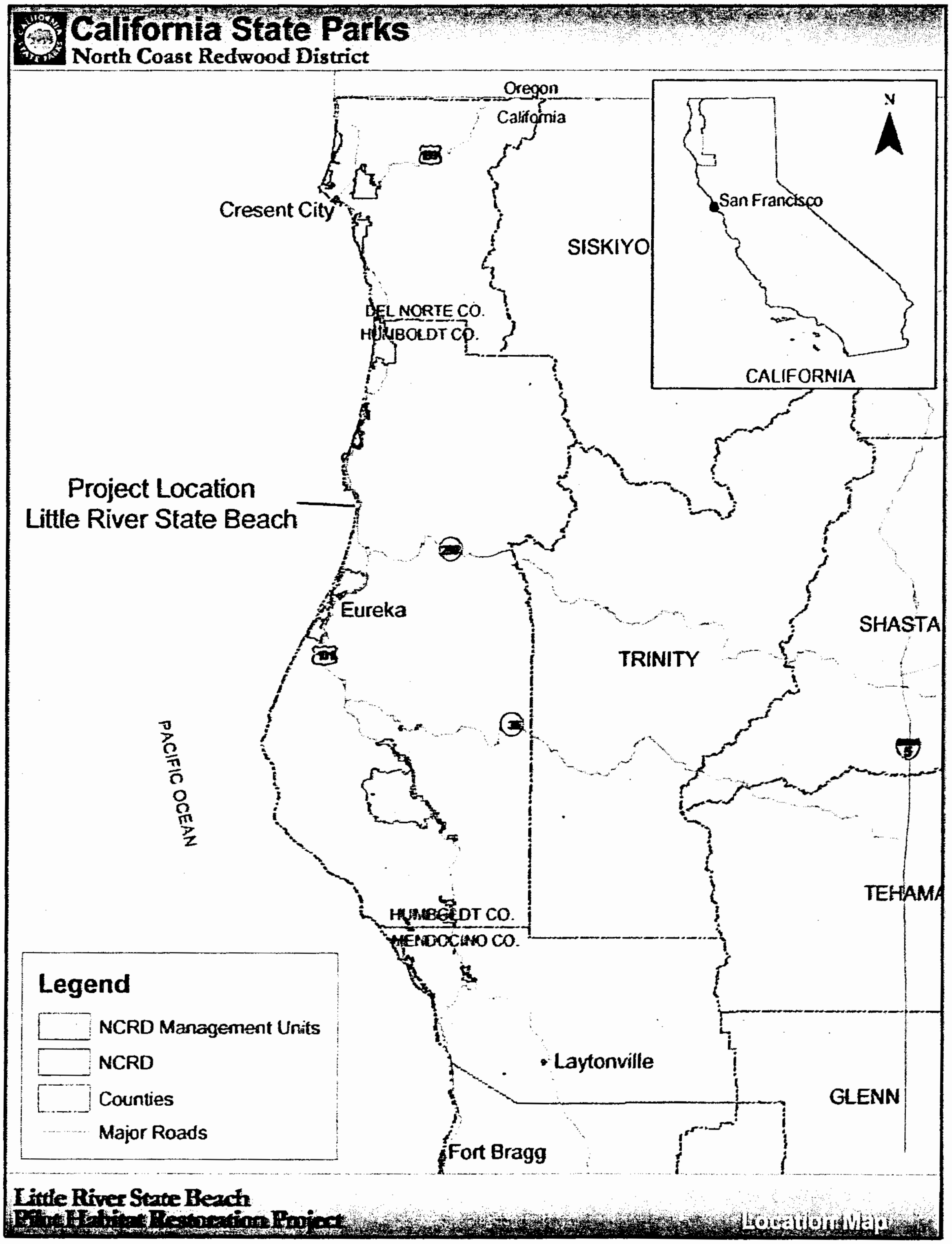
INTRODUCTION

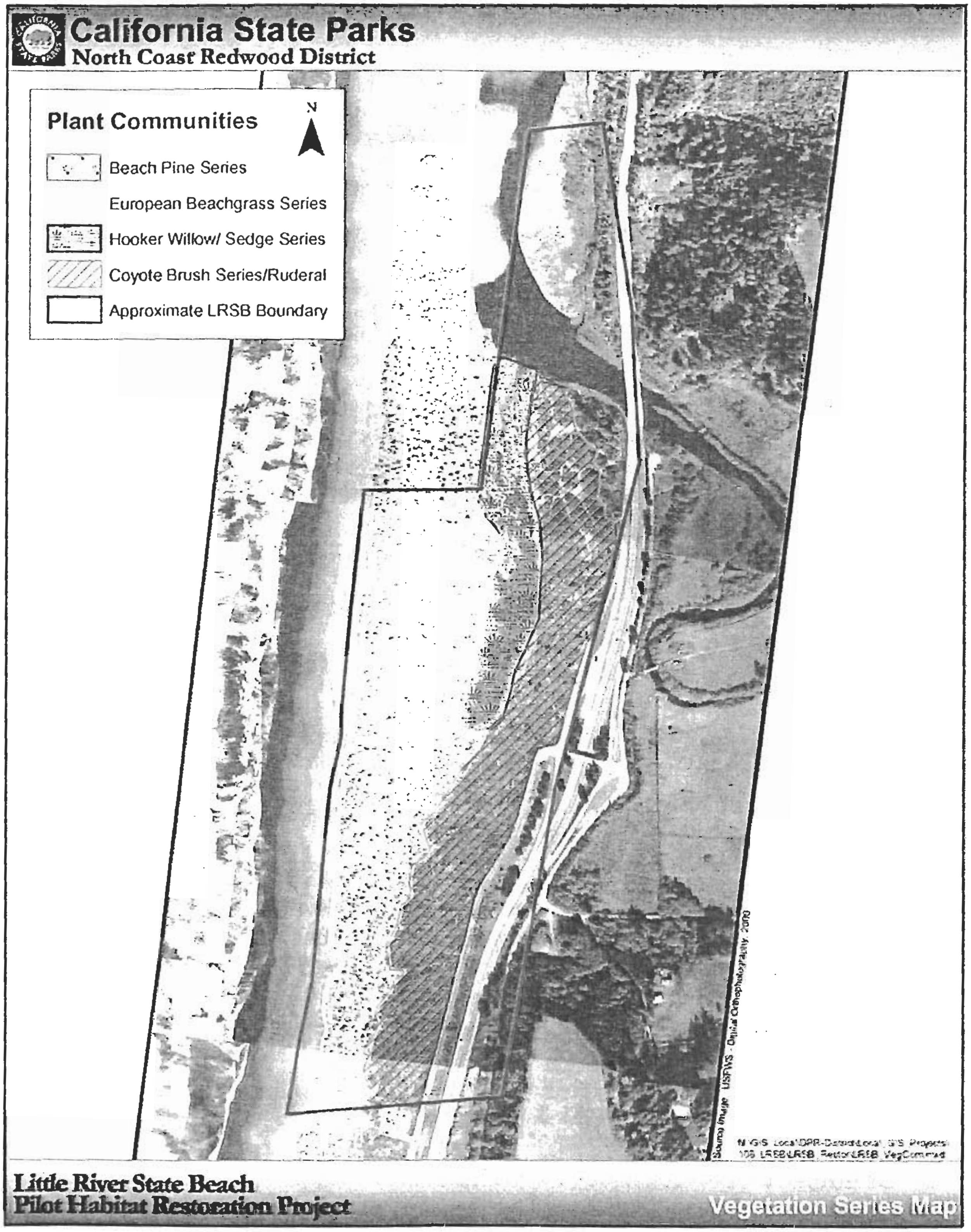
The North Coast Redwoods District (NRCD) has proposed restoration of the Little River State Beach (Figure 1) ecosystem, largely through the mechanical removal of exotic vegetation (primarily *Ammophila arenaria,* hereinafter referred to as *Ammophila*). Potential issues surrounding the physical aspects of the project include blowing sand inundation of nearby public infrastructure, road corridors and wetlands, increased vulnerability of the infrastructure to oceanic hazards that might result from removal or changes in existing dune barriers, and estimation of restoration technique that would most rapidly and accurately mimic natural physical processes. The early conceptual vision for the project included mechanical removal of all exotic vegetation across the width of the beach; this design would have increased exposure of the nearby infrastructure to sand movement and oceanic hazards. As a result it was imperative to have some understanding of the physical processes operating on the beach. Following the earliest design proposals and since the initial monitoring period for this project new designs have been proposed that will retain most of the backdune topography and native vegetation (e.g., coyote brush and beach pine series, Figure 2). The modified conceptual design should decrease the potential exposure of the infrastructure (compared to initial proposals) though this study remains important to assess and document rates of change that could occur from the project and to provide information to fine tune the final conceptual design.

The NCRD initiated a pilot project for removing *Ammophila arenaria* with heavy equipment during the late winter of 2004-2005. The pilot project had many facets for analysis; this report focuses on the physical changes that resulted from the pilot project. The general physical setting and conceptual physical hazards associated with the site was described by Vaughan and Fiori (2004).

It should be noted that this study captures only one year of data in a very dynamic geologic setting. The study period captured a winter with above normal rainfall (~150%) and there was large surf that challenged the restoration plots; average wind frequency and velocity over the project period was slightly below normal. We believe that the data reflects a period within an "average" range of expected climatic conditions and can be used to extrapolate current "average" conditions over the next several years.

We strongly caution the reader that extreme oceanic or tectonic events could affect these results and that climate models indicate both warming and more precipitation over the next 80 years in northwestern California (Kuepppers et al., 2005). Climate change could affect vegetative response and other parameters that could influence the average trends predicted by this analysis (we factor some of these items into overall risk associated with the project). Though we are not climatologists we note that the explosion of *Ammophila* on North Coast beaches has occurred during a period global climatologists describe as the warmest in at least 400 years, even though *Ammophila* has persisted for over a century on some North Coast beaches (however, we did not investigate specific North Coast climate trends over the previous century).


California State Parks
North Coast Redwood District
Oregon
California
N
San Francisco
CALIFORNIA
Cresent City
SISKIYO
DEL NORTE CO.
HUMBOLDT CO.
Project Location
Little River State Beach
Eureka
SHASTA
TRINITY
PACIFIC OCEAN
TEHAMA
HUMBOLDT CO.
MENDOCINO CO.
Legend
NCRD Management Units
NCRD
Counties
Major Roads
Laytonville
GLENN
Fort Bragg
Little River State Beach
Pilot Habitat Restoration Project
Location Map


California State Parks
North Coast Redwood District
Plant Communities
N
Beach Pine Series
European Beachgrass Series
Hooker Willow/ Sedge Series
Coyote Brush Series/Ruderal
Approximate LRSB Boundary
Little River State Beach
Pilot Habitat Restoration Project
Vegetation Series Map

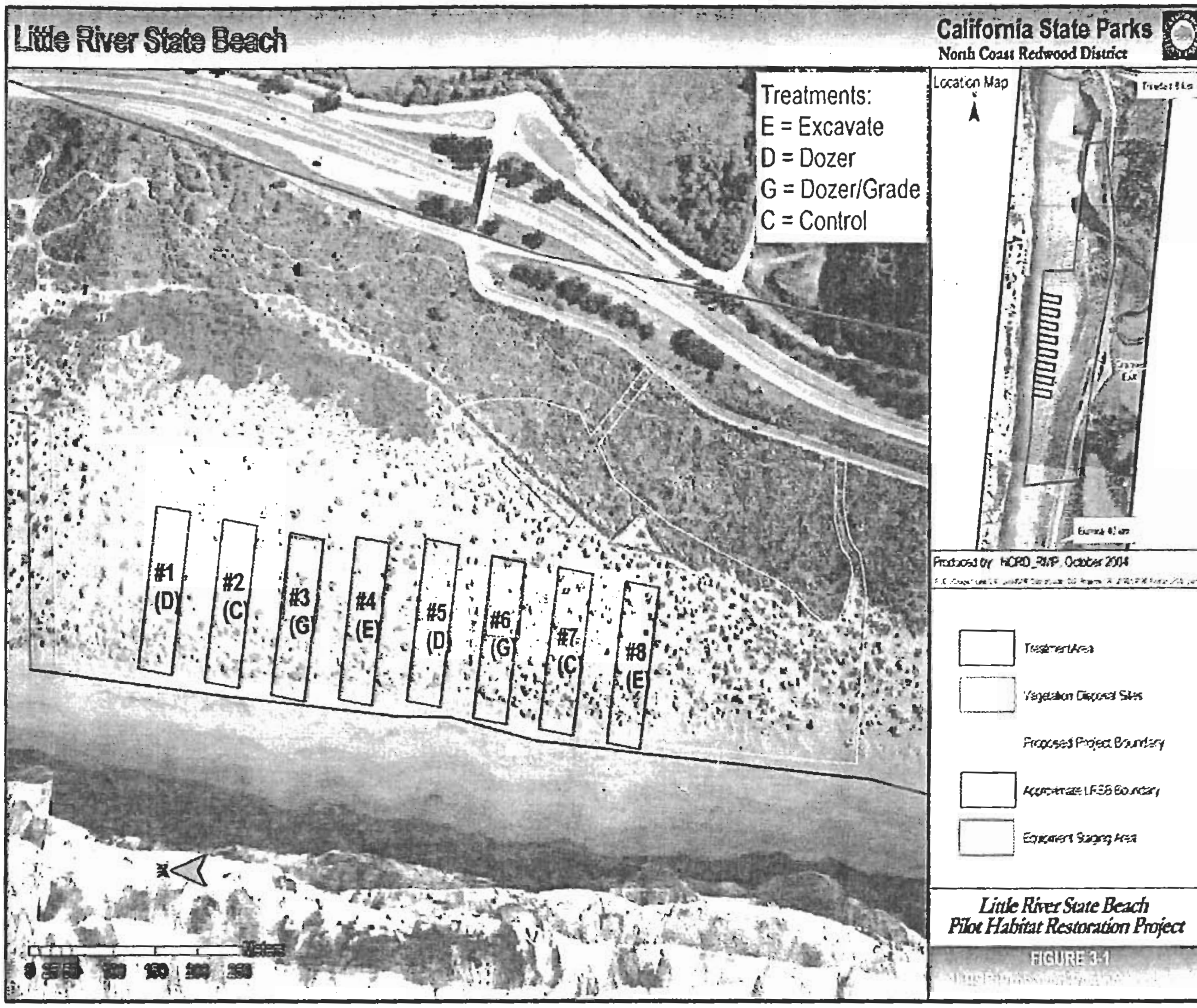
METHODS

AEOLIAN EFFECTS

Because there was little empirical data for assessing the change that might result from the mechanical treatments in this particular setting, and to diminish risk during the early analysis phase, sites were selected that were comparatively removed from existing infrastructure. A total of eight restoration plots in the nearshore dunes were developed, two each for three mechanical treatment methods (Dozer, Excavator, and Grade) and two untreated control plots (Figure 3). The 150 meter by 40 meter (492 feet by 131 feet) rectangular plots were oriented so that their long axes (roughly east-west) were roughly perpendicular to the surf and oblique to the prevailing wind direction (roughly N44W).

The Grade treatments employed a dozer to remove *Ammophila* and grade the foredunes to an approximate 3 percent slope, smoothing the foredune sand landward until the sand supply was exhausted. This resulted in a shore parallel break-in-slope in the middle of the plot. The deflation planes, which occur approximately in the eastern two-thirds of the plot, were flattened so that it virtually had not relief. For the Dozer method a dozer with a brush rake attachment was used to remove *Ammophila* while attempting to retain the existing macro topography to the maximum extent possible. Similarly, for the Excavator method an excavator was employed to pluck *Ammophila* from the dunes while attempting to maintain the existing macro topography. In both the Dozer and the Excavator treatment plots, dozers were used to create two blow outs per plot in the foredune. Each blow out was approximately 3 to 7 meters (10 to 23 feet) wide and slightly above grade. The intent of the blow outs was to mimic natural foredune conditions.

Two disposal methods were originally proposed in the pilot restoration plan, one which involved the removal of *Ammophila* to an off-site facility and a second that involved on-site disposal. The off-site disposal proved to be infeasible due to the inability to separate the *Ammophila* from the sand. The on-site disposal method originally consisted of three disposal sites that were identified within the project area where the *Ammophila* would be buried a minimum of about 1 meter (3.3 feet) under clean sand. Two of these disposal sites were within the Grade treatment plots just behind the foredune. Here, the *Ammophila* that was removed from the site was buried up to 2 meters (6.6 feet) deep within the plot before final grading. The third burial site was located in the backdunes; however, due to a high water table sufficient depth could not be obtained in the disposal pit. Therefore a third method was employed where the *Ammophila* and sand were pushed through the back (east end) of the plots by a dozer and integrated into existing dune ridges outside of the plots. The piled vegetation was mixed with sand and masticated during transport; this mixed pile visually appeared to have little change in topographic form over the monitoring period. From this, and its



generally downwind location, we conclude that the organic matter acted as a mulch to help arrest this potential sand source and thus it did not have a significant impact on the plots.

We used a TOPCON GTS-212 electronic total station to measure elevation data across the eight plots shortly after the mechanical treatments. In general, staff measured visually significant breaks-in-slope that exceeded 0.3 to 0.6 meters (1 to 2 feet) along distinguishable dune forms. Sufficient data was collected at interdune areas to demonstrate the general character of the landform and to demonstrate that these areas had been considered in the mapping effort. We collected data from the entire plot and generally in a perimeter about 10 meters (~30 feet) outside of the plot, as we expected some change outside of the plots as sand escaped the plot in response to the vegetation removal.

There were three periods of detailed topographic survey. The first survey occurred as soon as practicable after the heavy equipment treatments (late winter of

2004-2005) to provide baseline data. The second survey, in the fall of 2005, captured changes following the dominant period for prevailing northwesterly winds and before winter storms might affect the sand balance in the plots. The third survey, in the late winter and early spring of 2005-2006, provided data for an annual comparison. All data were referenced to known temporary benchmarks on the County road and tied into a permanent benchmark on the Highway 101 bridge across Little River.

We initially had a crew of two and sometimes three resources staff to complete the field surveys. The late winter 2004-2005 and fall 2005 survey crews had at least one member that had experience on three to four previous survey projects. The late winter 2005-2006 survey generally had no highly experienced staff members, though the survey crew was trained in the data collection techniques. Due to staffing shortages some of the data collection occurred over a few weeks for each survey interval. Therefore the comparative response intervals for the individual plots are not identical. We regard this difference to be insignificant in light of natural variability affecting the project.

Because of data collection and possibly some instrumentation error, some of the raw data were rotated from their true position; these errors were rectified with a generally high degree of confidence using detailed field notes during the processing phase of the analysis. The data from each period of survey were modeled using a TIN and kriging to capture the topographic forms and to extrapolate the data to areas with comparatively less coverage. The elevations between various periods of survey were compared to demonstrate areas of change over the period in question. The tolerance for the comparisons were set at 0.25 meters (0.82 feet), indicating that areas with less than this amount of change would display no change, which is reasonable given the tolerance on the data collection.

We also assessed aerial photography including newly discovered aerial photography obtained in 1988, just as the most modern *Ammophila* field began to take hold in the embryo dunes seaward from the coastal scrub vegetation. We also measured varves (individual growth layers of sand [assumed to be the equivalent of annual growth rings on a tree]) observed in the foredunes from mechanical cuts in the treatment plots to help corroborate the numerical analysis from the survey data.

Using tape and clinometer measuring techniques we developed a representative topographic profile across a prominent linear dune ridge that postdated the 1988 aerial photography for comparison with the more detailed information developed during plot measurements. We tape measured the maximum amount of wind blown sand movement observed in a dune form to estimate a maximum movement rate from the plots. We visually compared the results of our modeled topographic change surveys to actual field conditions and visually re-evaluated the changes over the last few years on the beach below the vista point at the south end of Clam Beach County Park.

SURF EFFECTS

We estimated wave run-up into the plots over the project period by examining the extent of logs, sticks and other beach debris that clearly had an oceanic origin and that were deposited over the initially debris limited plots. We visited the site shortly after a known period of wave run-up challenged the plots to observe the extent of continuous soil moisture within the plots that could only be attributed to wave run-up. We also visually monitored the plots during one of the major winter storms of the winter of 2005-2006.

SETTING AND ASSUMPTIONS

The eight plots are located in the nearshore dunes (consisting of the foredune and deflation plain) in the northern two-thirds of Little River State Beach, south from Little River. The volumetric comparisons focused on the four northernmost plots, one each for the three mechanical treatment styles and one untreated control plot. The most deflated portion of the eight plots (eastern half to quarter of the plots) typically had some quantity of water during rainy periods. The persistence of the water and its areal extent within the plots generally increased to the north. Soil moisture can inhibit wind blown sand movement (Gill, 1996). While this factor may have affected the results, our visual estimation of the water extent and review of monitoring photos from the winter period suggests that soil moisture differences did not substantially affect the aeolian results for the four northernmost plots. Our field observations of flow and visual assessment of the areas of change shown by the results (subsequent section) also suggest that there is an element of fluvial erosion of the sand on the east end of the plots that retained some component of their original topography. This should be considered in the overall analysis to estimate transport rates from the foredune to the backdunes; however, for comparative purposes of the treatment styles we assumed fluvial erosion to be equivalent at the measured plots (however, note that the grade plot did not have significant relief at its east end).

We also assumed that the critical fetch required to generate sand movement from the beach and into the foredune area and the prevailing winds were approximately equivalent (N44W) for the northernmost plots (there is a slight, progressively westerly swing in the prevailing wind going south along the beach due to the diminishing effect of Trinidad Head). Because there is a 40 meter (131 foot) wide strip of semi-continuous *Ammophila* between each of the treatment plots we also assumed that sand blown out of the plots would be captured by the vegetation before reaching the adjacent plot over the life of the monitoring period. We also assumed that volumetric change over the plots reflects roughly horizontal transport of sand in or out of the plot and does not reflect vertical consolidation of the sand over the monitoring period. This is a conservative assumption in that it will tend to maximize the estimated rate of sand transport, which is important for assessing the risk to infrastructure.

The distance between the foredune and the surf zone decreases somewhat to the south, making these sites more amenable to assessment of surf effects. Assessment of surf effects is more important in the southern part of the project area because of the lesser distance from the County road and paved parking lot to the wave slope.

RESULTS

PLOT CHANGES

The volumetric changes for each of the four plots revealed some mildly surprising results (Table 1). For example, the control plot actually had a decrease in sand volume over the approximately one year monitoring period (-0.03 $meters^3/meters^2/year$ [$m^3/m^2/yr$]). The grade plot (0.04 $m^3/m^2/yr$) and dozer (0.05 $m^3/m^2/yr$) treatment plots had similar flux, while the excavator plot, which retained the most topography, had more than double the flux rate of the other plots (0.11 $m^3/m^2/yr$).

AIR PHOTO OBSERVATIONS

We examined rectified aerial photography from 1974 and a newly-discovered, enlarged print aerial photograph, from 1988, of the project area Figure 4. We also compared the 1988 photography with photography taken in 2000 (the year 2000 example of aerial photography is not shown but photographs of slightly later and earlier vintage are depicted on figure 4). This examination placed the 1974 vegetated dune extent slightly west from the current major wetland area (no clear major wetland area existed at that time). By 1988 the vegetated dunes had retreated slightly east from the current primary backdune ridge. The 1988 photography revealed a sheet of embryo dunes that extended from the wave slope to the area occupied by the current major wetland; a few isolated mats of dune vegetation extended across the beach, with slightly greater concentrations of scattered dune vegetation within the east side of the embryo dune complex. The major wetland still had not developed at its current location in 1988. Comparison of the 1974 and 1988 photography showed that the somewhat stable vegetated dunes (vegetation type not identified) extended about 100 meters (~330 feet) farther seaward in 1974, indicating that this vegetation was eroded by surf attack and/or consumed or buried by a pulse of sand during this period. From this comparison it appeared that the beach prograded westward (widened) about 120 meters (~395 feet) between 1974 and 1988 (8.6 meters [~28 feet] per year).

The 2000 photography revealed that the embryo dunes observed in 1988 had been replaced with a semi-continuous sequence of vegetated dunes and locally

Table 1. Treatment method calculations.

Treatment style/plot #	Measured flux ($m^3/m^2/yr$)	Adjusted flux [1] (A) ($m^2/m/yr$)	Target storage compartment (central or south) area [2] (B) (m^2/m)	Time to fill one target compart-ment at flux rate - (B/A=C)) (yrs)	# of plot boxes (D) (fore dune to target)	Profile volume source - time to fill (CxD= E) (yrs)	Source volume adjust-ment [3] (Target area to north/tar-get area) (F)	Prevailing wind volume source - time to fill (ExF =G) (yrs)	Range for filling (E to G)(yrs) Rounded to nearest 5 yrs
Dozer plus excavator (1)	0.05	0.08	Central 1.95	24.4	4.5	109.8	.96	105.4	105-110
Dozer plus excavator (1)	0.05	0.08	South 0.94	11.8	2	23.6	2.07	48.9	25-50
Grade (3)	0.04	0.07	Central 1.95	27.9	4.5	125.6	.96	120.6	120-125
Grade (3)	0.04	0.07	South 0.94	13.4	2	26.8	2.07	55.5	25-55
Excavator (4)	0.11	0.14	Central 1.95	13.9	4.5	62.6	.96	60.1	60-65
Excavator (4)	0.11	0.14	South 0.94	6.7	2	13.4	2.07	27.7	15-30

1) Measured flux less flux within control plot
2) Derived from Figure 3 in Vaughan and Fiori, 2004
3) Based on orientation of prevailing wind with respect to profile and target location.

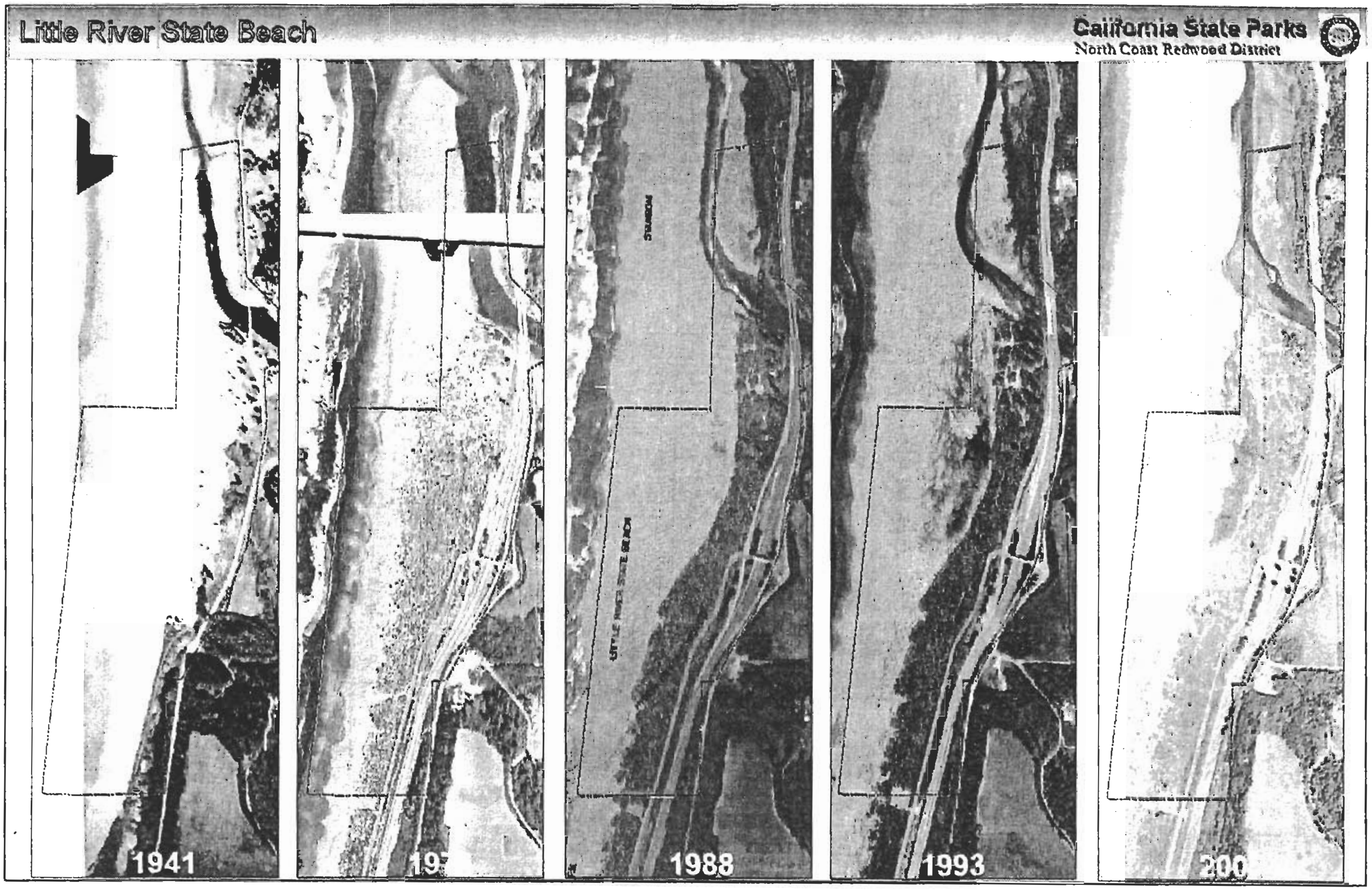


Figure 4. Sequential aerial photography at Little River State Beach (the red line delineates the property boundary).

deflated areas. A distinct backdune ridge near the eastern edge of the 1988 embryo dune sequence had developed, as well as the major wetland fronting the backdune ridge. The densely vegetated primary backdune ridge extended about 30 meters (~100 feet) seaward from the eastern edge of the active embryo dune sequence observed in 1988. By 2000 a foredune had also developed about 275 meters (~900 feet) seaward from the west edge of the current wetland. We estimate that the beach/dune complex prograded about 65 meters (~215 feet) between 1988 and 2000 (5.4 meters [~18 feet] per year). Between 1974 and 2000 the total progradation was about 185 meters, yielding a rate of about 7.1 meters (~23.3 feet) per year.

As part of the preceding analysis we measured the distance from a fixed location (the Crannell overpass over Highway 101) to the foam line observed in the surf on each air photo. While the measurement technique itself was consistent, the location of the foam line is dependent on many variables, such as wave energy, shape of the beach at the time of the photo, and tides, in addition to simple measurement error. As such the analysis should be viewed as a first approximation of measurable change. We therefore reviewed a more rigorous analysis of the entire California coastline by the United States Geological Survey (Hapke et al., 2006). This study examined both long term (mid-1800's to 2000) and short term (about 1970 to 2000) rates of coastal change, using rectified historical maps, air photos, and LiDAR. Hapke et al. developed an algorithm to examine error caused by the confounding factors in comparing measurements from various time periods, such as tides. Their analysis yielded a long term rate of accretion at Little River State Beach of about 2.5 meters per year and a short term rate of about 4.7 meters per year. They also estimated a regional measurement error of about 0.4 meter per year from this analysis. The 4.7 meters per year estimate is substantially less than our single point of reference for the entire period of air photo analysis (1974 to 2000, 7.1 meters per year) but comparable to our measured rate from 1988 to 2000 (5.4 meters per year). However, they also recognized that local error could be significantly greater than their regional estimate, particularly along beaches with gentle slopes, like Little River. Because of the rigor of their analysis the progradation rates proposed by the USGS should be used for initial reference; however, future monitoring should consider that local error may be high at this location and that shorter term accretion rates in the 5 to 7 meter per year range may be reasonable. Our air photo analysis also is consistent with another study at Gold Bluffs Beach where the rate was comparatively higher from the mid-1970's to the late 1980's and has since slowed, albeit at a still high rate of accretion (Vaughan, 2006).

Foredune Varve Accumulation

Observation of the beach below the viewpoint at the south end of Clam Beach County Park in 2006 revealed a fairly dense network of *Ammophila* had reinvaded a nearly bare beach and embryo dune complex documented by 2001 aerial photography. While the recolonized *Ammophila* had not yet reorganized into a distinct foredune, it was trapping sand that locally had some aspects of an incipient foredune. This data supports the inference that *Ammophila* can begin having a significant effect on sand movement within about five years. State Park Environmental Scientist Amber Transou reported no *Ammophila* below the viewpoint about three years ago (personal communication, 2006), indicating that *Ammophila* can have an effect on sand transport within three years of sprouting. Transou's more limiting observation is likely more accurate.

In early 2005 we counted several distinct layers in representative mechanical cuts through the foredunes. Measurement of dune crest elevations on our three profile measurements near the plots (Vaughan and Fiori, 2004) revealed elevations of about 2.1, 3.2, and 4.2 meters (6.9, 10.5, and 13.8 feet), increasing northward (i.e., where the sand supply from Little River appears more accessible). We infer that each layer reflects an annual deposit of sand that was trapped during each *Ammophila* growth period. Generally, each of these layers had a thickness of about 0.1 to 0.2 meters (4 to 8 inches) in the middle of the treatment plots, the general vicinity of the dune crest measuring 3.2 meters (10.5 feet). Using the observed layer thickness range we find the following: the 2.1 meter (6.9 feet) dune could have formed in 10.5 to 21 years; the 3.2 meter (10.5 feet) dune could have formed in 16 to 32 years; and the 4.2 meter (13.8 feet) dune could have formed in 21 to 42 years. The 1988 air photo revealed no pronounced foredune; therefore the maximum age of the foredune is about 17 to 20 years (1988 to 2005, plus three years of incipient accumulation [using the vista point example]). All of the calculated rates for the development of each dune crest fall or nearly fall within the predicted range for foredune development calculated from the 1988 aerial photography limiting age and observations of *Ammophila* sprouts' effect on sand transport. More detailed investigation of each dune cut may have improved this age correlation at specific sites.

The primary backdune ridge crest, which post dates 1988 and is roughly coincident with the profile showing a foredune crest of about 3.2 meters (10.5 feet), had a measured elevation of about 3.3 meters (10.8 feet) in 2006. These data indicate a minimum vertical accumulation rate of 0.18 meters (0.6 foot) per year, within the range suggested by varve observation at the foredune, though clearly with a different sand source area (the nearshore dunes, rather than the beach).

Maximum Dune Front Migration

We measured one 0.9 to 1.5 meter (3.0 to 5.0 feet) thick dune lobe extending southeast from the grade plot as migrating a maximum of about 12.2 meters (40.0 feet) between February 2005 and July 2006, a maximum rate of about 0.75 meters (2.5 feet) per month. While this movement was the maximum observed in association with the heavy equipment work, it should be noted that the sand was over running areas that contained *Ammophila*, which could have retarded its migration.

Previous and Recent Beach Profile Work

As part of our earlier beach profile work we measured the amount of cut and fill that would result from restoring (i.e., flattening) the beach seaward from the more prominent back beach dune ridge (Vaughan and Fiori, 2004). This cross sectional profile had units of meters^2 to calculate area. We showed the area of fill that might result from sand blowing into the backdune area in units of meters^2/meter (m^2/m) for each of the three profiles to forecast the extent of dune burial in the backdune. This resulted in an estimated fill storage area of 0.94 m^2/m for the southernmost profile (by the parking lot), a fill storage area of 1.95 m^2/m for the central profile (which bisected restoration plot seven) and a fill storage area of 1.87 m^2/m for the northernmost profile (just north of restoration plot one). These profile results balance cutting from the nearshore dunes and filling (storage areas) in the backdunes within the plane of the profile, which is oriènted more westerly than the prevailing wind direction.

We also calculated a fill rate to create the backdune ridge that we measured in June 2006. We found a vertical varve accumulation rate of about 0.18 meters/year (~7 inches/year) at the crest of this dune (see foredune varve accumulation rate). We found this post-1988 dune had an area of 0.69 m^2/m or a maximum accumulation rate of about 0.04 m^2/m/yr over the last 18 years.

SURF OBSERVATIONS

The largest run-up reported during the project observation period occurred on March 9, 2005. This event was not associated with any particular storm observed on the coast, though-off shore storms and a relatively high tide (7.5 feet in Trinidad) may have accentuated the run-up. Run-up did not extend significantly past the eastern edge of the cuts in the foredune in any of the plots, except for plot four (excavator treatment), where the run-up extended nearly through the entire plot (about 115 meters [~375 feet] past the foredune). This site is in the middle of the treatment area and thus had an average distance from the wave slope (in comparison with the closer southern plots and the more removed northern plots).

ANALYSIS

AEOLIAN EFFECTS

The profile storage areas are oblique to the predicted sand sources. Because the Stanson property lies to the northwest, the receiving area at the northernmost profile will not be greatly affected by removal of vegetation on State Park land. Thus we used the storage areas at the central profile and the southernmost profile, in combination with the flux rate from the three treatments and the travel distance from the source areas to their targets, to estimate how long it would take to fill the potential storage areas. To facilitate comparison between a volume and areal measurement we assumed that the plots had an equal thickness of change over the entire plot (this is not accurate over the shorter duration of this monitoring period but is more accurate over the longer term and in the face of a uniform treatment style over the entire beach). Because we assume unity (or one) as the area of the equivalent thickness change in the plots we can convert our flux rate (in m^3/m^2/yr) to m^2/m (the storage area metric units) to see how long it would take to fill the storage areas. Our observation of the topography at the backdune ridge indicates that the topography in the third dimension has some uniformity, supporting this assumption. The three-dimensional storage compartments extend into the area behind the primary backdune ridge but are still generally removed from infrastructure, with the exception of the southernmost storage compartment. The centerline of any storage compartment is the storage (i.e., fill) area on the relevant profile line (see Figure 3 in Vaughan and Fiori, 2004). The compartment's lateral extent is approximately defined by the mid-point between the profiles as observed in plan view (see Figure 2 in Vaughan and Fiori, 2004), although the sand source areas are progressively farther north from the respective profiles as one travels seaward (because of prevailing winds).

For this exercise we took the three flux rates and assumed that a restoration area was directly upwind from its target, in this case the central and southern compartments. We then measured the distance from potential restoration areas to their respective targets, to calculate how long it might take to fill the storage areas if the beach was relatively unvegetated. We have estimated a range of times for filling each of the two analyzed storage compartments to account for the greater potential volume of sand the profile data shows lies northwest from the profiles, rather than directly on the profile line. This analysis addresses sand that was actually stored at the foredune, within the plots or seaward from the backdune ridge between 2004 and 2006. Sand that is delivered to the beach in the future will likely continue to accumulate in the vicinity of the storage compartments – this is addressed in a later section.

We assume that the losses in the control plot largely result from fluvial erosion and possibly greater deflation at the back edge of the plot (these losses may have actually been greater as the control plot results integrate gains in the foredune but to simplify our analysis we have used the overall control plot result). Although we assumed fluvial erosion over the monitoring period to be equivalent for all of the measured plots, we anticipate that fluvial erosion and deflation will diminish in the dune swales as embryo dunes develop after the treatments and begin to bury and smooth the topography (c.f., the 1988 air photo). Therefore, one other adjustment that we made was to subtract the losses observed in the control plot from the other treatment methods to determine a final flux rate (e.g., the dozer plot [0.05 $m^3/m^2/yr$] minus the control plot [-0.03 $m^3/m^2/yr$] = 0.08 $m^3/m^2/yr$). This seems reasonable as the maximum accumulation rate for the primary backdune ridge that developed since 1988, largely from deflation of the dune swales, is 0.04 $m^3/m^2/yr$. We divided each respective storage area by the flux rate for each treatment style (e.g., 0.94 m^2/m [for the southern storage profile] divided by 0.08 $m^2/m/yr$ [for dozer] = 11.8 years) to determine how long it would take for the measured rate in the cross sectional line of a plot to fill the storage areas identified along the previously obtained long profiles (Vaughan and Fiori, 2004) – because we assumed uniformity in the third dimension, this also applies to volumetric calculations. We then measured the number of plots (i.e., graphic measurement of the number of plot outlines) that would need to be filled between the storage area and the foredune in the direction of the prevailing wind (e.g., 2 for the southern profile storage area). This number was multiplied by the duration of filling for one storage profile (e.g., 11.8 years x 2 = 23.6) to calculate the time needed to transfer the sand from the foredune and to fill the target storage area with the estimated source volume within the plane of the profile. To provide a range to account for the increasing sand volume to the north we multiplied that result by the ratio of the calculated storage area of the profile to the north to the calculated storage area within the target profile (e.g., central storage [[1.95 m^2/m] divided by southern storage [.94 m^2/m]] x 23.6 years = 48.9 years – say 50 years). Note that this final calculation will result in a substantial change in elevation in the stored material when compared to the storage areas shown in our earlier report (Vaughan and Fiori, 2004), being much higher in the southern storage area and slightly lower than shown for the central profile (we have disregarded the northern profile storage area because there will not be much treatment area on State Parks land northwest from that profile). The stability of the higher southern profile storage area at higher elevations may be difficult to maintain at substantially higher elevations without intervention (see following discussion).

Using these criteria we find the following durations will be needed to fill the central storage area (by treatment technique): dozer -105 to 110 years; grade - 120 to 125 years; and excavator - 60 to 65 years. The southern storage area results show: dozer – 25 to 50 years; grade - 25 to 55 years; and excavator - 15 to 30 years. Final results for all calculations were rounded to the nearest five years.

To help constrain a more extreme case we calculated the travel time for the largest, clearly visible dune front that resulted from the treatments (grade plot, ~0.75 meters/month [~9 meters/year]; we visually estimated the dune front to measure ~one m^2/m). Because the accumulation appeared to be related to its proximity to the wave slope and currently active embryo dunes we used the area just inside the southernmost cut in the grade plot as the source location for this material. Other than this exception we generally used the same assumptions as used for the flux rate in terms of travel to and filling of storage areas. We did not use a ratio comparison of the storage areas because our estimation of the dune front area is based on direct observation. For this extreme example the sand from the grade plot would fill the southern compartment in about 25 years and the central compartment in about 90 years. Substantial filling of the respective compartments from foredune sources would begin in about 10 to 15 years and 30 years.

SURF RUN-UP

The plot number four treatment method (excavator) resulted in a slot in the foredune; this would tend to provide more impetus to surf that broached the slot. Retention of differentially lower topography east from the foredune likely encouraged surf that crossed the foredune to retain momentum and travel farther into the plot. If similar magnitude run up occurred in the southernmost plot (the narrower part of the beach) it would have fallen about 30 meters (100 feet) short of the backdune ridge.

DISCUSSION

Our estimates are based on simple volumetric calculations using empirical data from a one-plus year study. We have not estimated the frictional forces that might retard the migration rate while the sand over runs the existing coastal shrub vegetation, nor the potential release of sand that could occur if the coastal shrub was rapidly consumed. We imagine that there are other variables that could and will affect the final migration rate. However, the accumulation rates that we have observed and measured since the 1974 aerial photography are generally supportive of our findings.

Our visual observations of the measured plots and the graphic results of the changes indicate that unvegetated, higher topographic points received substantial deflation. We infer that this helps explain the doubling of the flux rate in the excavator treatment plot (attempted to retain existing topography), in comparison with the other two treatments, which either smoothed out or had more effect on the existing topography.

We walked through the target areas that might be affected by sand release and observed that the primary backdune ridge has a windward slope of about 24 degrees.

Slopes of 20 degrees or more are likely to intercept all but the finest sand (White and Tsoar, 1998). The slope will likely be able to maintain that angle either because of its currently dense cover of *Ammophila* or its proposed future cover of native vegetation. This dune ridge is more discontinuous and lower to the south. It is likely that some sand will be able to scale the ridge or travel through gaps in the dune more easily in this vicinity. Ideally, the sand would be stored as far from the infrastructure as reasonably possible to minimize the risk for offsite effects and possibly to minimize the impact to the existing coastal scrub vegetation. At the same time storing the sand more seaward will subject it more frequently to extreme oceanic events. However, we note that the back beach dune ridge that post dates 1988 actually prograded seaward as it was colonized by *Ammophila* and coyote brush and did not appear to be directly eroded by surf, at least recently.

One way to initially protect the coastal scrub, and possibly new plantings closer to the infrastructure, from the first pulses of sand would be to pile the masticated sand and *Ammophila* into the lower gaps in the prominent dune ridge. This technique was used successfully during the pilot project. This technique would help provide disposal, provide a mulch to help bind the relocated sand and provide an initial protective barrier to surf attack after the beach is lowered. This barrier is sufficiently removed from the wave slope so that attack will be sporadic (once the beach is opened up the largest run-up event we observed during the monitoring period would likely fall short of or barely reach such a barrier at the south end of the beach). Using the example of the backdune ridge that post dates 1988, this type of a barrier would tend to build seaward and initially diminish the potential for sand to over run the existing dune vegetation.

Based on our flux calculations the central compartment appears to have a very low risk for sand to migrate to areas of sensitive infrastructure within the effective design life of most engineered structures (50 years for most buildings – a road corridor requires some additional consideration however). The southern compartment has a moderate potential for sand to fill it within 50 years (depending on treatment style). Using maximum travel rates observed during the monitoring the compartments could fill within about half of the time reported by the flux rates – we do not consider this to be a representative measurement of how the site will initially respond over time. However, this rate should be considered in the timing for having some robust vegetation or barriers on site designed to begin intercepting more substantial quantities of wind blown sand (~10 to 15 years as a worst case under "average" conditions).

Our calculations mainly address sand that is currently in the nearshore dunes (between the foredune and primary backdune ridge). Sand accretion on the beach appears to have increased significantly after the 1964 flood. The average rate of accretion has slowed slightly in the last couple of decades, consistent with the pattern observed at the south end of Gold Bluffs Beach (Vaughan, 2006) though at lesser magnitude and with more recent reductions in accretion rate at Gold Bluffs Beach. Assuming a relative reduction in the accretion rate pattern persists, the aeolian accumulation rate will also decay over time. However, after sand from the treatment area is stored, additional sand will likely continue to fill the storage compartments as the beach continues to build seaward. Ideally, new and successive primary backdune ridges will migrate seaward with the accretion, thus creating new storage areas.

Evidence of this pattern was observed at the South Spit, where there are multiple backdune ridges.

In the event sand does migrate past the primary backdune ridge, the current restoration plan calls for creation of dune swales, which will include the planting of willows on the seaward side of the swales on the south end of the project area. These dune swales are largely targeted toward protecting the less elevated portion of the paved County road. This should help arrest sand that migrates beyond any natural or constructed barriers – it will be important that such barriers are functional if or when such migration begins. Monitoring of the effectiveness and adaptation of techniques to arrest sand in the future may be required as our calculations show that the southern backdunes will likely grow higher than the road (see earlier discussion regarding field height doubling that of our earlier profile estimates).

Our calculations reveal that it will take more than a decade, and likely a few decades, for the sand to have a substantial effect on the sand storage compartments. Because of the dynamic nature of the beach there is a moderate potential for either coastal flooding, tsunami, uplift or subsidence to overwhelm or alter the effects of this project over an assumed 50 year design life. This could result in either a positive or negative effect depending on the phenomenon being assessed. For example, we expect that a 100 year coastal flood would have substantial impact on the beach form (Vaughan and Fiori, 2004). The probability of a Cascadia subduction zone earthquake capable of producing a tsunami or affecting the elevation of the beach is greater than 35% over an estimated 50 year design life for the storage compartments (c.f., Waethrich, 1994). Therefore, while we regard this assessment important for assessing the offsite impacts of the project under "average" conditions, we also judge that this project has at least a moderate potential to take a different "long-term" path. If backdune barriers are constructed or develop as discussed here, the risk for coastal flooding and tsunami effects on the east side of the property will be reduced, though the magnitude of such an event will influence the final outcome.

The southern end of the continuous wetland is within the target area for sand migration once the treatments are initiated. In light of the moderately high concentration of *Ammophila* immediately adjacent we estimate the southern end of the wetland could disappear in 10 to 20 years at predicted rates of sand movement.

CONCLUSIONS

1) The flux rate from the four northernmost restoration plots revealed a loss of sand in the control plot, roughly equivalent gains in the grade and dozer plots, and more than double the gain of the those two treatments within the excavator plot.
2) Depending on treatment style the central storage compartment will take between about 60 and 125 years to fill, while the southern storage compartment will fill in about 15 to 50 years. It should be assumed for vegetative design purposes (e.g., willows, etc.) that significant quantities of sand could reach the southern storage compartment in ~10 to 15 years, if a proposed barrier to inhibit migration proved ineffective.
3) There is a moderate probability for oceanic or tectonic influences to reorganize the beach, and thus the results of this analysis, over an assumed 50 year design life for the project.
4) Enhancement of the primary backdune ridge could help slow dune migration to the east side of the property. Enhancing the barrier at this location would also place it beyond the reach of more frequent oceanic events than the foredune, thus preserving its integrity for a longer period of time. Moreover, wave energy would be more dissipated at the primary backdune ridge than at the foredune; therefore its influence on defeating wave attack could be relatively greater.
5) It is highly probable that the surface expression of the southern end of the current wetlands emanating from Little River will disappear or be substantially altered in the next couple of decades as sand migrates in response to the treatments.

RECOMMENDATIONS

1) While there may be other considerations, from a geological perspective either a grade or dozer treatment should be used to keep the rate of sand movement in line with historical norms. This will allow for a greater margin of error in terms of adaptive management, if needed.
2) Gaps in the primary backdune ridge should be plugged with masticated *Ammophila* and sand and matched as well as possible to the existing topography. The ridge's windward face should be as close as possible to 20 degrees or more. The ridge should be vegetated as soon as practicable with appropriate species selected by a qualified biologist.

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GLOSSARY

Aeolian – Applied to the erosive action of the wind, and to deposits which are due to the transporting action of the wind (also eolian).

Flux Rates – The amount of change in flow (in this case, the flow of sand) over a specified area (in this case, a restoration plot) over a unit of time.

Storage Area – The area in the plane of the cross section profile that shows the amount of sand that would be deposited in the backdunes if all of the nearshore sand in the same profile migrated to that location.

Storage Compartment – The target area for migration of sand that could be released into the backdune from the nearshore dunes or the beach. This includes the areas north and south from any single cross section profile to a point equidistant between any two profiles. These compartments would have units of volume, as opposed to units of area.

Varves – Any sedimentary bed or lamination that is deposited within one year's time or a pair of contrasting laminae representing seasonal sedimentation within a single year.

EXHIBIT NO. 5
APPLICATION NO.
1-09-026 - CALIF. DEPT. OF PARKS & RECREATION
MEASURES PROPOSED TO PROTECT SENSITIVE SPECIES & CULTURAL RESOURCES (1 of 3)

Appendix F. Measure to Avoid Take of Sensitive Natural or Cu Resources

This refers to all listed and or sensitive species and culturally significant features.

WESTERN SNOWY PLOVER

- Western snowy plover mitigation measures will be applied whenever operations are occurring in the nearshore dune habitat.
- Permitted snowy plover monitors will survey areas that work will be conducted in each day prior to operation. Snowy plover monitors will be onsite for the entire duration of operational hours to ensure that there are no snowy plovers present within the established spatial buffer zone and that they have not moved on site. If snowy plovers are observed within the spatial buffer zone of project activities, an alternative area where snowy plovers are not present will be picked.
- All staff and activities will remain in delineated project area in which presence/absence surveys will be conducted.
- Heavy equipment operations will be conducted outside of the WSP breeding season between September 15th and March 1st. All operations will occur during daylight hours.
- During the non-breeding season, a 50 meter (164 feet) spatial buffer zone will be maintained between WSP and restoration/enhancement operations. If the WSP monitor determines that operations are resulting in a behavioral disturbance to WSP then operations will be moved far enough away so as to eliminate the disturbance to the plovers.
- During the breeding season, a 100 meter (330 feet) spatial buffer zone will be maintained between WSP and restoration/enhancement operations. If the WSP monitor determines that operations are resulting in a behavioral disturbance to WSP then operations will be moved far enough away so as to eliminate the disturbance to the plovers.
- All operations will occur during daylight hours.
- Vehicles driven on the beach will be limited to 10 mph, or the minimal speed required to prevent getting stuck in sand. Vehicles will remain on the wet sand until reaching the treatment area. All vehicles will be escorted by a permitted snowy plover biologist. A snowy plover monitor will walk in front of vehicles to and from the waveslope. This will be repeated in the afternoon when work is completed for the day. There will be no night driving or driving during periods of diminished visibility.
- Trash will be contained in predator-proof containers and transported off site at the end of each workday.
- Lunch and breaks will be taken at the work site to prevent workers from disturbing plovers.
- No dogs or other pets will accompany workers to the work site.
- Heavy equipment will be fueled at the start of every day at a predetermined location (western ¼ of the nearshore dunes). Fuel will be delivered via a 4x4

truck at the start of each workday, and be administered by a fuel dispenser held in the bed of the truck. The truck carrying the fuel dispenser will enter the beach at the Clam Beach County Park vehicle entrance or through the newly created access path through LRSB. A snowy plover monitor will walk in front of the vehicle from the waveslope to/from the western ¼ of the treatment area, where heavy equipment will be fueled.

- All staff and activities will remain in delineated project area in which presence/absence surveys will be conducted.
- Outreach will be conducted to explain the project and its benefits to plovers, other listed and rare species, and the native coastal dune ecosystem.

BOTANICAL

- Floristically appropriate surveys will be conducted prior to the initiation of project activities and shall be in conformance with DFG guidelines (CDFG 2008). If sensitive plant species are found, 5 m (16.5 ft) buffer will be allotted and flagged. Any removal efforts targeted within the protected buffer zone will be removed by hand.
- Heavy equipment will enter the project area through an existing trail from the Clam Beach frontage road to the foredune, where it will be stored at the interface of European beachgrass and Coyote brush plant series. Heavy equipment will remain onsite until the completion of each year's implementation phases, at which time that equipment will exit from where it came. Objects to obstruct the entrance to the path will be placed at the trailhead once heavy equipment moves through.
- Symbolic fencing will be erected around treated areas to avoid human disturbance of newly created habitat and reseeding efforts.
- Interpretive signs will be used on the symbolic fencing to inform the public of the restoration project and sensitive species. The signs will focus on the restoration project.
- A Hazardous Material Spill Contingency Plan and Safety Plan will be reviewed daily and kept onsite.

CULTURAL

- If it is determined the find indicates a sacred or religious site, the site will be avoided to the maximum extent practicable. Formal consultation with the State Historic Preservation Officer (SHPO) and review by the NAHC/tribal representatives will also occur as necessary to define additional site mitigation or future restrictions.
- Prior to operating in area(s) identified in the confidential 5024 document as potentially culturally sensitive, the project manager will contact the North Coast District Archaeologist at least two weeks prior to operations. The Archaeologist (or his designee) shall determine the boundaries of the sensitive area(s) and flag with black and yellow candy-stripe flagging. The Archaeologist will determine if a tribal monitor needs to be present during operations within these area(s). No

heavy equipment will be allowed within designated culturally sensitive area(s).

- In the event that human remains are discovered, work will cease immediately in the area of the find and the project manager/site supervisor will notify the appropriate DPR personnel. Any human remains and/or funerary objects will be left in place. The DPR Sector Superintendent (or authorized representative) will notify the Humboldt County Coroner, in accordance with §7050.5 of the California Health and Safety Code, and the Native American Heritage Commission (NAHC) will be notified within 24 hours of the discovery if the Coroner determines that the remains are Native American. The NAHC will designate the "Most Likely Descendent" (MLD) of the deceased Native American. The MLD will recommend an appropriate disposition of the remains. If a Native American monitor is on-site at the time of the discovery and that person has been designated the MLD by the NAHC, the monitor will make the recommendation of the appropriate disposition.
- If the coroner or a tribal representative determines that the remains represent Native American internment, the NAHC in Sacramento and/or tribe will be consulted to identify the Most Likely Descendent (MLD) and appropriate disposition of the remains. Work shall not resume in the area of the find until proper disposition is complete as part of PRC §5097.98. No human remains or funerary objects will be cleaned, photographed, analyzed, or removed from the site prior to determination.

LITERATURE CITED

California Department of Fish and Game. 2008. Natural Diversity Data Base. Sacramento California.