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Subject: Review of Vegetation Islands, Executive Summary, Oceano Dunes SVRA

Project Description: At the request of California State Parks (CSP), California Geological Survey (CGS) geologists examined twenty (20) vegetation islands located within and/or adjacent to the Oceano Dunes State Vehicular Recreation Area (ODSVRA) ride area, San Luis Obispo County (Figures 4 and B-1). Portions of some islands have been revegetated previously by CSP to improve wildlife habitat and the esthetic values of the SVRA. Some of these efforts have been successful, i.e., several of the islands have grown in size. Other islands have retreated in size and may be in danger of being obliterated by encroaching sand dunes. As part of this project, CGS was asked specifically by CSP to: (1) examine vegetation on the leading edges of the vegetation islands in regard to their shape, size, and geomorphology; (2) determine if any islands could be combined or eliminated in an effort to balance the need for wildlife habitat with demands for additional ride areas; and (3) determine how CXTs located near several of the islands can be better protected so they do not have to be moved as often. The vegetation islands examined in this study include:

Vegetation Islands – West to East, North to South

7.5 Reveg	Eucalyptus Tree
Moymell	Eucalyptus South
Worm Valley	Tabletop
Pavilion Hill	Pipeline
Barbeque Flats (BBQ Flats)	Maidenform Flats
BBQ Flats South	40-Acre Woods
Heather	Indian Midden
Acacia	Indian Midden South
Cottonwood	Boy Scout North
Eucalyptus North	Boy Scout Camp

Geologic Conditions: The ODSVRA is located at the northwestern end of the Santa Maria River valley within what is known as the Callender dune sheet or complex (Cooper, 1967; Hunt, 1993; Orme and Tchakerian, 1986; Figure 1). The dunes lie within the Santa Maria Basin, a generalized northwest-southeast synclinal trough, formed by a series of compressional and rotational movements along right-lateral strike-slip faults that began during mid-Miocene (10 to 15 million years ago; Hunt, 1993). The historically active (within 200 years) San Andreas fault lies approximately 50 miles east of the ODSVRA (Figure 2). Faults closest to the ODSVRA that have known displacement during Holocene time (200 to 10,000 years ago) include: the Hosgri fault zone, approximately 10 miles off-shore to the west-northwest, and the Oso fault, approximately 10 miles to the north (Jennings,1994; Figure 2). Other faults showing evidence of displacement during late Quaternary (10,000 to 700,000 years ago) include, but are not limited to: the Santa Maria River fault, which runs along the northeastern edge of the dune complex; the Oceano fault, which crosses the dunes in the vicinity of Big Twin and Celery Lakes; and the Casmaila fault, approximately 8 miles south of Oso Flaco Lake.

Continued uplift and subsidence within the basin during late Pleistocene time has resulted in a series of northwest-trending ridges and valleys, underlain by marine sediments of Tertiary and Cretaceous age, as well as several marine and alluvial terraces of late Pleistocene age (Behl, 2000; Cooper, 1967; Hunt, 1993; Worts, 1951). Orme and Tchakerian (1986) recognize four phases of dune formation overlying the terraces, ranging in age from mid-Pleistocene to Holocene. The oldest, mid-Pleistocene dunes (25,000 to 80,000 years old), occur inland on emerging terraces within the Nipoma Mesa (Figure 1). Late-Pleistocene (6,000-25,000 years old) dunes mantle the larger coastal inlands, while Late Holocene dunes (2,000 and 6,000 years old) include older surface aeolian sands laid down during the present interglacial period. In the ODSVRA, terrace deposits are largely concealed by a thick sequence of more recent Holocene beach and dune sands, 15 feet or greater, that began to develop about 2,000 years ago, during a period of relatively stable sea level, and continues to present. Outside the ODSVRA ride area, a series of shallow dune lakes forms along the eastern boundary of the Callender dune sheet near its junction with the older dune deposits of the Nipoma Mesa. Most of the lakes are closed depressions, some of which support marsh vegetation, and have varied in shape and size during the past 100 years in response to changes in local precipitation, sand encroachment, and human modification.

Although portions of the Callender dune sheet are old enough and stable enough to have formed a soil profile known as the Oakley sand, most of the ODSVRA lies within the youngest, westernmost and most active portion of the complex. Here, the most recently deposited dunes occur directly inland from the present shoreline. According to the USDA (1984, 2005a, 2005b), soils within the project area are predominantly Beaches (Unit 107) and Dune land (Unit 134), both of which have a permeability that is very rapid and an available water capacity that is very low. Although surface runoff is slow, the erosion hazard of Beaches is high or very high because of wind and wave action, and the hazard of Dune land soil blowing is very high. In most places, aeolian transport of the sand is ongoing and the dunes are actively migrating inland. Sand supplied to the coastal dunes comes from the flats and banks exposed at low water and from dry inland margins of the beach.

Previous studies of beach and dune sands near and within ODSVRA (Tresselt, 1960; Orme and Tchakerian, 1986) indicate most of the sands are subangular to angular in shape and vary in composition between 81 and 90 percent quartz, 9 to 15 percent feldspars, and 0.25 to 7 percent heavy minerals. An analysis of 45 sand samples collected from the vegetation islands for this project indicates the majority of the sands collected are relatively well-sorted and are comprised of 70 to 95 percent fine sands, less than 10 percent very fine sands, and less than 0.5 percent silt/clay (see Appendix B).

Dune Processes: Dunes within the ODSVRA lie in the general northwest-southeast direction of the underlying geologic structure and prevailing winds of the area. However, the formation of the dunes – longitudinal, transverse, crescent-shaped barchanoid, and/or parabolic (Figure 3) – depends on wind currents, sand grain size, and amount of vegetation present. The dune processes observed within the ODSVRA are similar to those observed in undisturbed portions of the ODSVRA and in other dune sheets and complexes to the south within the Santa Maria River Valley.

Where undisturbed, partially vegetated longitudinal-shaped foredunes (i.e., such as those at 7.5 Reveg) are located nearly perpendicular to the beach along the west side of the ODSVRA. Because windblown sand accumulates around obstructions of any size, small clumps of newly sprouted vegetation are enough to begin the process of sand accumulation. The sprouting of pioneer vegetation on open flat beaches often is the beginning of dune formation. Once the process has begun, it is self-reinforcing. Small dunes collect more sand and continue to grow until some threshold size, dependent upon local physical conditions, is reached (Bagnold, 1965; Hill, 1984; Hunt, 1993; Gallant, 1997; Pidwirny, 2006). The dunes grow in height as the vegetation expands. According to Hunt (1993), the introduction of non-native beach grasses, such as those on the western side of Pavilion Hill, can result in dune growth that is taller and steeper than those formed by native species because the ability for sand to bind in the non-native species is greater.

East of the foredunes, and within the open-ride areas west and east of the ODSVRA vegetation islands, a series of predominantly unvegetated transverse dunes runs nearly parallel to the coastline. Because bare sand is much more susceptible to being moved by the wind, the transverse dunes in the ODSVRA tend to migrate downwind (eastward) as sand is eroded from the windward (west) side of the dunes and is deposited on the leeward (east) side. The transverse dunes form several steep (60-62%), sometimes crescent-shaped barchanoid, slip faces up to 100 feet or more in height. In general, the windward side of the transverse and barchans dunes is less steep (generally 15-20%) than the leeward slip face. However, the length, width and height of barchans vary greatly, as do their rates of advancement. Studies by Bagnold (1965) indicate that smaller, or shrinking, dunes tend to move faster than those with higher slip faces, or those that are growing in size.

In the ODSVRA, where winds are seasonally up to 50 miles per hour or more, it appears that the smaller, more rapidly advancing dunes gradually encroach in an en echelon fashion onto the more gentle windward sides of the older larger dunes with higher slip faces. As they move eastward, sands in the smaller encroaching dunes travel up and over the higher slip faces, eventually adding height to the larger dunes as they move inland. According to Bowen and Inman (1966), the average rate of dune advancement in the ODSVRA is approximately 2 feet per year, although rates may vary locally. CGS's review of sequential aerial photographs (Appendix D) indicates average rates of dune advancement in the ODSVRA may be greater, i.e., ranging from 1 to 7 feet per year along slip faces on the western side of the vegetation islands, and 6 to 18 feet per year along transverse and barchanoid slip faces in the open sand sheets.

As the transverse and barchan dunes in the unvegetated areas of the ODSVRA migrate towards the vegetated islands, the relatively straight (N-S) dune ridge lines begin to bend and/or break up into separate barchan dunes. Where relatively high slip faces already exist along the western edge of a vegetated island, sand movement along the slip face of the encroaching dune generally slows down. Sand within the unimpeded portions of the encroaching dune, however, continues to move faster, forming longitudinal or lobate ridges that often wrap around the sides of the vegetated island. These side ridges commonly enclose small flat valleys, also known as hollows, coves, deflation bowls, and dune swales. The dune-related flats, where protected by high dune slip faces to the west, are generally vegetated and remain open to the east.

Within ODSVRA, vegetation on the east/southeast edges of several vegetation islands (i.e., Worm Valley, Cottonwood, Eucalyptus Tree) has expanded to the east/southeast at a rate of approximately 3 to 4 feet per year. Vegetation helps baffle the wind by forming still, protected air pockets around and just above the vegetation layers. Higher velocity winds passing over the still pockets drop their load of entrained sand, and the sand within the pockets is shielded from being moved by the wind. The root network of established vegetation can also trap blowing sand and significantly slow the downwind migration of dunes (Bagnold, 1965; Gallant, 1997; Hill, 1984; Hunt, 1993; Pidwirny, 2006). However, the easternmost edges of the older dunes often assume a parabolic (reverse barchan) shape, and/or steep lobate extensions where bare sand accumulates and is exposed. Several of these unvegetated lobate extensions continue to actively encroach eastward, especially in the vicinity of Maidenform Flats, 40-Acre Woods, and Boy Scout Camp.

<u>Sediment Transport</u>: Sand in the ODSVRA generally moves in the direction of the prevailing winds, which are generally between 300 and 320 degrees NNW (Cooper, 1967; Inman and Bowen, 1966). However, irregular sand ripple patterns along the tops of the dunes and at the bottoms of the steep advancing slip faces represent localized pockets of changing wind velocities, wind eddies and wind reversals. Sand grains normally move only a short horizontal distance while in the air, generally on the order of a few inches to a few feet, and to a height of several inches to approximately 2 feet above the ground surface (Hill, 1984; Bagnold, 1965). Although extremely strong winds can raise smaller sized sand particles higher than 6 feet, the wind will not keep sand size particles suspended in the air for long periods of time such as it may do with silt-sized and smaller particles (Bagnold, 1965; Hill, 1984).

Most sand movement by wind is by the process of saltation, where grains skip along the ground surface (Figure 3). According to Bagnold (1965), the height of the rise of a sand grain depends on the upward velocity with which the grain leaves the surface. The higher the grain rises, the longer it is exposed to the force of the wind, and the greater is the velocity with which it hits the ground and another grain is ejected into the air. As a result of the continued bombardment of the surface, a slow forward creep of the surface grains takes place. Of the total weight of sand that flows past a fixed mark per second, the surface creep accounts for 20 to 25 percent, and saltation for 75 to 80 percent (Bagnold, 1965; Pidwirny, 2006).

Although the grains in surface creep receive their forward motion from the impact of other grains in saltation, the surface creep is responsible for changes in the sorting and size-grading of the sand deposits. For example, in the formation of sand ripples, the coarser grains always collect at the crest, whereas the smaller grains tend to be knocked over the crest into the troughs before coming to rest (Figure 3). However, in the formation of ridges, it is the finer grains that collect at the top and the coarser grains that collect at the bottom. Because of differences in the rate of advancement of grains in surface creep on sloped surfaces of varying sizes, ripples always run transversely to the wind direction, while ridges vary in direction and shape.

Sand transported into the ODSVRA is derived primarily from the coastal zone of the Santa Maria Basin. According to Hapke and others (2006), 70 to 95% of the beach sand in California is derived from coastal streams. Eroded materials from nearby, tectonically active mountain systems, and from the Santa Maria River and Santa Ynez River systems, are the primary sources of beach sand in the basin. Smaller amounts of sediment may originate from sea cliff erosion, erosion of the off-shore continental shelf, and smaller coastal streams. Aeolian transport of sands on the beaches between Pismo Beach and the Santa Maria River have been estimated to be between 38,000 cubic meters per year (about 30,000 cubic yards; Bowen and Inman, 1966) and 300,000 cubic meters per year (about 230,000 cubic yards; Mulligan, 1985). More recent studies by Griggs and others (2005) estimate about 150,000 cubic meters (114,690 cubic yards) of sand are blown inland each year along the 55 mile stretch of coastline from Pismo Beach to Point Arguello.

<u>Sedimentation and Moisture Retention</u>: The origins of stratification, or laminar structures, in dune deposits has been studied by numerous researchers including Bagnold (1965), Kocurek (1981,1986), Rubin and Hunter (1982), and Tsoar (1982). According to Kocurek (1986), the geometries of low-angle stratification are dune-specific and may offer insight to the nature and origins of dune development, transport, and migration. Likewise, Bagnold (1965) states that the internal structure of any dune can reveal its whole past history during the time the leeward slope has taken to travel forward from the position of the present windward edge. Much can be discovered by noting the structure at selected sites immediately below the existing surface, and by walking over it noting the boundaries between firm and soft areas.

According to Bagnold (1965), all deposits of windblown sand consist of thin layers or laminae, a few millimeters thick, in which the grading varies very slightly as a result of the proportion of fine material present. In some dune sands this layering may be undetected by the eye, or may collapse rapidly when disturbed. However, water detection experiments conducted by Bagnold under undisturbed conditions have shown that water will travel through the sand more quickly as the proportion of fine material is increased, thereby exposing the narrow layers of sand that run parallel to the successive surfaces over which the sand was driven by the wind. Such laminae may develop through the accretion of sand being deposited over a relatively smooth, nearly horizontal surface, or through shearing, as successive layers avalanche (or encroach) over steep dune slip faces (Figure 3). In both cases, during each depositional sequence, the coarser grains rise to the top and the finer grains sink through the material to the bottom. A certain firmness between layers occurs where the relatively angular, individual sand grains fit together.

Bagnold (1965) also notes that considerable moisture is found close below the surfaces of dunes, even in very arid conditions far above sea level. Bagnold attributes this to periodic rain showers and the uniformity of temperature of the dunes below a depth of 20 centimeters (about 8 inches); i.e., sand is such a poor conductor of heat, most diurnal temperature changes are inappreciable at a depth of 8 inches below the surface. Therefore, as long as the saturated air between sand grains remains unchanged, no water can be lost.

Moisture is also more common where vegetation is present. Bagnold (1965) observed that both the vegetated areas and those under which moisture is present consist of soft sand, whereas naturally barren areas were more firm underfoot. Further study by Bagnold showed that, where roots had not disturbed the sand structure, both vegetated and moist areas were built up of steeply encroaching laminae, while the barren areas were underlain by accretion laminae running nearly parallel to the surface. This is because, when applied to the accretion laminae, water runs rapidly sideways along the surface layers that contain fine material, and is prevented from sinking downward by the relatively non-conducting layers from which the finer material is absent. The moisture in these deposits remains close to the surface and soon evaporates. On the other hand, in the encroachment laminae, the water runs down the old shear planes and almost immediately reaches a depth where subsequent evaporation is negligible.

The above phenomena may explain why, in some of the ODSVRA vegetation islands (Cottonwood, Tabletop, Boy Scout Camp, Maidenform Flats, 40-Acre Woods, etc.; see Appendix D), vegetation (mostly willow) is often found growing up and over the steep dune faces that are encroaching upon the western side of the islands (Photo 1). A more thorough correlation of horizontal, low-angle and steeply dipping laminar structures (Photo 2) with the success of vegetation observed within the ODSVRA is needed to determine if such locations are viable future planting sites.

<u>Historical Changes</u>: A detailed summary of historical land use changes and impacts of man in the Santa Maria Basin is presented in Hunt (1993). Changes that affected development of the various dune complexes and their vegetation included: natural and Native American-induced fires in the 1700s; Spanish exploration and settlement in the 1700s; modification of wetlands and other water bodies by American expansion in the 1800s; continued subdivision of large ranchos, the completion of railroad lines, and the conversion of land for grazing, agriculture and urban purposes; and the appearance of industrial (i.e., petroleum development and sand mining), military, and recreational land uses in the 1900s. Vegetation in the dunes was also affected by the introduction of cars along the beaches in the early 1900s; the use of some dunes in large movie productions; and the use of vegetated dunes and vegetation islands as homes by the Dunites until the early 1970s (Hammond, 1992).

A list of events that affected the Callender dune sheet is presented in Appendix C. A more detailed history of changes in the individual vegetation islands within ODSVRA is contained in Appendix D. It is significant that the Callender dune sheet with its dune lakes remained largely open space and was used primarily for grazing in the late 1800s (Hunt, 1993). Non-native, invasive beach grasses were introduced on the northern Callender dune area near Pismo Beach and the west side of Pavilion Hill around 1905. While the dune lakes, marshes and adjacent wetlands appear to have shrunk in size by the late 1930s, most of the Callender dune sheet remained largely undisturbed until the late 1970s. Following World War II, the use of jeeps on the beaches and open dune areas became popular. However, until dune buggy use began in the late 1950s, off-highway vehicle (OHV) use on the back dunes was limited; i.e., until about 1965, vehicle use on the property owned by CSP was a combination of street and camping vehicles along the beach and in the vicinity of Oso Flaco Lake, and dune buggies in the back country. Based on the review of aerial photographs since the 1940's, OHV use in the current ODSVRA area mushroomed by the early to mid-1970s. In 1983, when the Pismo Dunes SVRA (now ODSVRA) was established, Oso Flaco Lake was closed to OHVs, and by 1984, OHVs within the Callender dunes and other dune sheets were prohibited except within the fenced areas of the SVRA. The Pismo State Beach Dune Preserve was also established at the northern end of the ODSVRA.

At the time ODSVRA was established for OHV recreational use, CSP adopted the policy that there would be no net loss of vegetation throughout the park. Numerous maintenance and revegetation efforts were initiated, including straw mulching and hydroseeding in the vicinity of 40-Acre Woods and Oso Flaco Lake in 1986/87 and the establishment of foredunes northwest and west of Oso Flaco Lake between 1989 and 1992 (California State Parks, 1985 to 2001). Test plots were established and various other methods of establishing new vegetation were introduced in the vicinity of Oso Flaco Lake, as well as in other parts of the ODSVRA. By 1994, projects were initiated at Worm Valley, Pavilion Hill, BBQ Flats, Cottonwood, Eucalyptus North and Pipeline to establish vegetation on the leading edges of the islands, slow down sand movement along the western edges of some islands, and periodically move fences to the east and southeast to capture expanding vegetation. 7.5 Reveg was also formally established in 1994/95 and fenced to encourage foredune development northwest of Pipeline. Plover nests, discovered during this process, are now protected by fences installed seasonally along the coast west of Oso Flaco Lake and north to Acacia vegetation island. Additional projects initiated between 1994 to the present have helped CSP staff to identify various revegetation methods that have led to both successes and failures associated within the individual islands within the ODSVRA.

Since 1985, efforts by CSP to maintain vegetation within the ODSVRA while providing OHV ride areas have, in general, proven to be effective. Even though unfenced vegetation in portions of the ride area has disappeared, the total acreage of vegetation within the ODSVRA has increased. According to a recent GIS analysis of aerial photos by CSP (Shanaberger, 2007), vegetation within the ride area of ODSVRA increased from 142.4 total acres in 1985 to 222.9 total acres in 2003; i.e., an increase of 80.5 total acres. Of these, the ODSVRA gained 123.2 acres of new vegetation, lost 42.8 acres of the 1985 vegetation, and 99.7 acres remained unchanged (Figure 4).

Today, dunes that are located within the Santa Maria Basin, but outside of the ODSVRA, are subject to future agricultural and urban development. The surface mining of sediments and construction of dams within stream beds of the Santa Maria Basin, as well as groundwater pumping, could affect the availability of sediment for coastal dune regeneration in the basin, including the ODSVRA. The introduction of non-native species to the ODSVRA and other nearby dunes could also alter dune-forming processes and affect wildlife habitat and wildlife migration within and between the vegetation islands. Consideration of these effects will be necessary in finding a balance between the protection of the vegetation islands within the ODSVRA and continued OHV vehicle use.

<u>General Conclusions</u>:

- Under natural sand dune processes, advancing dunes within the ODSVRA will continue to move inland at an average rate of 1 to7 feet per year along slip faces west of the vegetation islands and 6 to18 feet per year in the open sand sheets.
- Advancement is likely to be more rapid within the unvegetated transverse dunes and along unvegetated sand corridors between the vegetation islands. Where sand corridors are exceptionally wide, dune encroachment may occur from the north side of the vegetation islands as well as from the west (i.e. Moymell, Heather, Tabletop, Maidenform Flats, Boy Scout Camp).
- Between 1985 and 2003, the total number acres of vegetation within the ODSVRA increased from 142.4 acres to 222.9 acres.
- Vegetation on the east/southeast edges of several of the islands (i.e., Worm Valley, Cottonwood, Eucalyptus Tree) has expanded to the east/southeast at a rate of approximately 3 to 4 feet per year. Vegetation growth is also expanding in the vicinity of CXTs located along the east/southeast sides of the Pavilion Hill, BBQ Flats, Cottonwood, and Eucalyptus Tree vegetation islands.
- In some islands (i.e., Acacia, Boy Scout North, Boy Scout Camp), willow growing on the steep, back-facing scarps of the west side of the vegetation islands has been able to keep pace with the advancing dunes by tapping into the water table, and/or moist laminar sand deposits, and growing over the top of the dune slip face. Efforts to revegetate with lupine on flatter slopes along the west edge of other islands (i.e., Pipeline, 40-Acre Woods) also appear to be effective in the short-term.
- The presence of foredunes appears to contribute to the stability of revegetation efforts farther inland. While unvegetated, disturbed sands near the beach provide ideal Plover habitat during certain months of the year, the presence of foredunes along the coast facilitates a more gradual, sequential development of densely vegetated dunes inland (i.e., Dune Preserve, Pavilion Hill/Worm Valley, 40-Acre Woods, south of Oso Flaco Lake). Where non-native species have been introduced to the foredunes, (i.e., Dune Preserve, Pavilion Hill), vegetation and foredune development appears to be accelerated and increased in height.
- In all cases where vegetation is expanding, fencing is important to success. Because revegetation efforts in unfenced areas have failed, it appears that fencing is necessary to help generate new vegetation, as well as preserve existing vegetation.

- Where rates of dune advancement are greater than vegetation expansion, the dunes will continue to encroach upon, and cover, the vegetation under natural conditions. Vegetation islands at greatest risk include Moymell, BBQ Flats, BBQ Flats South, Heather, Tabletop and Indian Midden South.
- From both the review of historical aerial photographs and field inspections, it appears that islands with larger masses of vegetation are more effective in withstanding dune encroachment than smaller islands. This is because sand will either settle in or blow around the vegetative masses, thereby slowing down advancement of the major dune faces. As the sand blows around the vegetative masses encountered, the size, nature and shape of the dune will change. The rate at which a vegetated island will be buried by advancing dune slip faces can be reduced by increasing the size of the vegetation island and decreasing the rate of steady movement of slip faces along the edges, especially to the west and north.
- Based on the review of sequential aerial photographs, the establishment of ride areas through the vegetation islands is likely to destroy vegetation over the long-term unless ride corridors are designated, fenced, and carefully managed. Ride corridors between and/or within the vegetation islands must be relatively narrow to prevent the development of wind tunnels where the rate of sand movement is increased significantly.
- Additional comparison of sand sample results in this study with those of other grain size studies is needed to determine more specifically how sand size and transport affect the dune characteristics associated with each vegetation island and, ultimately, rates of potential dune encroachment. A more thorough correlation of horizontal, low-angle and steeply dipping laminar sand structures with the success of vegetation observed within the ODSVRA is also needed to determine if certain locations are more viable future planting sites than others.

<u>Recommendations</u>:

1. **General Recommendations to Maintain or Increase Existing Vegetation**.
   - Based on CSP prioritization criteria, CGS recommends CSP consider (1) rotating the closure of ride areas and corridors adjacent to heavily impacted vegetation islands every 2 to 5 years, and/or (2) moving ride area fences away from the vegetation islands seasonally during heavy winds. This would result in less sand disturbance around the perimeter of existing vegetation and give newly planted vegetation an opportunity to develop more rapid initial growth.
   - Based on the general northwest to southeast direction of prevailing winds, underlying geologic structure and dune formation, CGS recommends that revegetation efforts be focused (1) along nearly flat west/northwest edges of the vegetation islands where dune slip faces are shallow or absent (similar to Pipeline); (2) within relatively flat, sandy troughs or depressed flats/flutes that run parallel to the wind direction (i.e. sandy tongues in Maidenform and 40-Acre Woods); (3) in flat areas on the east/southeast sides of islands where growth is needed to promote mass in order to prevent elimination of the island (i.e., BBQ Flats South, Heather, Indian Midden South); and (4) on steep slip faces and/or on unvegetated flats at the base of the slip faces; i.e. to slow sand movement and give (willow) roots an opportunity to grow westward ahead of dune advancement.
   - Vegetation advancement along the eastern/southeastern edges of all islands should be encouraged by moving fences eastward as vegetation advances.

- Where vegetation islands are at risk of elimination, CGS recommends CSP consider (1) the short-term use of non-native species to augment and accelerate vegetative growth, and (2) the establishment of new foredunes along the coast (similar to 7.5 Reveg) to provide dune structure and slow down inland advancement of sand in the areas of high risk.
- Foredunes should be established along the coast west/northwest of all areas where inland vegetation is desired. The presence of foredunes encourages a more gradual, sequential development of densely vegetated dunes inland.
- To facilitate future management of the islands, CGS recommends CSP develop a Monitoring Plan that effectively detects vegetation changes within each of the islands. Changes should be monitored on a regular basis, either annually or biannually, and management priorities reassessed at least every 10 years. To provide reliable and meaningful monitoring data in such a rapidly changing environment, CSP should consider establishing monitoring stations that utilize fences and fence posts, combined with GPS and photography, to monitor changes.
- In addition to the General Recommendations to maintain or increase existing vegetation listed above, Suggested Management Options for each island, listed in Appendix D, should be considered and addressed.
- If feasible, additional sand samples should be taken from Pipeline and Maidenform Flats vegetation islands, and at various locations within the Dune Preserve and within the ride areas, to better determine how sand size and transport affects the success of future vegetation efforts. These results should be compared with previous sand size studies in the ODSVRA and combined with a more in-depth assessment of laminar sand structures, their relative moisture content, and their relationship to different vegetation types.

2. **Options for Combining/Eliminating Islands to Retain Riding Area Balance.** The following options are based only on the geologic processes active within the ODSVRA and do not take into consideration other resource priorities such as the protection of endangered species and wildlife habitat. Suggested Management Options for individual vegetation islands, listed in Appendix D, should be consulted in conjunction with implementation of the options listed below.
    - <u>Rely on Natural Processes to Shape Vegetation Islands and Ride Areas.</u> Under this option, CSP would leave fences around the vegetation islands and let current wind and sand patterns dictate the nature and future shape of inland vegetation islands. Under this scenario, it is likely that Moymell, BBQ Flats, BBQ Flats South, Heather, Tabletop, and Indian Midden South will decrease in size. It is anticipated that Moymell and Tabletop will disappear entirely within within 10 to 20 years. It is also likely that barren flutes and sand tongues within individual islands, such as Maidenform Flats and 40-Acre Woods, will grow in size. Vegetation islands with tall, steep slip faces to the west and dense vegetation to the east/southeast, such as Pavilion Hill, Worm Valley, 40-Acre Woods, and Boy Scout Camp, are likely to continue migrating slowly to the east/southeast. In order to maintain a balance between vegetation growth and ride areas under this option, CSP would need to monitor changes within each vegetation island, add foredunes to the west of some islands, and expand fences on the eastern/southeastern edges of others.

- Maintain the Status Quo. Under this option, CSP would leave fences around the existing vegetation islands and try to maintain current vegetation and ride areas by (1) reinforcing existing vegetated areas, and (2) revegetating bare areas within the current vegetation island boundaries. Considerable planting and monitoring would be needed to (1) reclaim Moymell and Tabletop; (2) revegetate the western/northwestern edges of Worm Valley, BBQ Flats, Heather, Acacia, Cottonwood, Eucalyptus North, Eucalyptus Tree and Eucalyptus South; and (3) vegetate bare sand tongues within Maidenform Flats, 40-Acre Woods, and Boy Scout Camp.
- Combine and/or Eliminate Selected Vegetation Islands. Under these options, the vegetation islands are grouped into several core complexes:
  - *Moymell/Worm Valley/Pavilion Hill/BBQ Flats/BBQ Flats South Complex*. In this complex, Worm Valley and Pavilion Hill are core islands that have shown considerable vegetative growth since 1985. Moymell, BBQ Flats, and BBQ Flats South have decreased in size and are subject to continued dune encroachment from both the west and northwestern sides of the islands. However, given the northwest to southeast prevailing winds, it may be possible to revegetate and connect some of the unvegetated area between Worm Valley, Pavilion Hill and BBQ Flats. The relatively large gap between BBQ Flats and BBQ Flats South may pose a problem to successful dune revegetation without considerable effort and the use of non-native species. For these reasons, CGS proposes the following options for this complex: (1) combine Moymell with Worm Valley and Pavilion Hill and open the BBQ Flats South area to future riding; (2) combine Worm Valley and Pavilion Hill with BBQ Flats and open both Moymell and BBQ Flats South to future riding; or (3) combine the five islands by revegetating back to their previous configuration. Option (2) could be used to offset combined re-vegetation efforts in the vegetation island complexes listed below, while option (3) would require opening an equally sized ride area within one of the other vegetation island complexes.
  - *Heather/Acacia/Cottonwood Complex*. Within this complex, Heather is the island most vulnerable to dune encroachment from the north and northwest. CGS proposes the following options for this complex: (1) combine Acacia and Cottonwood and open Heather to future riding; (2) combine Heather and Acacia; or (3) combine Heather, Acacia and Cottonwood. Options (2) and (3) would require considerable effort to reshape and plant the sand corridor between Heather and Acacia. In addition, both (2) and (3) would require CSP to look for equally sized ride areas within other vegetation island complexes.
  - *Eucalyptus North/ Eucalyptus Tree/ Eucalyptus South Complex.* A review of aerial photographs and the literature indicate that these three islands were previously joined together as one large island. Although the western edges of the three islands and bare sand in the ride corridor between Eucalyptus North and Eucalyptus Tree have been impacted by strong winds and vegetation loss, this series of islands appears to be less impacted by winds and rapid dune encroachment than the other islands. For this reason, CGS expects that efforts to revegetate and combine these islands would have a relatively high chance of success. CGS proposes the following phased approach: (1) revegetate the narrow corridor between Eucalyptus Tree and

Eucalyptus South to join the two islands; and (2) close, reshape, fence and replant the ride corridor between Eucalyptus North and Eucalyptus Tree. Both phases will require CSP to look for equally sized ride areas in other vegetation island complexes.

- *Tabletop Complex*. The Tabletop Complex is one of the areas within the ODSVRA most highly impacted by dune encroachment. A review of aerial photographs and the literature indicate the Tabletop area has received above average amounts of sand since the 1930's and 40's, long before major OHV activity in ODSVRA. With numerous small vegetation islands and added sand erosion around the edges, vegetation loss has been increasing for the past 60 years. Unless CSP decides to maintain the status quo for this area, it is likely that small islands within the Tabletop Complex will disappear within the next 10 to 20 years. If CSP efforts are focused on expanding and/or combining other vegetation islands, CGS proposes this area be considered for future riding.
- *7.5 Reveg and Pipeline Complex*. Since 1985, revegetation efforts within this complex have been highly successful. CGS proposes that CSP continue to maintain the vegetative growth within these two islands by (1) revegetating the western edge and sand flutes within Pipeline, and (2) encouraging the southeastward migration of 7.5 Reveg. Because 7.5 Reveg is a planned foredune, consideration should also be given to extending 7.5 Reveg to the southeast and combining it with Pipeline. This would require CSP to look for an equally sized ride area in another vegetation island complex.
- *Maidenform Flats and 40-Acre Woods Complex*. Based on the review of aerial photographs and the literature, vegetation patterns in this area have changed significantly over the past 100 years. What was once vegetated is now bare sand and what once was bare sand is now vegetated. Since 1985, the revegetation of bare sands in the southern portion of 40-Acre Woods has been highly successful. However, large flutes/sand tongues within both Maidenform Flats and 40-Acre Woods continue to move eastward. In order to provide a balance of vegetation and ride area in this complex, while also reducing the rate of dune encroachment into the lake areas to the east, CGS proposes the following phased approach: (1) revegetate all bare flutes/sand tongues and ridges in an effort to reconnect Maidenform Flats with 40-Acre Woods and reduce the rate of sand migration to the east; (2) once vegetation is fully established, open the western portion (1/4) of 40-Acre Woods to seasonal riding; (3) monitor vegetated areas for 3 years to evaluate the impacts of riding; and (4) based on monitoring results and protocols, determine the feasibility of developing a seasonal trail system in other portions of the 40-Acre Woods as recommended previously by CGS (2007).
- *Indian Midden/Indian Midden South/Boy Scout North Complex*. Since 1985, revegetation efforts within this complex have been relatively successful. However, Indian Midden South remains at risk of dune encroachment because of its small size. CGS proposes two options: (1) combine Indian Midden South and Indian Midden (now excluded from the ODSVRA ride area), or (2) open Indian Midden South for future riding.

- *Boy Scout Camp Complex*. Revegetation efforts in this area have been highly successful since 1985. CGS proposes that vegetation in this area be maintained and that efforts be focused on revegetating bare sand tongues within and to the south of this area, in order to reduce the rate of dune migration to the east; i.e. into the lake area.

3. **Recommendations for CXTs.**
   - Where vegetation is encroaching upon CXTs on the south/southeast sides of Pavilion Hill, BBQ Flats, Cottonwood, and Eucalyptus Tree vegetation islands, CGS recommends CSP consider creating fenced corridors around the CXTs large enough for maintenance trucks to access the CXTs. To determine the feasibility of this option, CSP could develop and monitor one of the sites as a test case. The nature and size of the fenced corridors would be modified periodically as vegetation advances.
   - In addition to providing maintenance truck corridors, CSP should consider developing OHV parking areas either outside of, or within, the fenced CXT corridors, so that use of the CXTs does not interfere with their maintenance.

References Cited: (See Appendix E).

Signed: Original Signed

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FIGURES

APPENDICES

Figure 1. Location of Callender dune sheet within the Santa Maria Valley dune complex. Excerpted from Hunt, 1993, figure 2. Scale approximately 1"= 5 miles.

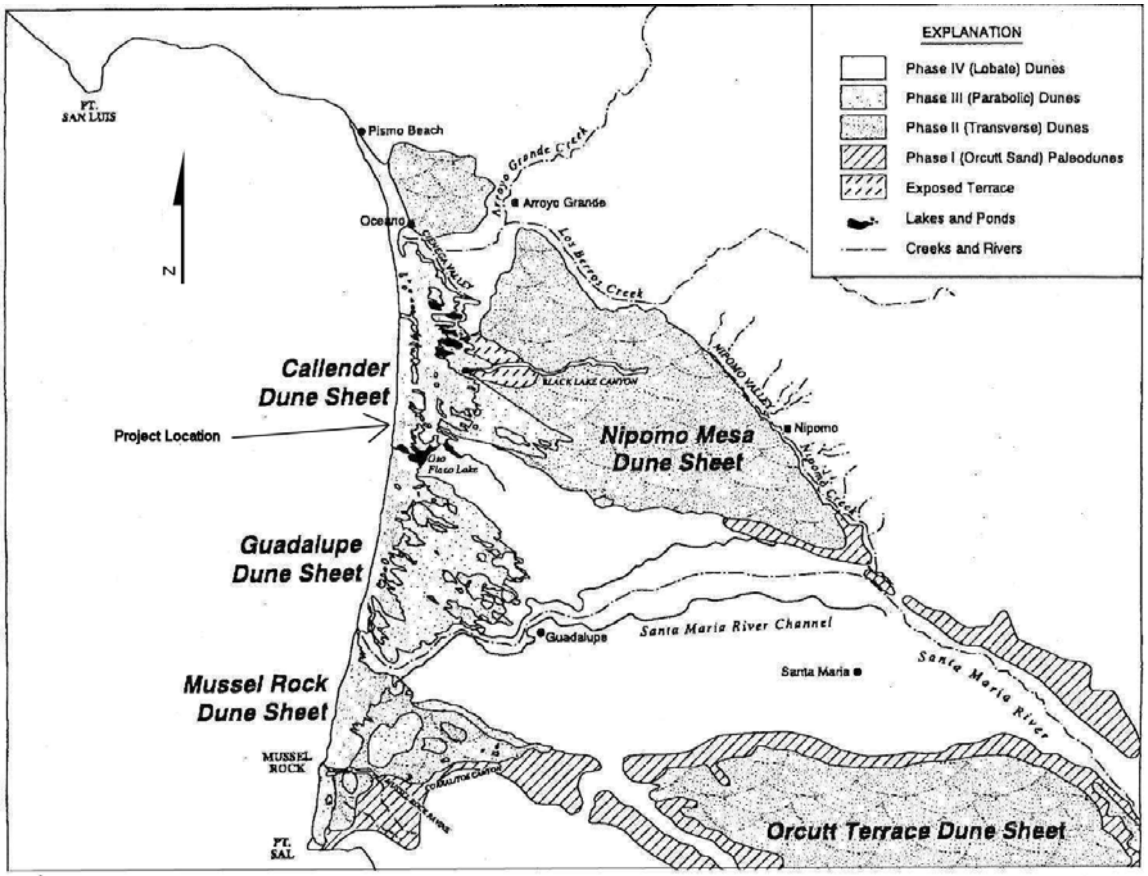

Figure 2. Location of faults in the vicinity of ODSVRA (see text for explanation). Excerpted from Jennings, 1994. Scale approximately 1:750,000.

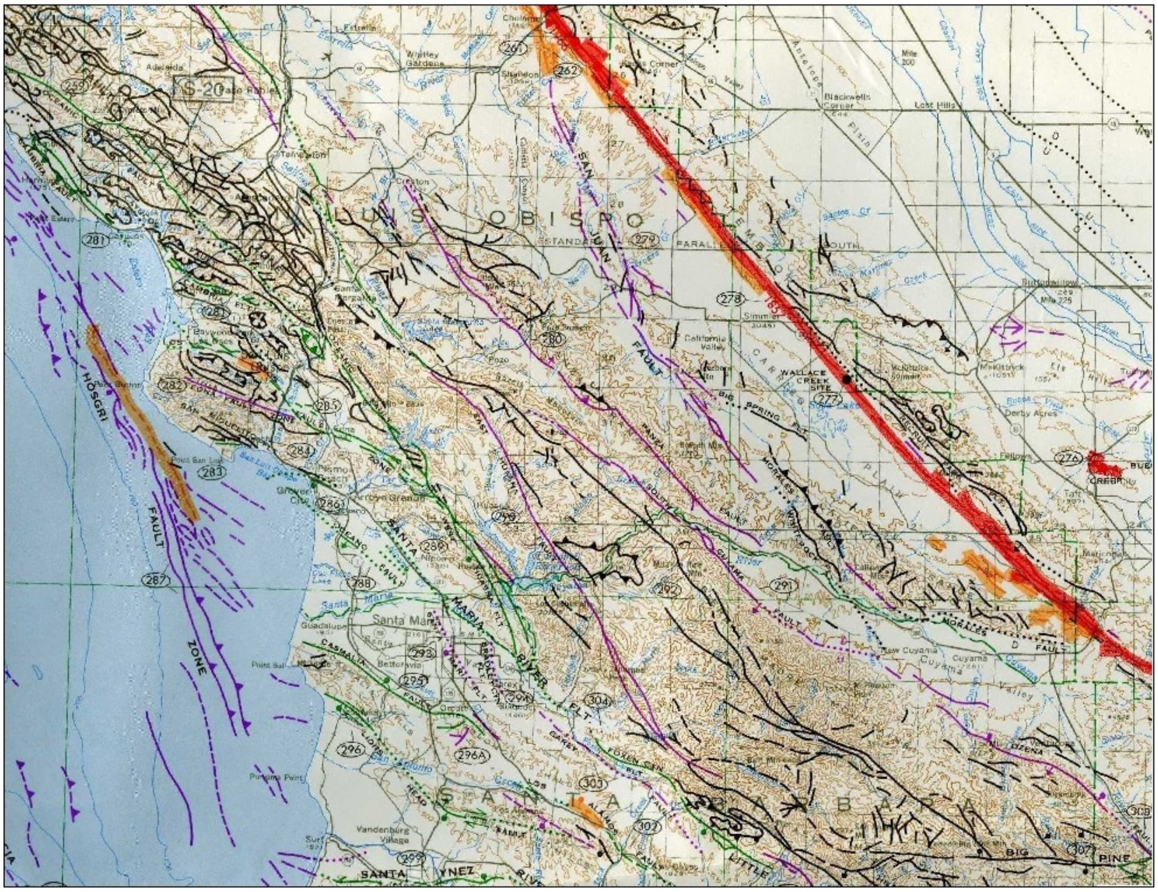

Figure 3. Dune Processes and Landforms. Excerpted from Parsons, 2002.

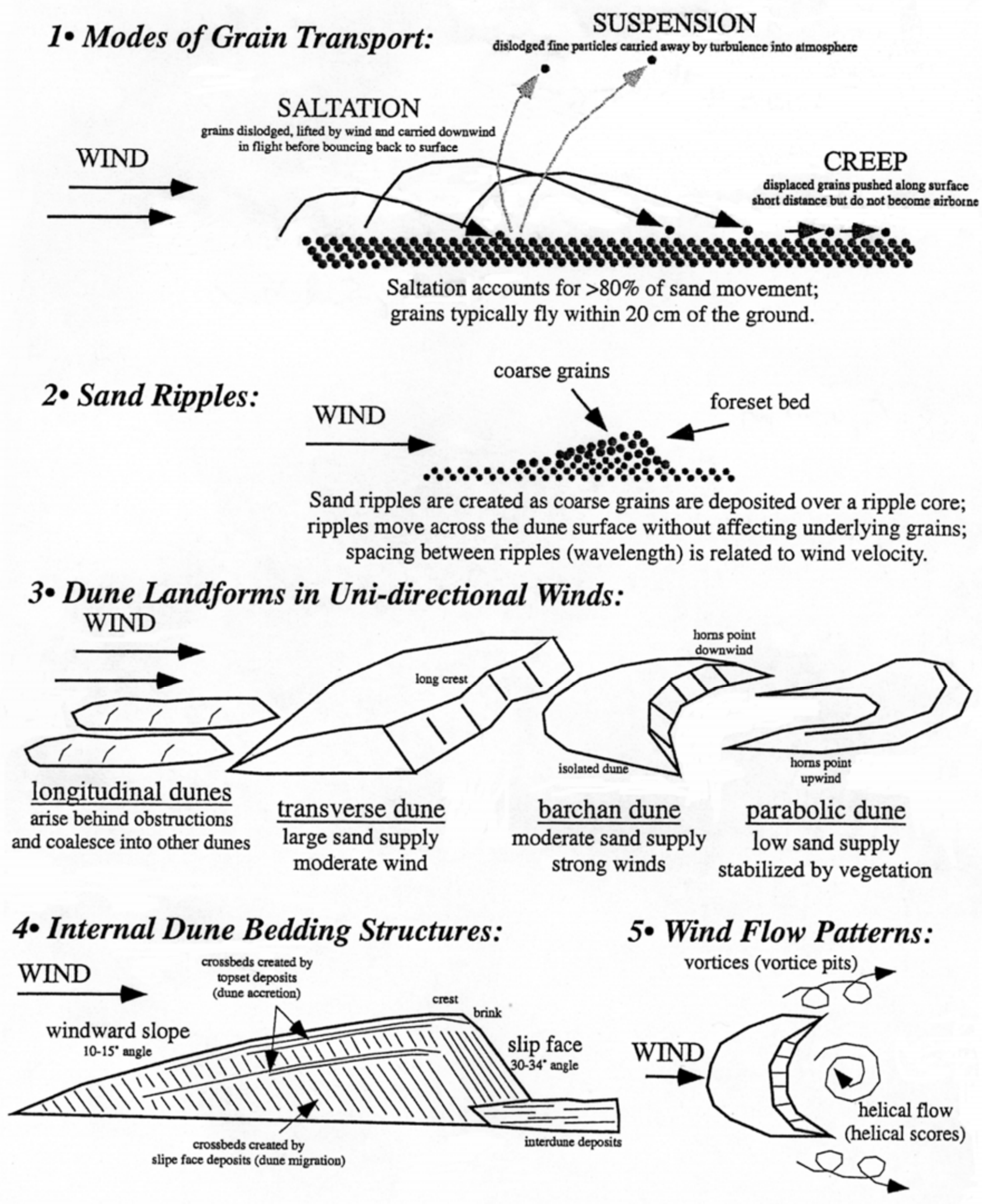

Figure 4. Vegetation Change Analysis, Oceano Dunes SVRA, 1985 to 2003. Analysis by Robert Shanaberger, GIS Analyst, CSP, August 2007.

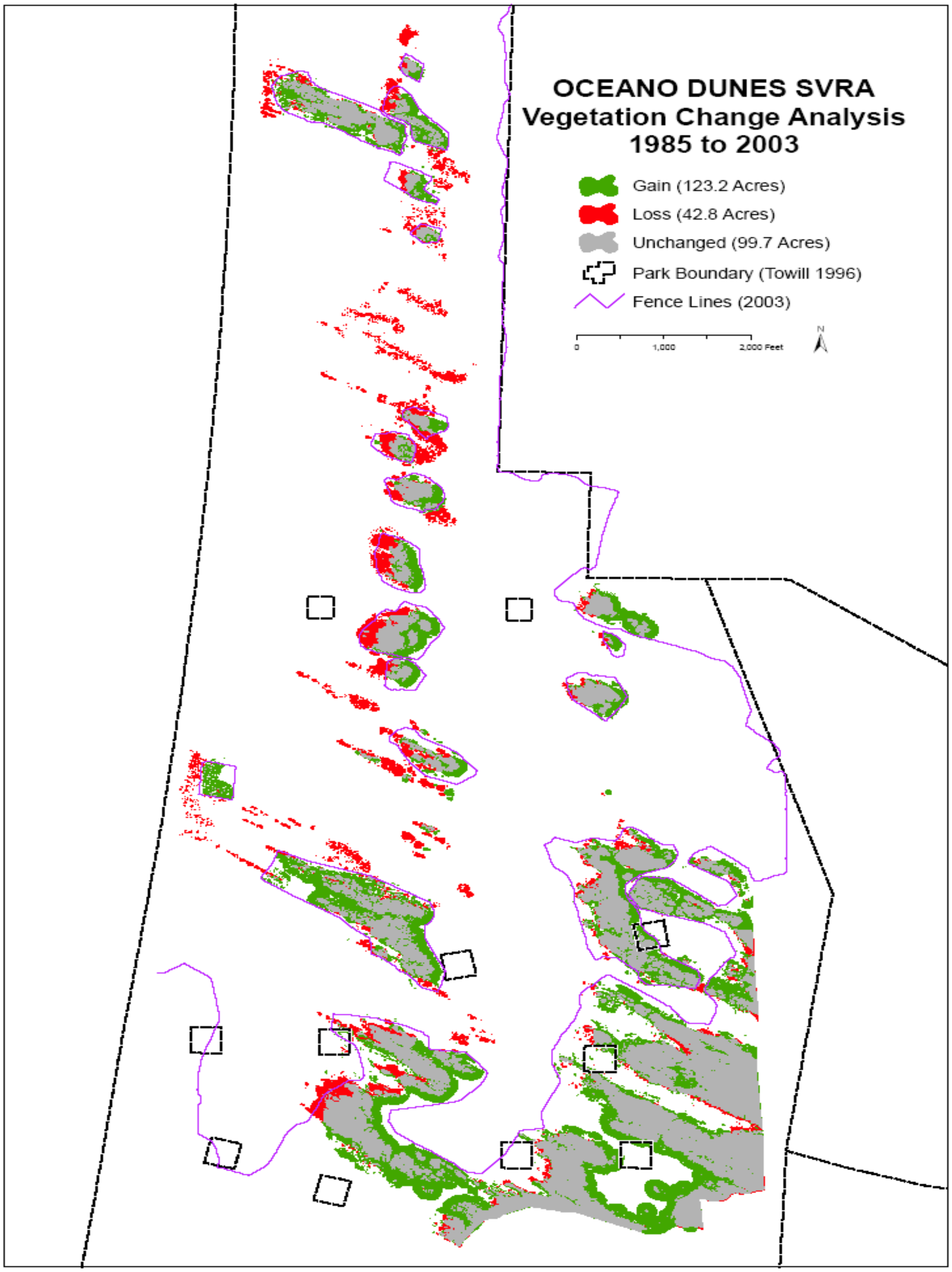

Photo 1. Example of willow growing up and over steep dune face encroaching upon west side of vegetation island. Photo by Donn Ristau, February 2007.

Photo 2. Example of laminar sand structures observed throughout ODSVRA. Photo by Donn Ristau, February 2007.

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APPENDIX - A

ODSVRA VEGETATION ISLANDS – TERMINOLOGY

Barchan/Barchanoid Dune: a moving, isolated, crescent-shaped sand dune lying transverse to the prevailing direction of the wind, with a gently sloping convex side facing the wind so that the wings of the crescent point downwind (leeward), and a steep crescent-shaped slip face formed as the extremities advance more quickly than the center. Nearly circular hollows may form in front of the slip face. Double barchans are common where another dune is immediately adjacent to the windward side.

Dune-Related Flat: the low, usually flat area found on the leeward side of higher dune faces. The flats are formed by wind erosion, as the wind deflects sand around the dune face. The flat is often scoured close to the local groundwater level, so that vegetation can readily begin growing in the parts of the flat that are somewhat sheltered from strong prevailing winds. Also referred to as a hollow, cove, slack area, deflation bowl, flat valley, and/or dune swale by CSP personnel and in references used for this study.

Flute/Sand Tongue: a shallow channel, trough or lobate depression of scoured sand that has moved outward from the leeward side of a dune slip face with the long axis generally parallel to or in the same direction as the prevailing wind. Because the strong prevailing winds blow unimpeded down the center of the flute/sand tongue, the center of the feature is often lower than the leading (downwind) edge and sides. Small ridges usually form along the sides and leading edges, some with slip faces of sand cascading onto adjacent topography. Within ODSVRA, the edges of most flutes/sand tongues are partially to well vegetated.

Foredune: A coastal dune occurring at the landward margin of the beach, or at the landward limit of the highest tide, more or less completely stabilized by vegetation. At ODSVRA, foredunes form in the general direction of the NW prevailing winds, nearly perpendicular to the coastline.

Leeward: downwind or direction in which the wind is going; in ODSVRA the leeward side of the dunes is to the east.

Longitudinal Dune: a dune that forms perpendicular to the coastline in the general direction of the prevailing winds; i.e., the foredunes in ODSVRA tend to be longitudinal in shape.

Parabolic Dune: a sand dune with a long, scooped-shaped form, convexly bowed in the downwind direction so that its horns point upwind (windward), and, when fully developed, approximates the form of a parabola. These dunes are characteristically covered with sparse vegetation and are found along the coast where strong onshore winds supply abundant sand.

Transverse Dune: a dune that forms parallel to the coastline and perpendicular to the prevailing winds; in ODSVRA, the transverse dunes are usually unvegetated.

Slip Face: steep slope or scarp on the leeward side of an advancing dune; in ODSVRA, slip faces are approximately 61% in steepness and may grow to over 100 feet in height. Generally, the higher the slip face, the slower it moves.

Wind Valley: a narrow depression or pocket directly in front of a dune slip face, formed as the dune encroaches upon an obstruction (i.e., a vegetated hill) and wind scours the sand between the slip face and the obstruction. Over time, a wind valley may wrap around the edges of the obstruction, forming narrow valleys along the windward edges of the obstruction, and/or may, in turn, become vegetated.

Windward: upwind or direction from which the wind is coming; in ODSVRA the windward side of the dunes is to the west.

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APPENDIX - B

ODSVRA VEGETATION ISLANDS – SAND SAMPLES

Purpose: During the geologic review of vegetation islands in the Oceano Dunes State Vehicular Recreation Area (ODSVRA), California Geological Survey (CGS) staff collected a total of 45 sand samples from 18 of the 20 vegetation islands within the ODSVRA and four sites adjacent to Milepost markers 4, 5, 6, and 7 along the beach. The purpose of the sand analysis was to determine relative percentages of sand grain sizes at different locations to detect, on a reconnaissance-level scale, gross similarities and differences in surface grain sizes as they relate to dune shape, wind direction/velocities and vegetation densities/types.

Existing Soils Data: According to the USDA Soil Conservation Service/Natural Resource Conservation maps (1984, 2005a and 2005b), the western edge of the ODSVRA is formed of Beaches (Unit 107), while the remainder of the study area is primarily Dune land (Unit 134). Beaches are partly covered by waves during high tide and are exposed during low tide. Typically, this layer is stratified with layers of sand or gravel; some portions are covered by cobbles. Permeability is very rapid; available water capacity is low or very low; surface runoff is slow; and the erosion hazard is high or very high because of wind and wave action. This unit is used almost exclusively for recreation.

Dune land, like Beaches, is used for recreation in most areas. This map unit consists of hilly areas along the coast that are composed of sand-sized particles that shift with the wind. While most Dune land is almost devoid of vegetation, some areas, such as the vegetation islands within the ODSVRA, are partially vegetated and somewhat temporarily stabilized. Permeability of this map unit is very rapid; available water capacity is very low; surface runoff is slow; and the hazard of soil blowing is very high.

In the southeast corner of the ODSVRA near Oso Flaco Lake, small patches of Psamments and Fluvents, wet (Unit 193) are exposed. This unit consists of small, very poorly drained basins in areas of Dune land or in coarse textured valley alluvium near streams and river bottoms. The soils are wind- or water-deposited sands and loamy sand that commonly contain layers of organic material. Areas where these soils are present are generally very poorly drained, with free water within 10 to 20 inches of the surface for most of the year. Because areas underlain by these soils have little or no farming value, they have been used mainly as wildlife habitat.

According to Tresselt (1960), dune sands at Pismo Beach are 85 to 90 percent quartz (silica); 10 to15 percent feldspars (albite, pink orthoclase) and 0.25 to 1.5 percent heavy minerals (hematite, leucoxene, magnetitie, chlorite, biotite, glaucophane, and garnet, with rutile and calcite rarely present). Orme and Tchakerian (1986) examined mineral composition of the Santa Maria dune complex in regard to various dune phases. Mineral compositions were found to range between 81 to 84 percent quartz; 9 to 14 percent feldspars; and 5 to 7 percent heavy minerals (magnetite, hematite, biotite, garnet, and amphibole).

Orme and Tchakerian (1986) also found that quartz grains within the dune sands were mostly subangular to angular, with subrounded to rounded grains comprising only 11 to 24 percent of the grains. Unlike desert sands which are generally subrounded to well-rounded from abrasion over long periods of time, these coastal grains indicate little rounding prior to deposition. Orme and Tchakerian attribute this to the limited abrasion time available in previous, rapidly changing, nearshore and fluvial environments along the fast-eroding continental margin.

Several other analyses of beach and dune sands within and near the ODSVRA (Cooper, 1958; Kroll, 1975; Parsons, 2002; and Moody, 2003) were consulted during this reconnaissance-level investigation. However, a detailed plotting of locations and a comparison of samples of previous findings with CGS findings were beyond the scope of this study.

Sample Collection: Forty-five (45) samples were collected using hand-driven 6-inch long, 2.5-inch diameter, thin-walled brass tubes, typically used in a Modified California Split Barrel Sampler. The open-ended tube ends were sealed with removable plastic caps. Locations of the samples are shown in Figure B-1. While samples were taken randomly, three main zones of vegetation development and dune advancement are represented from west to east as follows:

Table B-1: Vegetation Islands Samples – West to East, North to South

Milepost 4	Moymell	Indian Midden
Milepost 5	Worm Valley	Indian Midden South
Milepost 6	Pavillion Hill	Boy Scout North
Milepost 7	Barbeque (BBQ) Flats	Boy Scout Camp
7.5 Reveg	BBQ South	
	Heather	
	Acacia	
	Cottonwood	
	Eucalyptus North	
	Eucalyptus Tree	
	Eucalyptus South	
	Tabletop	
	Pipeline (none taken)	
	Maidenform Flats (none taken at Maidenform)	
	40-Acre Woods	

An attempt was made to collect from the top of the west (windward) side of the steep dune scarp slip faces encroaching upon the vegetation islands, the east (leeward) or leading edge of vegetated flats within the vegetation islands, and, less frequently, on the north side of islands where sand ridges are encroaching from the north as well as/or instead of from the west. No sand samples were taken from the Pipeline or Maidenform vegetation islands; however, multiple samples were taken in the 40-Acre Woods portion of the Maidenform Flats Area (see Table B-3) where California State Parks (CSP) requested additional input on various alternatives for addressing dune encroachment into Oso Flaco Lake (California Geological Survey, 2007). Silt/clay particles, observed on the west side of coastal perimeter fences in the protected zone north of Milepost 4 and in the vicinity of 7.5 Reveg, were collected but not analyzed.

Due to the relatively large number of samples and the loosely consolidated nature of the sand, the samples were transferred directly as collected, top to bottom, into enclosed sampling jars. While the top 6 inches of sand were sampled at most locations, the sample sizes varied in weight due to moisture content, an organic and/or small shell component in some samples, and/or a thin crust in samples taken from striated (thinly bedded) and vegetated areas. In most sample areas, some degree of moisture was encountered 3 to 6 inches below the surface.

Sieve Analysis: Per ASTM Standard D421-85 for dry preparation of soil samples for particle-size analysis, samples received from the field were exposed in the laboratory to air at room temperature until dried thoroughly. Where present, organic materials were removed prior to shaking. The loosely consolidated nature of the sand precluded the need for further break-up of aggregated materials. Each sample was then weighed using an OHAUS Triple Beam Balance, metric model, taking into consideration the tare. Next, each sample was placed into four stacked ASTM E-11 Specification, wire mesh USA Standard Testing Sieves and a receiver, with the following dimensions:

Table B-2: USA Standard Sieve Size and Equivalent Size Conversions

Sieve Size	mm opening	inches
No. 10	2.000	0.0787
No. 40	0.425	0.0165
No. 100	0.150	0.0059
No. 200	0.075	0.0029

After securing the test sieve lid, the sieves were clamped onto an electric shaker and shaken for 5 minutes. Sand remaining on each sieve and in the receiver was weighed and the percent weight computed into five general categories:

Coarse:	Sands remaining on the No. 10 sieve, greater than 2 mm
Medium:	Sands remaining on the No. 40 sieve, less than 2 mm but greater than 0.425 mm
Fine:	Sands remaining on the No. 100 sieve, less than 0.425 mm but greater than 0.125 mm
Very Fine:	Sands remaining on the No. 200 sieve, less than 0.125 mm but greater than 0.075 mm
Silt/Clay:	Material remaining in the receiver, less than 0.075 mm

Results: Results of the sieve analysis are shown by percent in Table B-3 and graphically by location in Figure B-1. Based on these findings, the majority of sands in the samples collected are greater than 70 percent fine sands, with a less than 10 percent very fine component and less than 0.5 percent silt/clay component. In all but two samples, there is no coarse component and the medium sand component is greatest in only one sample taken along the beach. In general, samples taken in vegetated and/or flat areas on the northern and eastern sides of the vegetated islands have a higher silt/clay component (0.1 to 4.7 percent) than samples taken from the western side of the islands (0.1 to 0.7 percent).

General Conclusions: Sands within the samples collected appear to be relatively well-sorted. This may be a result of progressive sorting in and near the surf zone prior to wind transport. The degree of sorting by the wind as sand grains are carried inland may also be more dependent upon local topography and wind patterns than the distance the grains have traveled from the beach. Nevertheless, grain size, grain shape, mineral composition, surface morphology and vegetation characteristics are important in distinguishing various dune phases and stages of dune encroachment (Orme and Tchakerian,1986). Grain size and mineral composition distributions are temporal responses to physical and chemical weathering. Surface morphology reflects the intensity and duration of post-depositional weathering and erosion, while vegetation changes are linked to plant successions that reflect changing soil properties.

Additional work plotting and comparing samples in this study with those of other grain size, mineralogy, dune morphology and vegetation studies is needed to draw more specific conclusions on how sand size and transport affect the dune characteristics associated with each vegetation island and, ultimately, rates of potential dune encroachment. To be complete, additional samples should be taken from Pipeline and Maidenform vegetation islands, and at locations within the various dune preserves, as well as within the ride areas. There also should be more correlation with moisture content, microclimates and vegetation types. Sampling to greater depths may also be useful to evaluate degree of sorting with depth and possible correlations to the success of revegetation efforts in given dune morphologies.

TABLE B-3: SAND SAMPLE RESULTS
Percentage Sieve Grain Size

Sample #	+10 (Coarse)	10-40 (Medium)	40-100 (Fine)	100-200 (Very Fine)	-200 (Silt/Clay)
MP-4 (wet zone)	0.2	4.4	87.8	7.4	0.2
MP-5 (below high tide)	0	28.8	67.4	3.7	0.1
MP-6 (Plover area)	0	16.8	82.2	0.1	0
MP-7 (low tide line)	0	59.3	40.5	0.2	0
7.5 Reveg (E side swale)	0	38.1	60.2	1.6	0.1
MM-1 (N side ridge)	0	0	91.7	7.8	0.5
MM-2 (SE corner flat)	0	10.2	77.7	10.7	1.4
WV-1 (W side top)	0	0.8	93.8	5.1	0.3
PH-1 (N side valley)	0	15.3	70.0	12.3	2.4
PH-2 (W side top)	0	1.1	91.0	7.8	0.1
PH-3 (S side flat)	0	7.2	83.0	9.6	0.2
BBQ-1 (SE corner bog)	0	30.0	62.0	6.4	1.6
BBQ-2 (NE side flat)	0	4.5	89.5	6.0	0
BBQS-1 (NE side ridge)	0	0.3	92.7	6.2	0.8
H-1 (SE corner flat)	0	8.3	80.5	10.0	1.2
H-2 (NW corner top)	0	0.1	87.0	12.7	0.2
A-1 (E side flat)	0	2.2	92.5	4.8	0.5
A-2 (W side top)	0	4.7	83.4	11.5	0.4
C-1 (W side top)	0	8.3	83.4	7.9	0.4
C-2 (NE side ridge)	0	0.3	85.6	11.8	2.3
C-3 (E side flat)	0	4.8	82.3	10.8	2.1
EN-1 (W side top)	0	25.4	68.0	6.1	0.5
EN-2 (E side flat)	0	14.9	78.8	4.5	1.8
ET-1 (W side top)	0	2.7	84.8	12.3	0.2
ET-2 (E side flat)	0	0.5	89.7	9.1	0.7
ES-1 (E side flat)	0	22.0	72.5	4.3	1.2
ES-2 (NW corner top)	0	45.0	47.2	7.1	0.7
TT-1 N side corridor)	0	1.7	89.0	8.9	0.4
FA-1 (W side top)	0	0.2	93.6	6.0	0.2
FA-2 (W side bottom)	0	7.0	87.7	5.1	0.2
FA-3 (N side ridge, veg)	0	6.2	85.7	7.1	1.0
FA-4 (N side transect)	0	1.7	95.0	3.2	0.1
FA-5 (transect trough)	0	0.1	85.1	14.1	0.7
FA-6 (W side depression)	0	3.3	89.7	7.0	0
FA-7 (E side flute)	0	15.2	77.2	7.3	0.3
FA-8 (S side ridge)	0	33.1	60.0	6.5	0.4
IM-1 (E side flat)	0	20.6	76.9	2.1	0.4
IM-2 (SE corner ridge)	0	0.9	90.7	7.9	0.5
IMS-1 (W side top)	0	1.1	90.0	8.3	0.6
IMS-2 (SE side flat)	0	7.6	87.3	4.1	1.0
BSN-1 (W side top)	0	24.7	71.1	4.1	0.1
BSN-2 (SE corner flat)	0	26.8	69.0	2.8	1.4
BSC-1 (E side flat)	0.3	28.7	65.9	3.9	1.2
BSC-2 (NE side flat)	0	0.8	85.0	9.5	4.7
BSC-3 (W side top)	0	12.2	82.2	5.3	0.3

Figure B-1: Oceano Dunes - Sand Sample Sites

2009 NAIP Imagery

Legend

- Sample Sites
- OceanoDunes
- Vegetation Islands

0 1,000 2,000 4,000 6,000 8,000 Feet

0 0.25 0.5 1 1.5 2 Miles

SCALE = 1:36,000

CGS
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APPENDIX - C

ODSVRA VEGETATION ISLANDS – CHRONOLOGY OF HISTORICAL CHANGES WITHIN THE CALLENDER DUNE SHEET

(from Cornell, 2001; Hammond, 1992; Hunt, 1993 and USFWS, 2007)

Pre-1796: Large shell mounds with arrowheads, points and chips left by various Native American groups; black sands from cooking fires.

1796: Extensive burns around present-day Pismo Beach caused by Chumash Indians (Crespi, 1984); first Spanish expedition to transverse Santa Maria Basin camped near Oso Flaco Lake; then proceed north between the dune lakes and the beach, crossing the dunes near the mouth of Arroyo Grande Creek.

1772-1804: Establishment of mission lands in vicinity of dunes; dunes subjected to relatively light livestock grazing.

Late 1830s to 1840s: Coastal lands divided into land grants; Callender dune sheet lands primarily within El Pismo Rancho (1840) and Bolsa del Chamisal Rancho (1837) land grants; grazing increase from pre-land grant times.

1830s to 1879: Significant changes in the number and size of dune lakes, lagoons and marshes associated with the dune coastal sheets between Pismo Beach and Arroyo Grande Creek, depending on precipitation and groundwater extraction; changes also noted in the vicinity of Oso Flaco Lake.

Early to mid-1870s: coastal roads established within dunes; wharves constructed at Pismo Beach for exporting cereal crops and importing building materials; dunes still mostly open space and used for grazing.

1882: El Pismo Rancho subdivided for sale.

Early to mid-1880s: Pacific Coast and Southern Pacific Railroad routes established.

1893 to mid-1890s: Town of Oceano founded; recreation beach developments began in dunes adjacent to Oceano and Pismo Beach.

1895: Southern Pacific Railroad route completed; marshes backing barrier dunes south of Pismo drained; route follows boundary of Callender and Nipomo Mesa dune sheets; route still follows original survey.

1895: Oceano Dance Pavilion built on the beach (Hammond, 1992); measured 60 by 90 feet with many-gabled roof; sides open, two floors constructed to allow dancing; wooden boardwalk added across dunes to Oceano Hotel; short railroad spur added to freshwater lagoon; pavilion successful for 60 years.

Mid- to late1890s: Callender dune sheet and dune lakes remained largely open space used for grazing; clamming along beach.

1899-1900: First person know as a Dunite, Edward C. St. Claire, enters dunes to live. Others follow shortly after turn of century.

1904: Los Angeles realtors purchase several thousand acres south of Oceano; dunes parceled into lots named Oceano Beach; some cabins built; additional lots promoted to south called Halcyon Beach; a third community is laid out farther to the south and named La Grande Beach.

1907: A larger, La Grande Pavilion opens on the beach near current Pavilion Hill vegetation island location; pavilion is located on the highest dune between Oceano and Oso Flaco Lake; thousands of horse-drawn wagons and buggies; barbecues in dense thicket behind pavilion; non-native ice plant and dune grasses planted to stabilize moving sand where pavilion faced surf; more than 8000 lots advertised for sale; 740-foot pier constructed into ocean.

1915: La Grande Pavilion collapses in ruin; difficult access; soft and shifting sands; wind breaking windows; property lines difficult to discern; people living in dunes scavenged lumber from pavilion to build small cabins in vegetation islands.

1930s to 1965: Callender dune sheet still relatively undisturbed, undeveloped.

1934: A portion of dunes near Pismo set aside as a State Beach, including 500-acre Dune Preserve.

1938: Heavy storms cause steamer ship to ground ¼ mile south of Pavilion Hill and dump 146,000 board feet of lumber onto beach; Dunites salvage lumber to repair and build new cabins.

1938 to 1939: Dune lakes appear smaller on air photos; most of intervening marsh land is drained; large-scale expansion of agriculture, oil production, military lands and development in surrounding Pleistocene dune sheets.

1941: U.S. Coast Guard moves into Oceano Dance Pavilion and turns it into headquarters for patrolling beach, establishing guard posts; Dunites offer cove and buildings at Moymell as shelter to reduce patrol time and help WW II war effort.

1945: Machine-gun emplacements at Moymell removed; armed patrol of beach ends.

1949-1961: Mouths of Arroyo Grande Creek and Oso Flaco Creek change dramatically, in part, due to dune advancement and, in part, due to human modifications in parts of the drainages.

1956: CSP proposes establishment of great State Park from Pismo Beach to Pt. Sal.

1962 to 1963: PG&E proposes construction of nuclear power plant on dunes near Oso Flaco Lake; effort is opposed in following years (Cornell, 2001).

1965: Minus 2 feet tides uncover vast stretches of tidal flats; 143,000 people ascend beaches to dig Pismo Clam (now considered endangered); over one million clams taken (Cornell, 2001).

1971: Off-Highway Vehicular Recreation Division established within CSP.

1972: Passage of California Coastal Zone Conservation Act and creation of California Coastal Commission.

1974: Announcement that PG&E dune lands proposed for nuclear power plant would become part of the CSP system.

1976: State mandate for all public agencies to protect rare and sensitive plant and animal habitats; California Department of Fish and Game study indicates water quality problems associated with fertilizer and pesticide runoff at Oso Flaco Lake.

1980: USFWS declares Nipomo Dune Complex most unique and fragile ecosystem in state and #1 in need of protection; is designated a National Landmark.

1982: Perimeter fencing and vegetation island fencing required under permit.

1983: Pismo Dunes SVRA (now called ODSVRA) established; Oso Flaco Lake closed to off-road vehicles; CSP signs agreement with Unocal to manage 280-acre parcel in Callender dunes as buffer zone for SVRA.

1984: San Luis Obispo County and Santa Barbara County Local Coastal Plans prohibit off-highway vehicle use except in fenced areas of SVRA.

1986: Coastal Conservancy approves first phase of Nipomo Dunes Enhancement Program; includes agreement for manned gate to control off-road vehicle use in designated areas; identification of sensitive dune resources including wetlands, endangered species, and need for revegetation or other protection needs.

1991: Management Plan for Nipomo Dunes Preserve approved by Coastal Commission; Nature Conservancy enters agreement with CSP for management of Oso Flaco Lake Natural Area.

1994: Unprotected willow ridges within ODSVRA fenced with partial fences to discourage vehicle crossings.

1998/99. Plover fences first required under Federal Permit/Take Avoidance Strategy.

2003/04. Current Plover fence boundaries required under court settlement.

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APPENDIX – D

ODSVRA VEGETATION ISLANDS – CURRENT CONDITIONS, CHANGES OVER THE PAST 60+ YEARS, AND SUGGESTED MANAGEMENT OPTIONS

The following description of the current conditions and of the physical processes working to cause changes in the vegetation island study area is based upon:

- field observations made during spring 2007
- conversations with California State Parks (CSP) staff
- inspection of air photos taken in various years between 1930 and 2007
- published and unpublished references, including field notes of some of the revegetation efforts undertaken at Oceano Dunes State Vehicular Recreation Area (ODSVRA) since 1985.

All air photos and references reviewed for the project are listed in Appendix E. Figures included in Appendix D were "clipped" from a GIS layer of 2003 air photo coverage of the area provided by CSP. Each figure (D-1 through D-11) shows one or more of the vegetation islands.

Numbered "Orientation Markers" mentioned in the text are the same locations as those along the beach and along the Sand Highway shown on the CSP color brochure of the ODSVRA, printed October, 2002.

Location of the Vegetation Islands

The vegetation islands investigated during this study are located within or adjacent to the open ride area of ODSVRA. The main public vehicle access to the ODSVRA is via Pier Avenue in the town of Oceano. Approximately 0.5 mile south of the Pier Avenue entrance, Arroyo Grande Creek crosses the beach. From Arroyo Grande Creek to just south of Orientation Marker 3, a distance of approximately 1.5 miles, vehicle use is restricted to a narrow strip along the beach. Inland from the strip is the fenced Pismo State Beach Dune Preserve. From the south boundary of the Dune Preserve, the open ride area extends a little over 3 miles south to the Maidenform Flats area, just north of Oso Flaco Lake. The northern half of the open ride area extends just over 0.5 mile inland from the beach. The southern half extends approximately 1 mile inland from the beach. Abutting the eastern fenced boundary of the open ride area is private property, which contains more open sand dunes, vegetated dunes, and several natural "dune" lakes. The Guadalupe Dunes, which lie south of Oso Flaco Lake, are managed by U.S. Fish and Wildlife Service and CSP. The area south of Oso Flaco Lake has been closed to off-highway vehicle (OHV) use since 1983.

Geomorphology of the Oceano Dunes Area

The entire study area is covered by geologically young dune sand, a small portion of which is currently vegetated, but most of which is bare sand subject to movement by the prevailing northwesterly winds blowing in from the ocean. Geologic and climatic conditions have been favorable to the development and cyclical inland movement of large sheets of sand dunes for many thousands of years. When the rate of sand movement slows down, vegetation can take hold and stop the inland movement of the dunes. When conditions change and the rate of sand movement increases again, younger sand sheets can move inland over the top of the older stabilized sheets.

In the ODSVRA area, Cooper (1967) identified the most recent sand sheet as having developed over the past 4,000 to 6,000 years, after sea level stabilized at close to its current elevation. Cooper determined that these recent dunes have moved inland in three distinct waves. Each wave was caused by some change in conditions that initiated an increase in the rate of sand movement. The waves are oriented parallel with the shoreline, and are designated by Cooper as the “Outer” (Western), the “Middle”, and the “Inner” (Eastern) waves. Each wave consists of a sand ridge that stands above the surrounding topography, built up from numerous smaller individual dunes. The Western and Middle sand ridges are associated with valleys that lie along the eastern toe of the ridges, as much as 60 to 100 feet lower in elevation.

The valley that lies east of the Western sand ridge contains the line of vegetation islands that stretches from Maidenform Flats to Moymell. This western valley continues north of Moymell into the Dune Preserve. The valley east of the Middle sand ridge contains the vegetation islands extending from Boy Scout Camp to Indian Midden. This valley continues north of Indian Midden into the dune lakes area, where many of the lakes also appear to lie along this same valley. The Eastern sand ridge appears to be actively overriding older, vegetated dunes, and is not associated with a distinct continuous linear valley along its eastern flank, as the other sand ridges are.

General Changes in Vegetation and Topography Since 1930

The changes in vegetation and topography were evaluated by using seven sequential sets of aerial photographs taken between 1930 and 2007. Some of the sets did not cover the entire study area, and some did not provide the type of coverage necessary to see the ground stereoscopically (in 3-D) in order to observe the topography. However, the overall air photo coverage was adequate to determine trends in the changes that the islands have gone through during the time period. The air photos “sets” used in the study include:

- 1930, a single photo covering Oso Flaco Lake to Heather island
- 1949, a single photo covering Eucalyptus islands to the Dune Preserve; and an index composite photo covering the entire study area
- 1956, stereo coverage of the entire study area
- 1963, a single photo covering Oso Flaco Lake to Heather island
- 1970, stereo coverage of the entire study area
- 1992, stereo coverage of the entire study area
- 2003, photo coverage (but not stereo) of the entire study area
- 2007, photo coverage (but not stereo) of the entire study area

The changes in vegetative cover over the past 60+ years can be observed by comparing the 1930 and 1949 air photos to current conditions, as observed during field work and on the most recent air photos. Some areas have dramatically decreased in vegetative cover while others have increased.

The areas which show a significant decrease in vegetative cover are the vegetation islands within the western valley between Oso Flaco Lake and Moymell, and the areas of foredune vegetation located just inland from the shore between Pipeline (Orientation Marker 8) and Pavilion Hill (Orientation Marker 5). The change in the western valley is the most striking, where the vegetative cover once stretched almost unbroken along the valley from north of Moymell to Oso Flaco Lake. A minor reduction in vegetative cover is noticeable just north of Oso Flaco Lake on the 1956 photos from an expanding network of OHV trails, but otherwise there is little change in vegetation cover in the western valley observed until the 1970 air photos. By 1970, increasing OHV use had broken the vegetation cover into 20 or so separate islands, with corridors of bare sand between them, and with a dense network of trails imprinted on each of the islands. By 1970, the foredunes north of Orientation Marker 7 (west of Eucalyptus islands) were gone.

The 1992 photos show the effect of ever increasing OHV use in the study area and the establishment of Oceano Dunes SVRA in 1983, which restricted OHV use to the fenced open ride area, and established fencing around the remaining vegetation islands within the open ride area. Between 1970 and 1992, the gaps between islands widened, and many islands disappeared completely. However, it was also obvious that, where islands had been fenced, the area covered by vegetation inside the fence line had increased since 1970. There was also a noticeable increase in vegetative cover in other fenced areas during the same time interval in the foredunes south of Orientation Marker 8 and within the Pismo State Beach Dune Preserve. Changes between 1992 and 2007 show the same trend, with the total amount of vegetation within the fenced islands increasing, and previously vegetated areas outside the fenced islands disappearing completely. Vegetation in the islands was generally lost on the west side to encroaching sand dunes, and was increased on the east side, as fences were moved out to protect it.

Several portions within and immediately adjacent to the study area experienced a moderate to significant increase in vegetative cover between the 1930s and 2007. These areas include the middle valley, just east of the Middle sand ridge; the area east of the open ride fence line; and the area north of Oso Flaco Lake. The number of vegetation islands in the middle valley actually increased from what it was in the 1930s. There was a slight increase in vegetation around Boy Scout Camp, no change in Boy Scout North, and a large increase in vegetation around Indian Midden and Indian Midden South. In the northern part of the middle valley around the dune lakes, large patches that used to be bare sand 60 years ago are completely vegetated today. The leading edges of the Eastern sand ridge, east of the ODSVRA do not appear to have moved eastward much. Some of the areas that were large isolated patches of bare sand in 1949 became vegetated by 2007. The area bordering Oso Flaco Lake on the north, that had been bare sand in the 1930 photo, is completely revegetated today, due to revegetation projects done by CSP in the late 1980s and continuing through the 1990s.

Although stereoscopic air photo coverage was not available to allow direct observation of the topography in the vegetation islands in the 1930s and 40s, we did have the map in The Dunites (Hammond, 1992) which described the topography in much of the study area during the Dunite “era” of the 1930s and 40s. Based on the descriptions in Hammond, and the topography observed on 1956 stereoscopic air photos of similar areas, it was possible to determine fairly closely what the topography was in the 1930s and 40s.

In the 1930s and 40s, the western valley, located along the eastern foot of the Western sand ridge that stretched from north of Moymell down to Oso Flaco Lake, contained several large islands that all had tall slip faces along the west side, and large sheltered flats or “coves” located to the east of the slip faces. Both the flats and tall slip faces were well vegetated, apparently mostly with willow.

During the 1930s and 40s, one large island with one long slip face extended from north of Moymell down to the BBQ Flats South area. As OHV activity increased from the 1950s through the 1970s, the EW oriented trails across the island became wide corridors of bare sand, which effectively separated the one large island into several smaller islands. As the bare corridors became wider, the topography changed. Closely spaced smaller barchan dunes replaced the one large western slip face, and sand buried the island flat. Slip faces formed along the margins of the open corridors, so that the smaller islands became enclosed on three sides (N, W, and S) with tall slip faces, leaving the protected flat much reduced in size. The flat remained open to the east, and vegetation was free to expand to the east.

In 1930, there was a wide expanse of open sand between BBQ Flats South and Heather. Most of the large western valley was filled in by a group of large sand tongues that had advanced from the Western sand ridge across the valley to the base of the Middle sand ridge. A few long narrow EW trending valleys with narrow ridges lining them were all that remained of the broad western valley in this area. These long narrow valleys appeared to be gaps between the sand tongues where the large valley had not been filled in yet. It is not clear what caused the sand to stream across the valley here, rather than getting caught and retained on the tall slip face along the west side of a protected flat, as had been done in the large island to the north. However, the process had been in motion for decades by the time the 1930 photo was taken. During the period from the 1950s thru the 1970s, the remnant ridges and flats became smaller, until they disappeared completely as shown in the 1992 photos. The area now is an open dune field occupied with a series of transverse and barchan dunes that extend from the coast to the crest of the Middle sand ridge.

In the 1930s and 40s, another large island occupied the western valley and extended from the vicinity of Heather to Cottonwood. It had a tall vegetated slip face along the west side and an extensive flat to the east. There was a narrow open sand gap between Cottonwood and the Eucalyptus island group. The three Eucalyptus islands were also connected as one large island at this time, with a single tall vegetated slip face on the west, and a large flat on the east. By 1970, the bare sand gap between the Cottonwood and the Eucalyptus island groups had widened substantially, and the two large islands were intricately laced with bare riding trails of varying widths. By 1992, the two large islands had been divided into the six smaller islands present today, with much wider open sand gaps between the islands. The open sand gaps have the same altered topography that developed in the gaps between islands in the Moymell to BBQ Flats area. The gaps contain closely spaced barchan dunes; formerly existing flats are buried by sand; and tall slip faces have formed along the edges of the open sand gaps. Each of the remaining smaller islands now has tall slip faces on three sides, and a smaller flat open to the east.

In the 1930 photo, there is another wide gap in the large western valley, where most of the valley had been filled in by sand tongues extending across the valley from the Western sand ridge to the base of the Middle sand ridge. The gap is present from Eucalyptus South to the vicinity of Pipeline. Three distinct large sand tongues are visible on the air photos in this gap. Narrow strips of vegetation remain on the narrow ridges and flats, not yet covered by sand along the margins of the tongues. Another narrow strip of vegetation remains along the eastern margin of the western valley, in the remnant flat, not yet filled in by the advancing sand tongues. Groups of barchan dunes are advancing westward across the bare expanses of open sand on the backs of the large sand tongues. By 1992, the narrow flat along the eastern margin of the western valley had been buried by sand, and only a few remnant vegetated knobs and narrow ridges remained. These constitute the Tabletop group of islands today.

In the 1930s and 40s, there was a large irregularly shaped island at Pipeline. A large flat was located on the eastern side of the island, protected by a tall slip face along its west edge. Several long narrow longitudinal ridges extended westward from the tall slip face, and some of these joined with the longitudinal foredunes that were present along the coast. There was a narrow sand gap between Pipeline and Maidenform Flats. Beyond the narrow sand gap, vegetation extended unbroken again from Maidenform Flats to Oso Flaco Lake. There were large flats behind tall slip faces extending along the western side of Maidenform Flats. A long EW trending ridge extended from the south side of Maidenform Flats to Little Oso Flaco Lake. The area on the northeast side of Oso Flaco Lake, between the lake and the broad E-W trending ridge along the south side of Maidenform Flats, contained a series of NW-SE trending tall narrow ridges that were covered with dune scrub vegetation. The area bordering the northwestern part of Oso Flaco Lake was a bare dune field blowing sand directly into the lake.

The vegetation in this area generally decreased as the density of OHV trails increased from the 1950s though the 1970s. The topography changed in those areas where large tracts of vegetation were removed. Vegetated old sand tongues became actively moving sand tongues again as vegetation was removed. Areas of tall, narrow ridges were smoothed and rounded and became barchan dune fields of open sand. In the mid 1980s, and continuing through the 1990s, CSP revegetation projects stabilized active dune sheets in Pipeline, and in the area adjacent to the NW portion of Oso Flaco Lake. The areas that had been barchan dune fields, as they were vegetated, became tracts of rounded small hills and narrow ridges.

The topography of the vegetation islands occupying the middle valley along the east side of the Middle sand ridge, Boyscout Camp to Indian Midden, remained relatively unchanged from the 1930s and 40s to the present. The vegetated area increased significantly in this time period, but the topography did not change dramatically.

Maintenance Projects Conducted on Vegetation Islands between 1986 and 2001

We were able to review some of the maintenance records of revegetation projects conducted by CSP in and adjacent to ODSRVA from 1986 to 2001. Descriptions of projects completed at specific vegetation islands are included with other information provided for each individual island listed below.

General information pertinent to the entire ODSVRA, including "lessons learned" from trying various techniques of revegetation of bare sand areas, includes:

- Revegetation can radically alter wind patterns, causing dramatic changes in topography close to the vegetation project. Because it may be difficult to accurately forecast the result of a vegetation project on wind patterns, it may be beneficial to try several approaches to see how they work over time, i.e., 3 to 5 years, before assuming things are going to continue in a certain direction. For example, CSP may need to temporarily fence off more areas, until vegetation is established, then pull back the fences.
- Revegetation projects conducted west of BBQ Flats and Cottonwood caused large blowouts at the south edge of the project, as the new vegetation altered wind patterns.
- CSP has periodically moved fences to the east and south to take in the vegetation that naturally expands that direction.
- CSP found that when trying to revegetate the west (windward) sides of vegetation islands, it was better to extend the revegetation project area westward all the way to the base of any large slip face that was present, rather than just part way. It was thought that the large slip face would help protect new vegetation better. Some projects which had extended only part way to the large slip face (which moves slowly) were buried in only one or two seasons by fast moving low slip faces 12 to 18 inches high.
- Trying to revegetate without fencing off the newly vegetated areas is a waste of effort and money.
- Ice plant is effective at anchoring the windward edge of foredunes, until native vegetation can take hold on the downwind portions of the dune. The ice plant can later be killed, and the roots will help hold the dune in place.
- The experience at Pipeline in 1995/96 (an 18-inch lift of sand moving quickly across hundreds of feet of revegetated area, completely burying it) led to the conclusion that sand transport to the west of the islands needs to be slowed down, so that revegetation efforts on the islands have a chance of succeeding. In trying to find an inexpensive way to cover lots of ground, CSP tried to broadcast barley and lupine without straw punching or hydroseeding. This worked only where strong winds were not coming in right off the ocean.
- The experience at Oso Flaco in 1995 demonstrated that bare sand areas upwind of a stabilization project will have an enormous impact on these projects once the strong seasonal winds begin to blow. A newly planted area that has become well vegetated prior to onset of the strong seasonal winds can be covered by sand in a matter of weeks. The plants cannot grow quickly enough to stay above the sand. Revegetation projects in these areas have a much better chance of success if there is a continuous band of vegetation upwind, starting with foredunes, and extending progressively farther downwind

to the east. Therefore, some revegetation projects may have to be done in multiple year phases.

- When looking at the downwind edges of the Coastal Dune Scrub islands (Worm Valley, Maidenform Flats), where sand has not been scoured to form deflation bowls/wetlands, the plant dominating that downwind edge of vegetation is always *Lupinus chamissonis*. It is a pioneer plant, able to grow in bare sand with little nutritive value, storing nitrogen in nodules on their roots and enriching the surrounding sand. This makes it easier for other slower growing woody shrubs like *Aricameria ericoides* to grow and continue the stabilization process. It took about 4 years for the mock heather to start germinating spontaneously in large numbers on the south side of the sand sheet west of Little Oso Flaco Lake . Once conditions become better for the more fragile native species, it makes sense to plant natives just along the west side (upwind) of where you want it to grow and let nature distribute the seed.

Summary of Dune Processes as They Interact with the Vegetation Islands

As indicated in several of the references we viewed, and as supported by field observations, the natural process of dune formation and vegetation island establishment is as follows. On the back beach, just inland from the high tide line, pioneer vegetation becomes established on small lumps of sand that form downwind from collections of seaweed that wash up on the beach. The small sand piles affect the wind flow in such a way that more sand deposits downwind from the initial sand hill. As more vegetation takes hold, the wind patterns are affected more, and additional sand is deposited. Longitudinal foredunes take shape and extend parallel with the wind direction for hundreds of feet inland. They can grow naturally into long narrow ridges about 20 to 30 feet in height. Narrow wind valleys form between the ridges. Natural vegetation is generally clumpy and scattered.

When the longitudinal foredunes become large enough, they affect the wind blowing over them so that, in the lee of the dune mass, a deflation bowl is scoured. Other names for this deflation bowl are “slack areas”, “flats”, and “coves”. Where the development of foredunes along the coast is fairly continuous, the deflation bowl elongates into a valley that forms roughly parallel to the coast in the lee of the foredunes. The leeward side of the deflation bowl or valley that forms downwind of the foredunes transitions into the windward slope of a transverse dune, or string of barchan dunes, in the bare sand area that slopes upward to the east. Bagnold (1965) indicates that where the lee side of a sand hill becomes oversteepened by the sand blown up onto to it, a slip face will form, and a barchan or transverse dune will form. The angle of the slip face is determined primarily by the size of the sand grains. In most dune environments it will be constantly 32 to 34 degrees (62 to 67%). At ODSVRA we measured nearly all slip faces to be between 60 and 62%.

Once a dune is formed, it can continue moving in a down wind direction while retaining its shape. Sand is blown up the gentle windward slope and cascades down the steep leeward slip face of the dune. The slip face can stay the same height, grow in height, or decrease in height. Bagnold (1965) observed that the rate a transverse or barchan dune moves in a downwind direction depends **directly** on the rate of sand movement over the brink of the slip face, and **inversely** as the height of the slip face.

Higher slip faces advance slower than shorter slip faces. He also noted that if the height along the length of a slip face is not constant, then the face cannot retain a constant ground plan. The shorter parts of the slip face will move ahead faster than the taller parts, and so the plan view of the slip face will change over time.

Dunes are shaped and enlarged by the wind. The dunes that have been constructed can then alter the wind patterns that originally formed them. It appears from field observations in the study area that high slip faces on transverse and barchan dunes can cause the wind to excavate deep deflation bowls immediately downwind of them.

Different types of vegetation interact differently with advancing sand dunes. The dune scrub type of vegetation generally does not appear able to grow fast enough to keep pace with high rates of influx of sand, i.e., where a slip face is encroaching quickly. However, willow does appear able to keep up with encroaching slip faces in many cases. It is able to grow fast enough to stay above the encroaching surface of the slip face. The willows probably begin growth in a wind sheltered deflation bowl or valley (flat, slack area, cove), which has been eroded down close to the local water table. We observed this condition in the field at numerous locations. Willows could also begin growing in the deflation flats downwind of a group of foredunes, such as 7.5 Reveg island, although we did not observe this during our field visits. A line of growing willows in a deflation valley would likely trap more sand, and possibly could build a vegetated ridge parallel with the valley, which would then function like many of the vegetation islands existing today farther inland.

Willows with their roots tapped into the groundwater table are in a good position to grow up an encroaching slip face. Ironically, the very slip face that is endeavoring to bury the willow may help the willow survive and keep pace with the influx of sand, by providing more water for the willow. Bagnold (1965) describes how the steeply dipping layers formed in the sand as the slip face advances produces favorable conditions for storing groundwater within a dune. Water infiltrates the dune, flows down the layer, filling up the layer from the bottom toward the top of the dune. This stored water is safe from evaporation. Whereas, where the layering in the sand is flat or nearly so, such as on the top of the dune or in gentle interdune areas, it is more difficult for the water to percolate deeply down into the sand. Water stored in horizontal layers also has a better chance of being evaporated.

The environment of a vegetation island with a tall slip face advancing slowly from the west may actually provide the means for certain types of vegetation such as willows to thrive and keep pace with the advancing sand. There appears to be a balance of conditions possible where willows could stay above the advancing sand of a tall slip face. Since vegetation causes drag on the wind column, it could cause the slip face to accumulate more sand and grow higher, thus slowing down the forward movement of the slip face even more.

Smaller barchans or transverse dunes, which move faster than bigger dunes with taller slip faces, will tend to climb up the back of a larger dune until it reaches the brink of the slip face of the larger dune, where it then adds its height to that of the larger dune, making the slip face taller, and slowing down its advance. It appears from comparing air photos, certain vegetation islands, where a tall slip face was present in 1956, did not show much eastward movement of the windward edge of the island. In other locations, where there were a series of smaller dunes present in a wide expanse of bare sand to the west of an island, there were often significant changes in the shape and location of the island between 1956 and 2007. It appears, that given the proper topographic setting, a given vegetation island could be expected to survive relatively intact for decades. However, given a different topographic setting, it would be difficult for vegetation to hold its own in the face of an active advancing dune field, and it could disappear within a decade or two.

Index to Individual Islands Studied

The 20 vegetation islands examined in this study are listed below, with corresponding page numbers. They are found in the text and on corresponding maps from west to east and north to south. Figures D-1 to D-11, at the end of Appendix D, show one or more of the islands.

Individual Islands – Conditions, Comments, Suggestions

1. 7.5 REVEG

Date of Site Visit: May 17, 2007

Time Spent in Field:
9:30-11:00 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Amber Clark - CSP
Ronnie Glick - CSP
John Schlosser - CGS

Shown on Figure D-6.

Existing Conditions: The island is approximately 500 feet long (NS) and 400 feet wide (EW). It is protected year round from riding. The fence along the west side stays in place year round, while the fencing on the other three sides is taken down each year during plover nesting season (March 1 to October 1). Fences are restored after the nesting season, when the surrounding area is reopened to riding.

The island is a set of eight or nine longitudinal foredunes, each 5 to 12 feet high, with valleys 15 to 20 feet wide between the dune ridges. The dunes are oriented parallel to the prevailing strong winds, which come from the WNW direction. They have formed narrow ridges with clumps of vegetation scattered along the ridgeline. The ridges are irregular in height, with some topographic knobs that have grown to approximately 10 feet in diameter and 4 to 5 feet higher than the adjacent ridgeline.

There is no European beach grass present, only the typical low-growing foredune species such as sea rocket, ice plant, yellow primrose, native grasses, and beach burr. The area is not completely covered with vegetation, and it appears that local clumps of vegetation may become buried or eroded by the strong wind, while other clumps begin growing and catching more sand. The valleys appear to be the main sand transport corridors through the island.

Because the area adjacent to the island is only seasonally open to riding, small clumps of vegetation begin growing almost as soon as the area is closed to riding. The clumps grow, catch sand, and begin forming small “proto” longitudinal fore-dunes. According to CSP staff, when the area is reopened to riding, most of the clumps of vegetation are obliterated by riding activity, but the ones that have been occupied by perennial vegetation do begin growing again the next season when the area is closed to riding. This suggests that, without riding, the natural condition in this particular area is for pioneer vegetation to begin forming longitudinal foredunes, like the ones that have formed inside 7.5 Reveg.

The growth of the vegetation and dunes in this area has affected the wind pattern downwind (E) of the island. A deflation bowl (the beginnings of a “flat” or “cove”) has formed along the eastern side of the island, about 500 feet in a NS direction and about 200 feet in an EW direction. The center of the deflation bowl has been eroded about 10 feet below the ground surface outside the bowl. Low broad longitudinal ridges of bare sand have formed along the northern and southern edges of the deflation bowl. The eastern edge of the bowl marks the toe of the windward slope of the main sand ridge that the Sand Highway is located on. Strong winds blow sand up the gentle (20%) windward slope about 1000 feet east to the top of the sand ridge. Numerous small barchan dunes are present on this unvegetated windward slope.

Sand sample 7.5 Reveg (Appendix B) was taken along the east side of the island within the deflation bowl.

Changes Observed on Air Photos: In 1930, scattered sets of longitudinal foredunes were present along the entire coastline from the town of Oceano to Oso Flaco Lake. These foredunes persisted, although in dwindling numbers and density, until at least 1970. By the early 1990s, the foredunes had essentially disappeared from the area between the Dune Preserve and the beach west of Maidenform Flats. There were a few scattered clumps of vegetation observed in the vicinity of 7.5 Reveg on the 1992 air photos.

Maintenance Projects: During the 1994/95 planting season, 7.5 Reveg was fenced. Heavy equipment was used to construct several “hummocks”. The hummocks were planted on the west (windward) side with ice plant, allowing native vegetation to take hold on the eastern (downwind) portions of the dunes. The ice plant apparently was effective in anchoring the dune until native vegetation took hold. The ice plant was subsequently killed but left in place to help hold the dune.

By 2001, the set of dunes had formed a large “slack area” or deflation basin downwind. At the time, CSP considered planting willow in the area, due to the presence of shallow groundwater. The intent was to eventually form willow ridges similar to the other vegetation islands in the park.

Comments: The vegetation on this island appears to be healthy and is expected to continue flourishing. The longitudinal dunes are likely to extend downwind in a south easterly direction if the fence on that side were moved to the east during the open ride season. It is not known how far the longitudinal ridges would extend downwind, but some of those that have developed in the Dune Preserve area and in the Oso Flaco Lake area since the 1950s are now 600 to 1,000 feet long.

The sand trapped in foredune complexes such as this reduces the amount of sand that is otherwise rapidly transported inland toward the vegetation islands that are currently being buffeted by wave after wave of barchan dunes. In the 1980s, when CSP decided to stabilize the bare sand sheets blowing into Oso Flaco Lake, it was recognized that foredunes had to be established upwind of the bare sand sheets before effective revegetation work could begin around the lake. The formation of foredunes, such as was done for the Oso Flaco Lake area, appears to contribute to the stability of revegetation efforts farther inland by reducing the amount and rate of sand movement downwind.

Suggested Management Options:

- Maintain the vegetation within 7.5 Reveg.
- Expand the area of foredunes to the south. This would trap more sand in the foredunes thus reducing the rate of sand movement toward Pipeline.

- Expand the island eastward, by allowing the longitudinal dunes to lengthen. At the same time allow the deflation bowl on the downwind side of the island to enlarge, and plant willows in the deflation bowl. The deflation bowl and vegetation growing in it would have to be fenced to protect it. From our current knowledge of dune processes, the willows would trap more sand, forming over a short time a sand ridge similar to the slip faces located along the western side of existing “willow cove” vegetation islands like Cottonwood and Acacia. It is likely that a new “willow cove” could be formed, which would migrate eastward over time, and become the replacement for the existing willow coves currently located to the east.

2. MOYMELL

Date of Site Visit: March 28, 2007

Time Spent on in Field:
9:00 a.m. – 11:00 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
John Schlosser - CGS

Shown on Figure D-1.

Existing Conditions: The island is approximately 250 feet long (NS), and 200 feet wide (EW). The shape is a parallelogram rather than rectangular, with the northern and southern sides oriented NW-SE rather than EW. The barchanoid dune slip face along the west side of the island has a complex shape, due to wind pattern interference caused by two willow knobs (small hills) located slightly west of the main body of the island. The top edge of the main slip face stretches between the two knobs. The main slip face is about 60 feet tall, sloping at 60%, and is partially vegetated with willows.

There is another slip face located about 40 feet west of the lip of the main slip face. This slip face, which is shorter, about 15 to 20 feet high, is about to contact the western face of the two willow knobs. The southern willow knob extends above the encroaching slip face, which apparently facilitates wind scour and formation of a wind valley between the willow knob and the base of the encroaching slip face. The valley is 6 to 20 feet deep, about 30 feet wide, and extends about 30 feet along the northern side of the willow knob and 75 feet along the southern side of the knob. The side slope of the wind valley on the willow knob side looks sand blasted, with roots exposed and active erosion evident. This condition is typical of wind valleys we observed elsewhere in the study area.

The northern willow knob does not extend above the encroaching slip face and, in fact, appears to be protected somewhat from the fierce winds that have been attacking the southern knob. There is no wind valley between the knob and the base of the encroaching slip face. However, the northern side of the willow knob does show evidence of recent wind erosion, such as exposed willow roots and exposed layering of the older sand that originally formed the willow knob. Sand ripples here are oriented predominantly EW.

Along north side of the island, there is a slip face which is 50 feet high on the western end and gets lower toward the eastern end. This northern slip face is part of a long fairly narrow ridge of sand that has the appearance of a transverse dune. However, it is oriented EW similar to an arm of a large barchan dune. There is a similar shaped ridge along the south side of the island, with a slip face that is considerably shorter in height. This barchan shaped arrangement of sand ridges with slip faces on the west, north, and south sides of the island is typical of most of the vegetation islands that contain central flats. Since the slip faces on all three sides are actively receiving sand, they are all advancing toward the center of the flat, slowly squeezing the flat closed. Willows climb up slip faces on the west, north and south.

The flat is open to the east. Because the wind pattern generated by the presence of the high dune slip faces tends to erode a deflation bowl on the lee side of the island, groundwater is close to the surface of the flat, and vegetation tends to naturally extend toward the east. The eastern edge of vegetation appears to have moved approximately 50 feet downwind in the last several years, and the fence has recently been moved east and south 50 feet. Willows, *Juncus*, lupine, coyote brush, blackberries, wall flowers, and other riparian species like stinging nettle, pampas grass, and cattail were observed growing in the flat. Sand grains appear coarser in the flat and along the ridge.

Sand sample MM-1 (Appendix B) was taken on the ridge along the N side of the island. Sample MM-2 was taken on the flat on the SE side of the island.

<u>Changes Observed on Air Photos</u>: The map in The Dunites (Hammond, 1992), showing conditions in this area during the 1930s, indicates there was a continuous vegetation island filling the valley that existed at that time from just north of Moymell to south of BBQ Flats South. The Dunite map shows a willow cove named Utter just to the north of this large island.

By 1956, open sand corridors had developed, that separated Moymell from Worm Valley to the south, and widened the gap between Utter to the north. Small barchan dunes were advancing eastward through the sand gaps between the islands.

By 1992, the corridors between the islands were wider; the main slip face along the western side of this group of islands (Utter, Moymell, Worm Valley) was in approximately the same location as it was in 1956, but, in the gaps between the islands, the main slip face had moved eastward 60 to 70 feet. Smaller barchans were present in the gaps to the east of the main slip face. Utter was about one third the size of present day Moymell, and it was surrounded on three sides by high slip faces. There was essentially no flat left to be protected by the high ridges. By 2007, Utter was completely gone. A continuous field of barchans now exists from the coast up to the next high sand ridge to the east.

Vegetation, present along the SW side of the main slip face of Moymell in 1992, was completely gone by 2007. A large ridge had built up along the northern side of Moymell by 1992. This same ridge was present in 2007. The southern ridge is much larger in 2007 than it was in 1992. Continued advancement of the slip faces on three sides of the flat reduced the size of the flat so that it is considerably smaller in 2007 than it was in 1992.

<u>Maintenance Projects</u>: In 2004/05, CSP punched in straw and planted lupine on the west of the main slip face. At the time, there was a relatively flat expanse of open sand, with a small slip face of a barchanoid dune some distance off to the west. Since then (in the last 3 years) the 15 foot tall slip face has moved in, covered most of the area that had been flat, and buried the straw and vegetation. It is unclear how fast this slip face moved east. However, it appears that a similar small slip face present on the 1992 air photos was about 50 to 70 feet farther west than its 2007 location. The rate of advance at this location was about 4 feet/year.

Comments: Due to its relatively small size, Moymell is likely to disappear within 20 years, just like Utter has disappeared since 1992. A mitigating factor is the fencing around this island, whereas, in 1992, it did not appear Utter was fenced. However, unless significant effort is expended to increase the size of Moymell, and the fencing can be moved eastward on a regular and fairly rapid basis to protect new vegetation as it expands, it is unlikely this island will survive in the long-term.

The rate of advance of the western slip face appears to be about 4 feet per year. The northern and southern slip faces may be advancing at even faster rates, because they are shorter and the rate of influx of sand to the slip face may be about the same on the north as it is on the west. Willows can help slow down the rate a slip face advances, but they do not appear capable of stopping the advance.

The flat part of the island, which provides plants with easy access to water and protection from strong winds, can likely be extended in an eastern direction, as long as it is protected by fencing. However, because the northern and southern sides of the flat are continually being squeezed by advancing slip faces, it does not appear as easy to extend the flat in a southern or northern direction. Once the island's central flat is squeezed closed from the north and south, it is unlikely a viable flat area can be maintained. Once the flat is gone, healthy vegetation is unlikely to survive.

One alternative may exist to the southeast, where a small deflation bowl has formed downwind of the sand ridge along the southern edge of the island. It may be possible to plant this area with willow and other vegetation, fence it off, and get the island to expand in a slightly southeastern direction, rather than just an eastern direction.
It is also possible that this island could be connected to Worm Valley to form a larger island, but a significant effort would be required to revegetate the bare sand ride corridor that currently exists between the two islands.

We did not observe any flutes or sand tongues on this island, however if one were to form in the future, it is very important to stop that sand transport process and revegetate the tongue as quickly as possible. One possible way to reduce sand transport along a sand tongue would be to mechanically construct a sand ridge at the upwind end of the tongue, using sand fencing or by construction with heavy equipment. We have observed "relict" sand tongues in other islands that have been cut off by from the wind by an approaching 20 to 30 foot slip face that gets within 50 feet or so of the sand tongue. Once the wind is cut off, the sand tongue advances more slowly, and it is easier to revegetate.

Suggested Management Options:

- One alternative is to allow Moymell to become open ride area.
- Another alternative is to maintain the island on its own.
- A third alternative is to connect Moymell and Worm Valley.

If it is decided to maintain Moymell:

- The best long-term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to determine what acreage is being gained each year and how quickly the fences in both areas should be moved (“in” on the west and north, and “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Moymell and Worm Valley:

- It would likely require a significant effort over several seasons.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along the western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.

3. WORM VALLEY

Date of Site Visit: March 28, 2007

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
John Schlosser - CGS

Time Spent in Field:
11:00 a.m. – Noon

Shown on Figure D-1.

Existing Conditions: The island is approximately 275 feet wide (NS) and 950 feet long (EW), with the island oriented in a NW-SE direction. There is an open ride corridor about 250 to 300 feet wide between the fence lines along the edges of Moymell and Worm Valley islands. Topography within the corridor is different than within the adjacent islands. The single steep slip face that previously existed along the high dune that forms the western edge of Moymell and Worm Valley has been divided into one gentler slip face at the ridge top and another slip face half way down the eastern slope. Although the ground surface slopes downward to the east, there no longer is a flat or cove at the base of the slope. It has been buried with sand.

The western side of the Worm Valley is a 50 to 60 foot high slip face, part of an encroaching barchanoid dune, similar to Moymell. Three isolated but prominent clumps of willows are present on small hillocks that extend above the general surface of the barchanoid dune at approximately the crest of the slip face. The toe of the slip face has advanced over the older, vegetated, pre-existing topographic surface of the island. Sand sample WV-1 (Appendix B) was taken just west of the middle willow hill. Sand ripples here are oriented N20W. The pre-existing surface consists of a short low sand ridge oriented NW-SE (parallel with the prevailing wind direction), extending easterly from the slip face in approximately the center of the island. Another longer and taller longitudinal ridge extends along the southern side of the island.

A low basin area, with *Juncus* grass and other water-loving plants, is present adjacent to the low ridge between the northern fence line and the ridge. This basin extends from the slip face approximately half way to the eastern end of the island. The basin is vegetated with lupine and wallflower as well. The low ridge and basin do not appear to be as windblown as the northern boundary of other vegetation islands. This may be due to the presence of a high slip face that extends from the west side of Moymell through the open ride area to the west side of Worm Valley. The high slip face appears to reduce the wind exposure on the north side of Worm Valley.

An old trail, visible due to bare sand exposures, crosses the low ridge from the north side of the island to the south. The large southern ridge is vegetated with dune scrub (coyote brush, lupine, etc.) rather than willow. The south slope of the southern ridge is gentle, and becomes almost flat before it encounters the southern fence line along the narrow ride corridor that winds between Worm Valley and Pavilion Hill.

Changes Observed on Air Photos: In the 1930s and 40s, Worm Valley was part of a larger island that extended from Moymell on the north to south of BBQ Flats South. As the number and density of OHV trails increased through the 1980s, Worm Valley became separated from Moymell and Pavilion Hill. The sand ridge that is present today along the southern part of the island was present on 1956 photos and was covered with what appeared to be dune scrub vegetation. Areas of willow vegetation shown on The Dunites map (Hammond, 1992) in the 1930s, and visible on the 1956 photos, were among the areas of vegetation that survived through the 1990s. Much of the older island covered with dune scrub vegetation disappeared by 1992.

Between1992 and 2007, the main slip face on the west side of the island remained in approximately the same position. Some additional sand and height appeared to be added, probably from small slip faces that advanced up to the main slip face location since 1992. The slip face appears to have less vegetation on it now. The three willow hills on the main slip face are somewhat reduced in size, but only by about 10 to15%, and they are still present, even though additional sand that has moved in from the west. The main slip face is beginning to wrap around the north end of island and push eastward into ride corridor. More sand appears to have moved into the sharp bend at the top (west end) of the ride corridor between Worm Valley and Pavilion Hill.

The small basin on the northwest side of the island, in the wind shadow of the main slip face, is more pronounced than in 1992. It appears to have shallow groundwater, with *Juncus* grass present. The large longitudinal ridge that runs NW-SE in the southern part of the island is about same size, but much more vegetated with dune scrub and lupine than it was in 1992.

It appears CSP has narrowed the eastern half of the ride corridor between Pavilion Hill and Worm Valley and moved the fence into the corridor. Vegetation in Worm Valley has become more dense inside the existing fenced area and the previously bare top of the southern longitudinal ridge.

Maintenance Projects: After failure of the barley seeding technique at BBQ Flats in February 1998 (due to very high winds), a more sheltered location for trying the barley seed technique was chosen. One acre of bare sand on the north side of Worm Valley was harrowed in March 1998 and broadcast seeded with barley. Fertilizer was added and the site was track rolled with a Catepillar Challenger (6 pounds/square inch ground pressure, fairly light). Then 500 containerized plants were added. According to CSP, this technique saves a lot of material and manpower expense.

The barley seed came in well and completely stabilized the site. All other plants died over a 2 year period, except lupine. This method can be done in more protected areas, not subject to strong winds directly off the ocean, where spring rains help to germinate the seeds.

Comments: None.

Suggested Management Options:

- One alternative is to maintain the island on its own.
- Another alternative is to connect Worm Valley and Pavilion Hill.

If it is decided to maintain Worm Valley on its own:

- The best long-term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being "lost" per year.
- The expansion of vegetation to the east and south should also be monitored, to determine what acreage is being gained each year and how quickly the fences in both areas should be moved ("in" on the west and north, and "out" on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Worm Valley and Pavilion Hill:

- Start by connecting fences between the two islands at the west and east end of the ride corridor to keep traffic out of the ride corridor. The current fences along the north and south sides of the ride corridor could then be removed.
- Once the ride corridor is closed, begin to revegetate it.
- It may be possible to get willows to grow up the slip face on the west side of the closed ride corridor if sand layering in the corridor is favorable. If the western end of the corridor is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a "head start" in stabilizing the sand ridge that will become the western side of the new enlarged island.

4. PAVILION HILL

Date of Site Visit: March 28, 2007

Time Spent on in Field:
Noon – 2:00 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
John Schlosser - CGS

Shown on Figure D-1.

Existing Conditions: The island is approximately 1,700 feet long (EW), 450 feet wide (NS), and is oriented parallel with the prevailing winds in a NW-SE direction. There is a narrow fenced ride corridor between Worm Valley and Pavilion Hill. The ride corridor climbs from the low flat area on the east side of the island, up a modified high slip face to the top of the hill, i.e., the top of the same slip face that forms the western edge of Worm Valley. The transverse dune that forms the west boundary of Moymell and Worm Valley ends where it meets the large sand ridge that forms the north side of Pavilion Hill. However the long east-facing 60 foot tall slip face does not end at Pavilion Hill but transitions into the 40 foot tall south-facing slip face of the sand ridge.

The slip face of the sand ridge is well vegetated, and the toe of the slip face is encroaching slowly out into a pre-existing flat valley that is well vegetated with a mix of well established dune scrub and riparian plants, including willows, coyote brush, black berries, and poison oak.

The prevailing NW wind appears to be concentrated along the north side of the island. Small, discontinuous low sand ridges have formed parallel to the larger sand ridge, between the larger ridge and the northern fence line. Some of these smaller ridges have small discontinuous wind valleys scoured between them. The whole north side, including the large ridge and the smaller ridges, shows evidence of wind erosion, with some plant roots and sand layering exposed in recently scoured areas. Willows cover much of the south-facing slip face of the large northern ridge. Lupine and more pioneer type vegetation partially cover the smaller ridges.

There is a large deep valley in the center of the island that is enclosed by the protecting northern ridge and by a similar sand ridge on the south. The valley is densely vegetated with willow and cottonwood overstory and thick blackberry and poison oak understory. The southern ridge is broader than the northern ridge, but is not as densely vegetated with willow. There are open sand pockets on the ridge, and much of the vegetation consists of coyote brush and other types of dune scrub and riparian plants. The southern slope of the southern ridge is much gentler than the slope that leads down to the central valley. The southern slope is covered with dune scrub and locally dense groups of lupine.

The large central valley extends to eastward to a large flat on the eastern side of the island. One CXT bathroom is located just outside the eastern fence line adjacent to the flat. The two ridges and the central valley extend westward from the CXT area, about two thirds the length of the island, where they come together in a huge, topographically complex mound of sand stabilized by European beach grass (*Amalfa*) and ice plant. The mound of sand that defines Pavilion Hill protrudes about 50 feet higher into the air than the two ridges. The mound has complex morphology, with numerous smaller mounds, small dunes, and slip faces of various sizes.

The topography of Pavilion Hill is grossly similar to the topography that has developed on other smaller vegetation islands. There is a large dune “ridge” present along the west side of the island and there are ridges extending eastward along the north and south sides of the island which are protecting a central vegetated flat. However, in this case, the western dune is an unusually high hill, and the ridges and central flat extending downwind from the western dune are all much longer than usual.

A large slip face has formed on the eastern side of the Pavilion Hill mound, which cascades down onto and is slowly burying the existing topography, i.e., the large central valley and the two flanking sand ridges. Along the northern side of the mound, and extending a few hundred feet eastward along the northern ridge, are multiple small barchan dunes with short slip faces. Apparently, an excess of sand has collected in this area and, where vegetation has not been able to keep pace, the bare sand has formed small barchans. The wind then pushes these small dunes eastward. A large deep wind valley has developed on the south side of the main slip face, between the slip face and the western end of the southern ridge. The large wind valley trends almost NS, and exits the island along the south fence line about one third the distance from the western edge of the island.

Vegetation on the large hill has increased considerably between 2003 and 2007. Most of the increased vegetation is *Amalfa*. Currently there is a fairly sharp transition line between the *Amalfa* covered area and native vegetation, which occurs along the base of the main slip face. No *Amalfa* was observed east of the transition line.

Several small longitudinal ridges have built up along the southern fence line, where localized scour is evident, due to the increased wind flow along the edge of island. However, increased sand and erosion are not as extensive as on the northern side of the island. Toward the eastern end of the southern ridge, it appears more sand is blown onto the slip face that extends into the central flat. The slip face is about 40 feet high and is moderately well vegetated. The rate of sand influx to the slip face is much less than the amount of sand being delivered to the slip face on the northern ridge.

In the case of Pavilion Hill, where a large cone-shaped dune sticks well above the surrounding topography, a large slack area formed in its wind shadow. Presumably, this large dune is a man-made dune constructed to provide a good vantage point for La Grande Pavilion dance hall that was built in1907. Pavilion Hill was anchored with European beach grass (*Amalfa*) and ice plant, so that it remained a stable feature that apparently has not moved much since it was built over 100 years ago. The “cove” downwind of the Pavilion Hill was mentioned in stories about events that took place at the dance hall in the early 1900s. It appears that the cove that was present then has persisted and become the deep valley that is present today.

Sand samples (Appendix B) were taken from the valley on the north side of the island (PV-1), from the top of the mound on the west side of the island (PV-2), and from the flat along the south side of the island (PV-3).

Changes Observed on Air Photos: The 1949 photos show the Pavilion Hill dome to be well vegetated, with perhaps a bit more vegetation than 2007. The flat and the long ridges extending east from the dome were also well vegetated. The entire island was part of a continuous vegetation island that extended from Moymell to south of BBQ South. The 1956 photos show the vegetation essentially unchanged from the 1949 photos. By 1970, a dense network of trails had significantly reduced the vegetative cover on the Pavilion Hill dome.

Topography visible in the1956 and 1970 photos is essentially the same as it is today on Pavilion Hill. However, the large flat that extended south of Pavilion Hill to BBQ Flats South was significantly segmented and reduced in size, as the sand ridge along the west side of the flat became buried by advancing sand. Barchan dunes now occupy the open sand area that has developed between Pavilion Hill and BBQ Flats. The large dome shaped hill of the west side of Pavilion Hill appears to be about the same size and shape as it was in 1992. A short (in length) but moderately high slip face of sand, present on the eastern side of the dome just below the high point of the dome in1992, is still present in 2007 but is much more vegetated.

The long ridge along the north side of the island continues to have similar topography, i.e., somewhat like the ridge along the flanks of a long parabolic dune or flute. The ridge is slightly higher than the bare sand open ride area to the north, but it has a slip face about 30 to 40 feet high on the south side. Sand blown in off the open sand sheet actively spills down the slip between the dense vegetation. Between 1992 and 2007, this ridge received quite a bit more sand, as indicated by bare spots in the slip face that previously was completely vegetated. The toe of the slip face also moved into the central flat about a distance of 40 feet (2 to 3 feet per year). The southern ridge is about the same size and dimensions as in1992, but is better vegetated. In fact, the vegetation everywhere inside the fence has noticeably filled in since 1992.

There are two small deflation bowls, one on the north and one on the south, located just east of the Pavilion Hill dome. They probably formed as a result of concentrated wind flow around the dome. Although the deflation bowl on the south side is more pronounced, both bowls appear to be about the same size in 2007 as in1992.

Maintenance Projects: In 1994, CSP moved the fence line down the hill to the west to protect an old asphalt road that used to connect an old pier with the pavilion dance hall in 1907. Also, portions of the foundation of the old dance hall were found, so more vegetation was planted to protect these features.

The 1994 revegetation project covered 2 acres, and consisted of blowing straw over the area; punching in the straw with a sheeps foot roller; waiting for seasonal rains and then hydroseeding with a mixture of wood fiber, fertilizer, guar gum, and native seed mix of sand verbena, beach evening primrose, sea rocket, beach burr, and surf saltbush. After hydroseeding, the area was rolled to get good seed/sand contact. This was followed by planting of 200 containerized plants. The project was completed in March 1995. Monitoring showed that a few years later, the plants had survived fairly well, but that small blowouts had occurred on south side.

During the 1995 season, CSP added 1 acre of revegetation. The same procedure was used and the project was completed in March 1996.

Comments: None.

Suggested Management Options:

- Maintain the vegetative cover and stability of Pavilion Hill dome on the western side of the island, and on the slip face on the northern sand ridge. This will help preserve the size and viability of the island's central valley.
- Move the fence out to the south and east, as feasible, to allow vegetation to expand in that direction. It is important to eventually get willow established in the newly vegetated areas.
- Establish a fenced corridor for access to the CXT at its current location. The corridor would need to be large enough for maintenance trucks to access the CXT, and to provide OHV parking so that use of the CXTs does not interfere with their maintenance. Modify the nature and size of the corridor periodically as vegetation advances.
- One option to maintain the long term health of vegetation in this area would be to close the ride corridor between Worm Valley and Pavilion Hill.
- Another option would be to connect Pavilion Hill, Worm Valley and BBQ Flats.

If it is decided to connect Pavilion Hill, Worm Valley and BBQ Flats:

- This would likely require a significant effort over several seasons.
- In addition to closing the ride corridor between Worm Valley and Pavilion Hill, a western slip face would have to be re-established between the SE end of Pavilion Hill and the NW side of BBQ Flats.
- Heavy equipment would be required for preliminary shaping of the sand ridge along the west side of the new island area, and shaping of the flat to the east of the sand ridge. After initial shaping, the area should be fenced and closely monitored to determine what effect the altered wind pattern has on topography.
- Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows to grow up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a "head start" in stabilizing the sand ridge that will become the western side of the new enlarged island.
- Allow natural expansion of the vegetation eastward into the flat by extending fencing to the east. This will require establishing a fenced corridor for access to the CXT at its current pavilion Hill location, or moving the CXT.
- Eventually, expand the fencing for the newly connected island of Worm Valley/Pavilion Hill/BBQ Flats to enclose the new flat that is expected to be formed. This will allow vegetation to expand naturally into the flat, and will protect any vegetation that will be planted in the flat, such as willow.

5. BBQ FLATS

Date of Site Visit: March 28, 2007

Time Spent on in Field:
2:00 - 3:45 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
John Schlosser - CGS

Shown on Figure D-2.

Existing Conditions: BBQ Flats is approximately 450 feet long (EW), 300 feet wide (NS), and is oriented parallel with the prevailing wind in a NW-SE direction. The topography of the island is characteristic of a relatively simple, large barchan dune with arms wrapping around the north and south sides of the flat inside. There is an advancing large slip face with willows growing out of the top. A long slip face cascades onto a pre-existing flat that is vegetated with mostly willow on the west and mixed vegetation on east side of the flat.

There is no wind valley between the slip face and the willow clumps at this location. This is because the slip face has over-run the willow clumps and buried them. Th willow clumps now stick out from the nearly flat windward slope. Many of the clumps located west of the crest of the slip face are dead. However, the slip face is well vegetated with live, healthy willows.

The barchan arm (sand ridge) along the north side of the island is fairly linear. Winds along the northern ridge are very strong, as evidenced by eroded roots. The barchan arm along the south side is not linear. Two slip faces extend southward off the southern arm (see Figure D-2). A 30 foot tall slip face extends directly south from the southern arm along the trend of the main slip face. Approximately 200 feet to the east, along the southern arm, another slip face breaks off to the south. This slip face is 20 feet tall at the point where it breaks away from the southern arm, but it grows in height as it extends south toward BBQ Flats South.

There is no sand ridge along the eastern half of the southern boundary of the vegetation island. The dogleg extension of the fence on the southeast side of the island encloses a bog area covered with wax myrtle and cattails. Sand sample BBQ-1 (Appendix B) was taken in the bog area. At least the upper 6 inches of “soil” in the bog is peat, which is underlain by sand.

A CTX bathroom is located just outside the fence on the north side of the fenced dogleg portion of the vegetation on the east side of the island. The CTX is near the center of the flat, which makes it difficult to fence off the rest of the flat, so that it could become vegetated like the dogleg area has become. Sand sample BBQ-2 was taken on the northeast side of the flat.

Changes Observed on Air Photos: In 1956, BBQ Flats was a crescent shaped flat, convex side pointing west, with a large western slip face. There were four patches of willows visible, in a sea of dune scrub vegetation that covered the whole flat. The northern willow patch was the largest. The next willow patch to the south was only 100 feet to the south, and was climbing the slip face of the oncoming western dune. It was about half as large as the northern willow patch. The third patch was to the south and was stretched out in a thin line along the slip face, or just below it. The fourth willow clump was at the far southeastern tip of the crescent shaped flat (i.e., the current BBQ Flats South).

By 1970, the middle two willow clumps had been reduced to pinpoints on the photos. The oncoming dune slip face had moved eastward 60 to 80 feet (approximately 3 to 4 feet per year), and essentially buried the willow clumps that had been on the slip face or just below. Also, the flat had a dense network of trails that appeared to go up the slip face as well. This indicates that some of the willow patch may have been destroyed by riding. However, in 1970, considerable dune scrub was still present on the floor of the flat and on the ridge immediately southeast. By 1992, all vegetation had disappeared except for the willow clumps on the north and south ends (BBQ Flats and BBQ Flat South, respectively). Apparently, these remnant islands had been fenced, so that between 1992 and 2007 the vegetated area actually increased in size.

Also in 1992, there was a slip face “ridge” along the north side of BBQ Flats, and a fairly straight slip face along the west side. There was not much of a ridge along the south side. The willow vegetation had grown up the slip faces on the north and west sides of the island. The rest of the island vegetation was in the small flat. In addition, there was no pond with cattails on the SE side of the island, where the fence line has been extended recently.

The size of the island appeared to stay about the same from 1992 to 2007, with exception of the SE extension where the bog is located. The ridge on the north is about the same size in 2007 as in 1992. The south half of the western slip face appears to have been augmented by a small slip face that was located west of the island in 1992. Since then, the smaller slip face has moved more rapidly to overtake the main slip face. Along the north half of the western slip face, another smaller slip face is still present and has not advanced as rapidly.

In general, there appears to have been more sand movement along the southern portion of the western slip face than there was in the northern portion. There appears to have been recently stronger winds along the southern side of the island, as evidenced by exposed willow roots along the ridge line. Additional sand appears to have been blown into the SW portion of the island. This is probably due to changing topography just to the west of the island, as more slip faces advance in from the west.

The biggest change between 1992 and 2007 is that the bog in the SE part of the island was not present in 1992, but was present in 2007, and that 6 inches of peat had apparently built up in the bog in only 15 years time.

<u>Maintenance Projects</u>: During the 1995/96 project season, CSP wanted to slow down the advance of windblown sand inundating the west and north edges of BBQ Flats. They attempted to vegetate the western side of the island to see if that would slow down the inundation.

CSP chose a relatively flat area, between the western edge of the vegetation and a high slip face to the west, approximately 2 acres in size. The same process was used as was described in the project for Pavilion Hill. The project was finished by January 1996. The project area grew up well, but the new vegetation changed the wind patterns radically, resulting in large blowouts along the southern edge of the project.

In later years, CSP tried to stabilize the top of the encroaching slip face, but high winds blew away the seed that was used to try to stabilize the dune. The slip face continued to move east and, by 2001, it had covered the January 1996 project area. The rate of advancement of the high slip face is estimated at approximately 13 feet per year, based on this information.

In February 1998, 2 acres on the west side of BBQ Flats were chosen for a different type of revegetation method. First, a harrow was used on the project site; then barley was broadcast seeded. Barley was used because it is drought tolerant and it rapidly produces a dense root system. Fertilizer pellets were also broadcast on the area, and then the seed and fertilizer were track walked in with a cat. The next step involved waiting for seasonal rain to get the seed to germinate. However, a very strong wind came 2 days after project completion, before the seed could germinate, and blew off the covering of sand, exposing the seed. The seed blew away and nothing grew on the project site. The project was considered a complete failure.

In 1999, the same project was completed by February, with the same results. A strong wind blew away the upper 1 inch of sand harrow, exposing the seed and blowing it away before it could germinate. The conclusion was that it is necessary to include straw spreading and punching to keep the sand in place to protect the seed until it can germinate. However, the additional treatment with straw mulch, punching it in, with hydroseeding costs more ($1,500 to $8,500 per acre) than just seeding with barley and lupine seed without any straw treatment.

<u>Comments</u>: Efforts to stabilize the bare sand west of the main slip face, using the technique of planting barley seed and lupine without punching in a straw mulch cover have failed. It may be that the more expensive method using straw mulch punched in with a sheeps foot roller, waiting for seasonal rains and then hydroseeding with a mixture of wood fiber, fertilizer, guar gum, and native seed mix of sand verbena, beach evening primrose, sea rocket, beach burr, and surf saltbush, as was used at Pavilion Hill, is what is needed to get vegetation growing on these harsher sites.

From studying the evidence it is obvious that in terms of longevity, a few larger vegetation islands will last longer than will more numerous smaller islands. If a larger island is to be formed in the Moymell to BBQ Flats South area, where there used to be one large island, the combination with the best chance of success appears to be a Worm Valley/Pavilion Hill/BBQ Flats combination. BBQ Flats is significantly larger than Moymell or BBQ Flats South. The open sand gap that will have to be revegetated is about the same between BBQ Flats and Pavilion as it is between Moymell and Worm Valley. So the revegetation effort would be about the same, but the area of existing vegetation to be added would be greater in the case of BBQ Flats.

A potentially much larger flat could be developed than what exists now in the Worm Valley/Pavilion Hill/BBQ Flats area. One that would have the potential for lasting many decades into the future (based on the behavior of the current islands). However this potential area of revegetated flat is currently open ride area, so for this expansion of vegetation to be possible, another area that is currently vegetate would have to be converted to open ride area.

Suggested Management Options:

- Extend the SE side of Pavilion Hill toward BBQ Flats, with the ultimate goal of attaching the two islands. This would likely require a significant effort over several seasons.
- Start by connecting fences between the two islands to keep traffic out of the current open ride area.
- Form a new sand ridge along the eastern margin of the future re-attached larger island. This would be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely the altered wind patterns would help excavate a deflation bowl downwind of the constructed ridgeline. This area should be closely monitored to determine exactly what the effect the altered wind pattern has on the topography.
- Form a flat downwind from the new sand ridge, either with heavy equipment and/or ideally with the help of the altered wind patterns.
- The flat to the east of the new slip face should be vegetated as quickly as possible. The vegetation should include a large component of willow which will help stabilize the new slip face as well as the flat.
- It may be possible to get willows to grow up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.
- It is important to retain as much of the current vegetation acreage of BBQ Flats possible until the attachment can be accomplished. Therefore, it is important to slow down the rate of encroachment of the west and north slip faces, by planting more willow in the slip face, and by vegetating the area upwind.
- Allow natural expansion of the vegetation eastward into the flat by extending fencing to the east. This will require establishing a fenced corridor for access to the CXT at its current location, or moving the CXT. If the CXT corridor is fenced, the corridor should be wide enough for maintenance truck access and OHV parking, so that CXT use does not interfere with its mainenenace.
- Eventually, expand the fencing for the newly connected island of Worm Valley/Pavilion Hill/BBQ Flats to enclose the new flat that is expected to be formed. This will allow vegetation to expand naturally into the flat, and will protect any vegetation that will be planted in the flat, such as willow.

6. BBQ FLATS SOUTH

Date of Site Visit: March 28, 2007

Time Spent on in Field:
2:00 - 3:45 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
John Schlosser - CGS

Shown on Figure D-2.

Existing Conditions: The island is approximately 200 feet wide (NS) and 270 feet long (EW). The island is oriented near EW, rather than the NW-SE orientation of many of the other islands. Its topographic setting is similar to BBQ Flats, with a high willow covered western slip face, and northern and southern ridge with slip faces that are encroaching into the central flat. A large approaching transverse dune, with a 60 foot high slip face, is located about100 feet west of the main slip face. The main slip face is essentially a willow ridge with a large slip face on the east side of the ridge and a short west-facing slope on the west side. A wind valley has formed between the approaching high slip face and the willow ridge. The wind valley is present along the southern two thirds of the willow ridge, but does not exist in front of the northern end of the ridge. Two small flutes (sand tongues) have broken through the line of willows on the willow ridge, extending toward the east. The enclosed flat is small.

The protecting sand ridges on the north and south sides of the flat both curve in toward the flat. The fence line around the island does not curve in, but extends straight eastward from the western boundary. Therefore, there are bare sand areas inside the fence line in the eastern part of the island, between the side ridges and the fence line. One sand sample (BBQS-1) was taken along the ridge on the northeast side of the island (Appendix B).

Changes Observed on Air Photos: In 1956, BBQ Flats was a crescent shaped flat, convex side pointing west, with a large western slip face. There were four patches of willow, visible in the photos, within the dune scrub vegetation that covered the whole flat. The northern willow patch was the largest. The next willow patch to the south was only 100 feet to the south, and was climbing the slip face of the oncoming western dune. It was about half as large as the northern willow patch. The third patch was to the south and was stretched out in a thin line along the slip face, or just below it. The fourth willow clump was at the far southeastern tip of the crescent shaped flat (i.e., the current BBQ Flats South).

By 1970, the middle two willow clumps had been reduced to pinpoints on the photos. The oncoming dune slip face appeared to have moved eastward 60 to 80 feet (3 to 4 feet per year) and essentially buried the willow clumps that had been on the slip face or just below. Also, the flat had a dense network of trails, which appeared to go up the slip face as well. This suggests that some of the willow patch may have been destroyed by riding. In 1970, there still was considerable dune scrub on the floor of the flat and on the ridge immediately to the southeast. By 1992, all vegetation had disappeared except for the willow clumps on the north and south ends (BBQ Flats and BBQ Flat South, respectively). Apparently these remnant islands had been fenced, so that between 1992 and 2007 the vegetated area actually increased in size.

In 1992, there were relatively small ridges with slip faces along the north, west, and south sides of the island, all vegetated with willow. There also was a small flat. Since 1992, the topography around BBQ Flats South has changed in that the side ridges are larger, and there is a 60 foot tall slip face coming in from the west about 100 feet away from the island. Also, there are two flutes extending into the island from the west. In addition, a minor increase in vegetation has occurred on the east side.

A wide sand gap between BBQ Flats and Heather also developed between 1949 and 2007. The large valley between the western and middle sand ridges, described in the geomorphology section above, contains the line of vegetation islands from Moymell south to Maidenform Flats. This valley is now filled with sand in the gap between BBQ Flats South and Heather.

This large gap in the western string of vegetation islands, is evident on the topographic map of the area, which was created using 1963 air photos. There are no enclosed depressions (below the 40 foot elevation contour) in this gap, whereas there are a string of such depressions to the north and south of the gap. Obviously this gap had been filled in with sand before 1963. Based on the vegetation pattern observed on the 1949 photos, the gap existed at that time also, although some thin long strips of vegetation, oriented NW-SE, were present. The 1956 photos, which can be viewed in stereo, show these strips of vegetation as narrow valleys elongated in a NW-SE direction, located between broad sand tongues which had bridged the bigger valley. The western edges of the narrow valleys lined up well with the western edges of a bigger valley that was still present in the vicinity of BBQ Flats South and Heather islands. So the narrow valleys appear to be remnants of the larger valley that had not yet been filled in with sand.

The 1956 photos also show a series of slip faces, or waves of transverse/barchaniod dunes, progressing eastward from the ocean to the middle sand ridge (where the Sand Highway runs today). The topography in the gap is strikingly different than the topography in the large valley where vegetation islands are present to the north and south. It appears that the vegetation islands create different sand forms than in the open dune fields. The large slip faces form along the west side of the vegetation islands, causing wind patterns to form deflation bowls on the east (leeward) side of the ridges. Without vegetation, the ridges do not grow as large, and there are no continuous deep valleys. Therefore, in the gap, the blowing sand moves relatively unimpeded from the ocean all the way to the top of the middle sand ridge.

Wherever foredunes were present, whether newly formed right along the shoreline or extending 1,000 feet inland as longitudinal dunes, barchan dunes formed downwind of them. If no foredunes were present, barchan dunes formed closer to the beach.

There were three prominent vegetated long, narrow longitudinal islands present on the 1956 photos between BBQ Flats South and Heather islands. They had the following dimensions: the northern island was 1,000 feet long by 100 to 160 feet wide; the middle island was about 500 feet long by 80 feet wide; and the southern island was 1,700 feet long by 100 to 160 feet wide.

By 1970, as observed on the air photos, these narrow vegetation islands had approximately the same dimensions, but a dense network of OHV trails had become established through them, so that individual patches of vegetation were quite small. By 1992, all traces of these islands were gone. Multiple barchans dunes were present in the area that used to contain these long linear ridges with narrow central valleys. A similar gap in the vegetation islands present in this western valley was observed on the 1930 air photo between Eucalyptus and Pipeline to the south.

Maintenance Projects: We are not aware of any revegetation projects conducted on BBQ Flats South.

Comments: Due to the relatively small size of the island, especially the island flat, it is unlikely that the island can survive more than 20 to 30 years without significant revegetation efforts to prolong its existence.

Suggested Management Options:

- One alternative is to open this area to future riding.
- Another alternative is to maintain BBQ Flats South.

If it is decided to maintain BBQ Flats South:

- The best long term approach is to allow the island to move gradually to the east. Fences should be moved to east at the same rate slip faces advance.
- To reduce the rate of slip face advancement, it is important that willow be established in the eastern portion of the flat as well as on the slip faces.
- The advancement of the slip faces should be monitored to determine how much vegetation acreage is being lost per year.
- The expansion of vegetation to the east should also be monitored, to determine what acreage is being gained each year and how quickly the fences should be moved.
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- The two small flutes/sand tongues along the willow ridge should be revegetated as quickly as possible.
- To help revegetate the sand tongues, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

7. HEATHER

Date of Site Visit: May 15, 2007

Time Spent on in Field:
12:15 - 1:15 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
John Schlosser - CGS

Shown on Figure D-3.

Existing Conditions: Heather is approximately 200 feet wide (NS) and 550 feet long (EW). The island is more elongated in a WNW-ESE direction, compared to the relatively compact shape of Acacia, Cottonwood and other islands. The western edge of the island is narrower and more pointed, the result of the northern and southern ridges squeezing in on the island's central flat.

Advancing transverse dunes with 20 to 40-foot slip faces are encroaching upon the western edge of the island. The main slip face wraps around the scattered willow vegetation on the western edge, and then extends a short distance east along both sides of the island before straightening out to a more NS orientation again. There is a wind valley at the western nose, where the main slip face is only 10 feet tall. As the wind valley turns along the northern side of the island, it crosses a portion of the main slip face to the north.

The western part of the northern ridge of the island has a heavily eroded reverse facing slope that forms the edge of the wind valley that continues down the north side of the island. This north-facing slope contains many exposed roots. The top of the northern ridge contains various types of vegetation including poison oak, willow, and *Senecio*. Sand ripples in the wind valley are 2 to 3 inches apart in some areas and 12 to 15 inches apart in other nearby areas. The wind direction that formed the ripples is from the west. The slope on the opposite side of the northern ridge (the slope which faces south toward the enclosed flat) is a slip face about 30 feet tall that is mostly unvegetated and covered with freshly deposited sand. The toe of the slip face is encroaching onto the vegetated flat.

Approximately 350 feet east of the western end of the northern ridge, a large 25-foot tall slip face turns in a northerly direction. From this point eastward, the ridge has only a 6-foot tall slip face on its south side. The large slip face that trends to the north is most likely part of a large transverse dune that encountered the vegetation island many years ago. As the dune continued traveling eastward along the north side of the island, the slip face on the northern ridge grew in height. It is expected that, as the transverse dune continues moving eastward, a large amount of sand will be added to the northern boundary and over time the slip face will grow from its present 6-foot height to approximately 30 feet. This assumes the willow vegetation will continue to keep up with the rate of sand input, as it has been able to do along the western part of the boundary ridge.

The south side of Heather has a broad wind valley extending from near the western edge of the island, along most of the southern side. The trough of the wind valley is lower than the sand ridge along the south side of the island. The southern fence line of the island is either within the trough of the wind valley or located just south of the wind valley. The western portion of the south boundary ridge is well vegetated on its north-facing slip face, which is about 25 feet tall. Most of the southern boundary ridge is not vegetated on the top, and the eastern portion of the ridge is not vegetated at all.

CSP recently moved the fences out along the northern, southern, and eastern sides of Heather, providing more space for vegetation to expand out into those areas. The vegetation in the flat is dense and consists of various types of plants including willow, heather, lupine, blackberry, and a yellow-flowered ice plant. Ripple marks near the SE edge of the island are 3 to 3.5 inches apart, with wind direction from due west.

The open ride corridor between Heather and Acacia varies from 125 to 200 feet wide between the fence lines. There is a series of four slip faces, each 20 to 40 feet high that occupies the approximately 800-foot long corridor. The stepped topography present within the ride corridor is completely different from the topography present within the adjacent vegetation islands. The islands have the basic horseshoe shaped set of ridges along the west, north and south sides, and the enclosed flat area in the center which opens toward the east. Sand samples (Appendix B) were taken from the SE corner of the flat area (H-1) and at the top of the ridge in the NW corner of the island (H-2).

<u>Changes Observed on Air Photos</u>: At the time the 1930 and 1949 air photos were taken, there was one large vegetation island in this area that included Heather, Acacia, and Cottonwood. There also were several long narrow strips of vegetation that extended northwesterly (parallel with the prevailing wind direction) from the large island toward the coast. By 1956, the vegetation had been reduced in size, especially the number and extent of the narrow vegetation strips northwest of the large island. Also, Cottonwood was almost separated from the rest of the large island by that time.

A wide sand gap developed between Heather and BBQ Flats South between 1949 and1956, filling in the large valley between the western and middle sand ridges between BBQ Flats South and Heather islands. This valley (described in the geomorphology section above) contains the line of vegetation islands from Moymell south to Maidenform Flats. The large sand gap in the western string of vegetation islands is also evident on the topographic map of the area, created using 1963 air photos to construct contours. There are no enclosed depressions (below the 40-foot elevation contour) in this gap, whereas there are a string of such depressions to the north and south of the gap. Obviously this gap had been filled in with sand before 1963. Based on the vegetation pattern on the 1949 photos, the gap existed at that time, although some thin, long strips of vegetation, oriented NW-SE were still present.

The 1956 photos, which can be viewed in stereo, show these strips of vegetation as narrow valleys elongated in a NW-SE direction, located between broad sand tongues which had bridged the bigger valley. The western edges of the narrow valleys lined up well with the western edges of a bigger valley that was still present in the vicinity of BBQ Flats South and Heather islands. The narrow valleys appeared to be remnants of the larger valley that had not yet been filled in with sand.

There were three prominent vegetated long, narrow longitudinal islands present on the 1956 photos between BBQ Flats South and Heather islands. They had the following dimensions: the northern island was 1,000 feet long by 100 to160 feet wide; the middle island was about 500 feet long by 80 feet wide; and the southern island was 1,700 feet long by 100 to160 feet wide. By 1970, as observed on the air photos, these narrow vegetation islands had approximately the same dimensions, but a dense network of OHV trails had become established through them, so that individual patches of vegetation were quite small. By 1992, all traces of these islands were gone. A sea of barchans dunes was present in this area that used to contain these long linear ridges with narrow central valleys.

The 1956 photos also show a series of slip faces, waves of transverse/barchanoid dunes, progressing eastward from the ocean to the middle sand ridge (where the sand highway runs today). The topography in the gap is strikingly different from the topography in the large valley where vegetation islands are present to the north and south of the gap. The large slip faces that form along the west side of the vegetation islands cause wind patterns that form deflation bowls on the east (leeward) side of the ridges. Without the vegetation, the ridges are not as large, and there are no continuous deep valleys. Therefore, in the gap, the blowing sand moves relatively unimpeded from the ocean all the way to the top of the middle sand ridge.

From 1956 to 1970, changes in vegetation cover at heather were small in comparison to that which occurred between 1970 and 1992. The main change from 1956 to 1970 was that considerably more bare sand trails were visible through the areas covered with dune scrub type of vegetation. Vegetation in 1970 appeared to be mainly willow growing on the flat and climbing up portions of the encroaching slip faces on the west and the north sides of the flat. A few willow clumps were located just west of the main western slip face. There were also a few remaining narrow strips of vegetation growing on narrow ridges of longitudinal dunes which extended 1000 to 1500 feet west of the island. A broad ridge, well vegetated with dune scrub vegetation, was present at this time between Heather and Acacia.

By 1992, all outlying vegetation to the west of the main slip face of Heather was gone. The main western slip face was in about the same location as it was in 1970, but much sand had apparently poured over the slip face. More bare sand and less vegetation were evident on the photos. All dune scrub vegetation that had been on the sand ridge between Heather and Acacia islands was gone. In addition, it appears considerably more sand was piled up along the north side of the island, and was encroaching into the flat. Sand was also encroaching into the flat from the south.

<u>Maintenance Projects</u>: We are not aware of any revegetation projects that were attempted at Heather island.

<u>Comments</u>: The natural processes working to close the northern and southern sand ridges, and to eliminate the central flat at Heather, are difficult to stop. Substantial revegetation efforts would be required to even slow down the process. Without significant revegetation, Heather is not likely to last more than about 40 years. While larger vegetation islands, especially those that have longer sand ridges along the

western side, appear more likely to last longer than smaller islands, Heather island has a pointed shape, with a short sand ridge along its western side.

It appears that the northern and southern sand ridges will soon close on the central flat of the island. When this happens, a willow covered longitudinal ridge will likely remain, with perhaps a small deflation bowl at the downwind end of the ridge. The geometry of Heather will be much different than the geometry of the typical vegetation island in the study area, (i.e., a horseshoe shaped set of ridges protecting a central flat that opens to the east). Wind patterns would be different, and once the island reaches the longitudinal ridge state, it may be more vulnerable to dune encroachment. Similar conditions exist today at Tabletop, where the few longitudinal ridges remaining appear wind blasted and declining in vegetation area.

If Heather were joined with Acacia, the enlarged island would likely last longer than either of the single islands. Rejoining Heather with Acacia and Cottonwood (see below) would produce an even larger island, with even greater longevity.

Suggested Management Options:

- One alternative is to allow Heather to become open ride area.
- Another alternative is to maintain the island on its own.
- A third alternative is to connect Heather and Acacia.

If it is decided to maintain Heather island on its own:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Heather and Acacia:

- It would likely require a significant effort over several seasons.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to determine what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.

8. ACACIA

Date of Site Visit: May 15, 2007

Time Spent on in Field:
10:30 - 11:30 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Tim Hanson - CSP
Nancy LaGrille - CSP
John Schlosser - CGS

Shown on Figure D-3.

Existing Conditions: Acacia is 250 feet wide (NS) and 300 feet long (EW). A series of transverse dunes moving from the west abut the island, modifying the western ridge area. There are boundary ridges and wind valleys along both the north and south sides of the island. The enclosed flat has its open side pointing more to the southeast rather than directly east like some of the other vegetation islands. The overall shape of the island is more rectangular than Heather, and it is oriented more NW–SE than Heather. The fence line observed during field work in 2007 is slightly different than the fence line shown on the 2003 site map (Figure D-3); it has been pushed out 20 to 50 feet on the north, south, and east and pulled in about 15 feet on the west side.

There is an isolated small clump of willows located approximately 100 feet west of the crest of the main slip face located along the western edge of the main mass of vegetation. The area between the willow clump and the main slip face is a windswept plain, functioning as the windward slope of the transverse dune whose slip face is the main slip face. The willow mound is severely windblown on the western tip, and willows are starting to die. However, stronger new growth is occurring on the eastern side. There are multiple-phased, braided sand ripples near the willow clump, containing dark red coarse grains. The wind direction forming the ripples varies from N30-60W.

The clump of willows is being engulfed by the slip face of another smaller advancing transverse dune. The slip face wrapping around the willow clump is about 20 feet tall. It extends southeast past the southern fence line into the ride corridor located between Acacia and Cottonwood and northeast about 100 feet before dying out. A much taller (60 foot slip face) and longer transverse dune is located approximately 100 to 150 feet west of the willow clump. This larger transverse dune extends north, well past Heather, and south, well past Cottonwood. The smaller transverse dune appears to reduce the wind velocity and sand delivery rate affecting the southern part of the main slip face along the western ridge of the island.

The main slip face along the northern part of the western ridge is subject to stronger winds that travel up the windward slope from the base of the large transverse dune located approximately 300 feet to the west. This northern section of the main western slip face has recently buried the pre-existing topographic surface, including two flutes (small sand tongues) that extend southeastward about 80 feet toward the interior of the island from the current western edge of vegetation.

Where the toe of the main slip face rests upon the old flute surfaces, it is only about 20 feet high, but on either side of the flutes the main slip face extends 60 feet or more down to the densely vegetated flat in the center of the island. It appears that growth of the willows has been able to keep up with the incoming sand to some extent. Currently, willow branches stick out of the gentle windward slope of the transverse dune. Willow hills now rise above the level of the advancing transverse dune along most of the western edge of the island, so there are no wind valleys between encroaching slip faces and the willow hills. Some dead and dying willow branches stick up through the surface of the gentle windward slope well to the west of the current crest line of the slip face. It could be that these dying willows have come in new as a result of the willow root system extending to the west, but more likely these wind blasted willows are remnants of what once was a group of willow islands, that have now been over-topped by the advancing sand.

There is a small narrow wind valley along the northern ridge of the island, which dies out along the eastern part of the northern ridge. There are many exposed willow roots, and the willows appear wind blasted along this heavily eroded north edge. The fence has been moved out about 50 feet from where it used to be. Evidence of the old fence line is marked by old peeler fence posts that are only 10 to 20 feet from the current edge of vegetation. At the east end of the northern ridge, sand ripples are 4 to 6 inches apart, with wind direction N20W.

Along the southwest edge of the island, to the west of the main slip face, the sand ripples indicate wind direction to be N30-35W. Sand sample A-2 (Appendix B) was taken near this location. Old fence posts are located within 10 feet west of the current main slip face. Apparently, the fence on the west side was moved well to the west at one time, and then more recently moved back in (to the east) again slightly.

A wind valley has also formed along the south ridge of the island. The wind valley has a shape similar to a long sand tongue, with the center axis of the tongue depressed slightly by wind erosion, and the edges of the tongue raised slightly into low narrow ridges with long relatively steep slip face slopes below the narrow ridges. The wind valley with this type of topography extends from the main slip face on the west side of the vegetation island at least half way down the length of the southern boundary ridge. Approximately half way down the southern edge of the island, a 20-foot tall slip face veers off from the ridge toward the south, and extends across the ride corridor between Acacia and Cottonwood. There are three slip faces within the ride corridor, each about 20 feet high. The open ride corridor between the islands varies from 125 to 250 feet wide between fence lines.

The central flat area is densely vegetated with Acacia trees (reportedly non-native and invasive), poison oak, and other larger, more climax-type vegetation. Along the eastern edges of the vegetation, more pioneer-type species are present, including lupine, popcorn flower, wall flower, and ice plant. The soil surface in the eastern, wind protected part of the island has a silt-rich crust. Sand sample A-1 (Appendix B) was taken from the east side of this flat area.

<u>Changes Observed on Air Photos</u>: On the 1930 and 1949 air photos, there was one large vegetation island in this area that included Heather, Acacia, and Cottonwood. Willow clumps, denoted as darker areas of vegetation on the photos, were present approximately in the same location as present day Heather, Acacia, and Cottonwood. The majority of the area making up the large vegetation isalnd was comprised of

vegetation other than willow, most likely dune scrub. There were several long narrow strips of vegetation extending northwest (parallel with the prevailing wind direction) from the large island toward the coast. By 1956, the vegetation had been reduced in size, especially the number and extent of the narrow vegetation strips northwest of the large island. Also, Cottonwood was almost separated from the rest of the large island by that time. Visible in stereo on the 1956 photos was a broad ridge covered with dune scrub vegetation, located between what today are Heather and Acacia.

From 1956 to 1970, the changes in size and condition of vegetation coverage were minimal compared to that which occurred between 1970 and 1992. The main change from 1956 to 70 was that more bare sand trails through the dune scrub vegetation areas were visible on the 1970 photos. A small sand tongue had moved most of the way across the open sand gap between Acacia and Cottonwood.

Between 1970 and 1992, the western slip face appeared to move 150 to 200 feet east during this interval (a rate of 7 to 9 feet a year). Vegetation on Acacia in 1970 was mainly willow on the western part of the flat, with willow climbing up portions of the encroaching slip face on the west, but much of the slip face was bare. There was no well defined slip face along the north side of the island. There were also several willow clumps just west of the main western slip face. Much of the eastern half of the island appeared to be dune scrub vegetation, and the broad ridge between Acacia and Heather was also covered with dune scrub. There were narrow strips of vegetation on narrow ridges on longitudinal dunes extending 1,000 to 1,500 feet west.

By 1992, all outlying vegetation to the west of the main slip face was gone with the exception of the small willow clump that is still present today. All vegetation on the broad sand ridge between the Acacia and Heather was gone. An open sand gap had opened up between Acacia and Heather, and sand was being actively transported through the gap as evidenced by the presence of moderate sized slip faces. Sand was beginning to pile up on the north side of Acacia, and a slip face had formed.

The open sand gap between Acacia and Cottonwood had widened and the tongue of sand between Acacia and Cottonwood was larger. The slip face at the eastern end of the tongue advanced about 350 feet eastward between 1970 and 1992, from part way down the southern boundary of Acacia to well out into the deflation bowl to the east of Acacia. The rate of movement of the slip face at the eastern end of the sand tongue during this time interval was about 16 feet per year. Another slip face had developed at the western end of the tongue.

Maintenance Projects: We are not aware of any maintenance projects conducted at Acacia.

Comments: The natural processes causing successive waves of transverse dunes to encroach on the island from the west, and causing the slip faces along the west, north, and south ridges to steadily encroach into the central flat of the island, would be difficult to stop. Likewise, it will require substantial revegetation efforts to keep the process at a manageable rate, so that Acacia can continue to exist. The evidence gathered in this study indicates that larger vegetation islands appear more likely to last longer than smaller islands, thus wherever it is feasible it would be advisable to rejoin two or more islands into one larger island.

Revegetation methods developed by CSP maintenance staff at ODSRVA to increase and maintain vegetative cover at the vegetation islands require considerable effort and expense. However, if they are employed here they should be adequate to maintain Acacia for a significant period of time, likely several decades or more.

As a priority, it is especially important to revegetate existing sand tongues (flutes) as well as any that develop in the future.

If two islands in this area (either Heather and Acacia, or Acacia and Cottonwood) could be rejoined into a larger island, it would very likely result in the enlarged island surviving longer than any of the single islands by themselves. The open sand gap between Heather and Acacia is approximately the same size as the gap between Acacia and Cottonwood. It appears that the revegetation effort required to rejoin either pair of islands would be approximately the same. The size of the vegetated area, and of the central flat, would be larger in the combined Acacia/Cottonwood island than in the combined Heather/Acacia island. Therefore it appears that an Acacia/Cottonwood combination would likely have the greatest longevity of the paired islands. Rejoining all three islands would produce an even larger island, which should increase longevity even more.

<u>Suggested Management Options</u>:

- One alternative is to maintain the island on its own.
- A second alternative is to connect Acacia and Heather.
- A third alternative is to connect Acacia and Cottonwood.
- A fourth alternative is to connect Heather, Acacia, and Cottonwood.
- In all options, a top priority should be to revegetate the sand tongues (flutes) – with willow if possible.

If it is decided to maintain Acacia island on its own:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy

equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.

- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Acacia and Heather:

- It would likely require a significant effort over several seasons.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.

If it is decided to connect Acacia and Cottonwood:

- It would likely require a significant effort over several seasons.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to

be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.

- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Cottonwood large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

If it is decided to connect Acacia with both Heather and Cottonwood:

- See suggested techniques for rejoining islands in the above discussion for connecting Acacia and Heather and Acacia and Cottonwood.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Cottonwood large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

9. COTTONWOOD

Date of Site Visit: May 15, 2007

Time Spent on in Field:
8:30 - 10:30 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Tim Hanson - CSP
Nancy LaGrille - CSP
John Schlosser - CGS

Shown on Figure D-3.

Existing Conditions: The island is approximately 400 feet wide (NS) and 600 feet long (EW). It is oriented in a NW-SE direction, with high sand ridges along the north, west, and south sides, and a large flat area in the center and eastern part of the island.

Approximately 250 to350 feet west of the island there is an advancing transverse dune with slip face 40 to 60 feet high. The slip face of another transverse dune has recently contacted the southwestern side of the island, where the slip face wraps around a small willow covered hill and then continues north into the open ride corridor between Cottonwood and Acacia. South of the willow covered hill the slip face forms the south western edge of the vegetation island. There is a small wind valley about 20 feet deep present at the along the southwest side of the willow hill. Willow roots and nearly horizontal sand layering is present on the sides of the eroded small hill. Sand sample C-1 (Appendix B) was taken on the flat ground just west of the wind valley. Sand ripples in the area were 6 to 12 inches apart with coarse grains on the top, indicating a wind direction of N50-60W that formed the ripples.

The northern part of the west edge of the island does not have such a clearly defined, linear slip face crest. Instead the crest along the northern part of the western edge is very irregular, with two 50-foot wide by 180-foot long sand tongues extending eastward from the general crest line to well inside the vegetation island. Sand sample C-3 was taken inside the vegetation, a short distance northeast of the eastern tip of the southern sand tongue. The sample location was on an older, now well vegetated, sand tongue that supported large 20+ year old willow trees. The willow leaves and other vegetation had a thick coating of dust from a wind storm that had occurred the week before our field visit. The ground surface had a crust of moss, decomposed leaves and fine silty dust. Other vegetation in the area included poison oak, Virginia creeper, and some cottonwoods.

The two sand tongues on the northwest side of the island have the typical sand tongue (or flute) topography, with a depressed axis where wind erosion occurs, and raised narrow ridges along each side, with long slip-face slopes below each of the side ridges. The slip faces are well vegetated with willow branches poking up through the freshly deposited sand. The bare sand tongues appear to be just the most recent in a series of sand tongue intrusions into this area. The older sand tongues are now well vegetated, and their topography has been modified to form longitudinal ridges. The series of old ridges are hidden somewhat by dense vegetation, but they extend from the northwestern edge of the island for several hundred feet southeast into the interior of the vegetation island. From the leeward end of the series of old sand tongues, steep slopes extend down 50 feet or more to the floor of the central flat.

The northern boundary ridge gets wind blasted, and there are many dying willow roots and old sand striations exposed on the eroded north side of the ridge. The rate of sand movement through the open ride corridor between Cottonwood and Acacia appears high, based on the presence of three 20-foot tall slip faces, and on the large sand ridge that has built up on the northern side of Cottonwood. This ridge currently has a bare slip face 30 to 40 feet tall facing into the interior of the island. Sand sample C-2 was taken along the northeastern side of the ridge.

Along the southern part of the western edge, the topography appears to be simpler, with a linear slip face forming the western edge of the island. Strong winds blow from the base of the high transverse dune, located to the west of the island, up the gentle windward slope of the transverse dune that has recently contacted the island and that forms the ridge along the southwest edge of the island. The slip face along the southwest edge is about 50 feet high, and most of the slip face surface has willow branches growing out of it. The orientation of the crest of the slip face changes from NW-SE along the southern part of the western edge to NS at the southwest corner of the island. At that point the slip face bends southward away from the island out into the open ride area, where the slip face is about 30 feet tall.

The southern boundary ridge beyond the southwest corner of the island is bare sand on top, with a 20 to 30-foot high slip face that is mostly vegetated. The slip face on the southern boundary ridge also bends to the south at a point about two thirds of the way along the south boundary. The slip face extends out into the open ride area, and beyond this point the southern boundary ridge becomes much smaller.

There is a CXT bathroom at the eastern side of the vegetation island, adjacent to the central flat. Some common vegetation in the flat includes lupine, *Senecio*, *Phacelia*, and poison oak. The vegetation island has affected the wind flow pattern so that there is a topographic low spot just east of the island, which forms a large bowl. The eastern side of the bowl transitions into the long, gentle windward slope of the large transverse dune that crests about a 1,000 feet to the east along the Sand Highway.

<u>Changes Observed on Air Photos</u>: On the 1930 and 1949 air photos, there was one large vegetation island in this area that included Heather, Acacia, and Cottonwood. Willow clumps, denoted as darker areas of vegetation on the photos, were present where the present day Heather, Acacia, and Cottonwood are located. The majority of the vegetated area making up the large island was comprised of types of vegetation other than willow, most likely dune scrub. There were several long narrow strips of vegetation that extended northwesterly (parallel with the prevailing wind direction) from the large island toward the coast. There was a large area of dune scrub present to the southeast of the location of present day Cottonwood.

By 1956, the vegetation had been reduced in size, especially the number and extent of the narrow vegetation strips northwest of the large island. Cottonwood was nearly separated from the rest of the large island by that time, and a 350-foot wide sand tongue separated Cottonwood from Eucalyptus North. Based on the pattern of vegetation observed on the 1930 air photo, it appears there was a sand tongue present between the two islands at that time, but the gap in the vegetation appeared to be only about 200 feet wide. A moderately tall slip face defined the north edge of the sand tongue, and formed the southern edge of Cottonwood as well.

Between 1956 and 1970, only minor changes in the vegetation coverage occurred. The main change from 1956 to 1970 was that more bare sand trails through the dune scrub vegetation areas were visible on the 1970 photos. By 1970, a small sand tongue had moved most of the way across the open sand gap between Acacia and Cottonwood. The sand tongue between Cottonwood and Eucalyptus North appeared to be about the same size as it had been in 1956. The large dune scrub vegetation area southeast of Cottonwood was still intact, but with a dense network of trails.

In 1970, there was a narrow ridge of vegetation located well to the west of the island. This was gone by 1992. The main western slip face appeared to move about 250 feet to the west during this interval, for an average rate of 11 feet per year. Several willow clumps that had been located in this area, west of the main island, were overwhelmed and removed by advancing transverse dunes by 1992.

By 1992, all of the long narrow strips of vegetation that had extended northwest of the island were gone. Almost all of the dune scrub vegetation that had been present southeast of the island was also gone. The open sand gap between Acacia and Cottonwood had widened and the tongue of sand between Acacia and Cottonwood was larger. The slip face at the eastern end of the tongue advanced about 350 feet eastward between 1970 and 1992, from part way down the south boundary of Acacia to well out into the deflation bowl to the east of Acacia. The rate of movement of the slip face at the eastern end of the sand tongue during this time interval was about 16 feet per year. Another slip face had developed at the western end of the tongue. The slip face along the north ridge of the island moved into the central island flat approximately 150 feet during this time interval (a rate of 7 feet per year), removing vegetation (mostly willows) along that slip face. The wide sand tongue on the south side of the island had received more sand, and the slip face along the south side of the flat continued to move into the flat.

<u>Maintenance Projects:</u> During the 1996/97 season, 1.5 acres west and north upwind of the island were treated. The project was reportedly completed in February 1996. The goal was to slow down the rate of sand movement into this island from the west and north. The fence was moved out, to allow protection for the newly revegetated area. The project involved blowing in straw, punching it in with a sheepsfoot roller, hydroseeding, then rolling or harrowing the surface to make good contact between seed and soil.

The project area grew well, but caused a wind shift, which caused a huge blowout just west of the project area, and at the south end of the project area as well. The excavated sand blew into the southern edge of the island. Over the next few years the blow out grew toward the east, and eroded the southern part of the revegetation project area. A few years later the new vegetation in the northern part of the project area was buried by blowing sand. However the project did succeed in slowing down the advancement of sand into the island and was considered a success. The maintenance staff felt that the project would have performed better if the revegetated area had extended up to the base of the high slip face to the west.

Comments: The dune environment around Cottonwood is very dynamic. The topography and the pattern of vegetation are constantly changing. The natural processes causing successive waves of transverse dunes to encroach on the island from the west, and causing the slip faces along the west, north, and south ridges to steadily encroach into the central flat of the island, are difficult to stop. It appears likely that, if the fencing around the island is held static and the vegetation is left unmanaged, the natural processes would eventually bury the island in sand. The vegetation would continue to shrink in size until it ceased to exist at this location.

How long it would take for the vegetation island to shrink out of existence is difficult to predict, but it probably would take several decades, if left unmanaged. Based on changes in vegetation observed on air photos in the ODSVRA vicinity between 1930 and 2007, areas as large as this island disappeared within 20 to 50 years. However many of those areas were not fenced to keep vehicles away from the vegetation.

Revegetation and maintenance techniques can be employed to slow the processes to a manageable rate, and to adapt to the processes, so that the vegetation island can continue to exist for a significantly longer period of time. The evidence gathered in this study indicates that larger vegetation islands appear more likely to last longer than smaller islands, thus wherever it is feasible it would be advisable to rejoin two or more islands into one larger island.

Revegetation methods developed by CSP to increase and maintain vegetative cover at the vegetation islands generally require considerable effort and expense. If they are employed here, Cottonwood could be maintained for a significantly longer period of time than it would survive without management.

As a priority, it is especially important to revegetate existing sand tongues (flutes) as well as any that develop in the future.

If Acacia and Cottonwood could be connected into a larger island, it would very likely result in the enlarged island lasting longer than either of the single islands by themselves. However, any future revegetation effort here should consider the potential for causing unexpected wind erosion, as occurred here in a previous revegetation project, in the area immediately west of the island.

Suggested Management Options:

- One alternative is to maintain the island on its own.
- A second alternative is to connect Cottonwood and Acacia.
- In both options, a top priority should be to revegetate the sand tongues.

If it is decided to maintain Cottonwood on its own:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in. This will require moving the CXT or establishing a fenced corridor around the CXT large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to determine how much acreage is being gained each year and how quickly fences in both areas can be moved (“in” on the west and north; “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Cottonwood and Acacia:

- It would likely require a significant effort over several seasons.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Cottonwood large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

10. EUCALYPTUS NORTH

Date of Site Visit: May 15, 2007

Time Spent on in Field:
3:30 - 4:10 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
John Schlosser - CGS

Shown on Figure D-4.

Existing Conditions: Eucalytpus North is approximately 500 feet wide (NS), 450 feet long (EW), and has a pronounced NW-SE orientation. There is a line of transverse and barchanoid dunes located about 400 to 500 feet west of the group of Eucalyptus islands. Most of the dunes have large slip faces 60 to 80 feet tall, except for a wind gap in the line of dunes where the slip faces are only about 30 feet tall. The wind gap is west of Eucalyptus North and northwest (upwind) of the ride corridor between Eucalyptus North and Eucalyptus Tree. This wind gap contributes to the erosion and sand inundation observed along the north side of Eucalyptus Tree, and the large flute of sand pushed out into Eucalyptus North at location A, shown on Figure D-4.

The area between the base of the tall dunes to the west and the western edges of the Eucalyptus islands is a long, gentle windward slope of the transverse dune that forms the western ridge of each of the Eucalyptus islands. The tall slip face along the western side of each of the islands is a segment of the longer slip face of this transverse dune. The fence line on the western side of Eucalyptus North is 150 to 200 feet west of the west edge of vegetation.

Location A, in the southwest corner of the island, is a 180 foot wide flute of freshly deposited sand which has extended about 75 feet eastward, burying the previously existing willow-covered slip face. The flute has an unvegetated slip face 60 to 70 feet high that extends out onto the island flat below. Because it lies directly east of the wind gap in the line of high dunes west of the island, there is a rapid influx of sand to this particular location. The flute is located between a small, wind-blasted, willow-covered hill that extends westward on the south side of the flute, and a narrow finger of vegetation that extends westward on the north side of the flute. Sand sample EN-1 was taken here, west of the crest. Sand ripples here were 5 to 6 inches apart, with a wind direction of N75W.

The crest line of the slip face at A lines up with the crest line of the slip face that continues south through the southern fence line and across the ride corridor between Eucalyptus North and Eucalyptus Tree. It actually goes to the east side of the little willow covered hill that marks the southern edge of the flute. The slip face just inside the fence line, adjacent to the ride corridor, slopes at a 61% angle, and is 40 to 50 feet high. A line of old fence posts here has been partially to completely buried. In the ride corridor, the slip face angle is 50%, but remains about 40 feet high.

The west edge of Eucalyptus North has a very irregular boundary between sand and vegetation, but generally is oriented NS. There are two other flutes along the western edge, one at the NW corner of the island and one in the middle, between the NW corner and the flute at location A. The central flute is 75 feet wide, 100 feet long, and appears to be less active than the flute at A, primarily because the slip faces along its margins are all heavily vegetated with willow.

The flute in the NW corner appears to be quite active, with a tall, unvegetated slip face along its eastern edge. It also has a recently very active lobe about 40 feet wide which is extending eastward more rapidly than the rest of the flute. Vegetation in the NW corner of the island, next to the fence, also has increased from that shown on the 2003 air photos used as field maps for this project (also used to make Figure D-4.)

The southern boundary ridge extends east from the high slip face located along the west side of the island. It is broad and generally unvegetated on top and on the south-facing slope between the ridge top and the southern fence line. Its steep interior (north-facing) slope is 20 to 40 feet high. Generally the slope is well vegetated, mostly with willow. Near the eastern end of the island the steep slope of the southern boundary ridge turns abruptly to the south and continues across the ride corridor into Eucalyptus Tree south of the corridor.

The northern boundary ridge is smaller and shorter than the northern ridge of most of the vegetation islands in the study area. It is not nearly as windblown as other islands, probably because the ridge of dunes located on the broad sand tongue between Eucalyptus North and Cottonwood provides protection from the wind. Lupine as well as willows grow on the ridge and slip face. Sand sample EN-2 was taken from the vegetated flat near the fence southeast of the northern ridge.

The SE corner of the island protrudes out to the east. In general lupine and *Juncus* grass extend 10 to 15 feet east of the existing fence line along the entire east side of the island. The deflation bowl or flat that has formed in the wind shadow on the east side of the island is considerably larger than what lies inside the eastern fence line. Vegetation could be extended eastward fairly rapidly in this flat if it were fenced off.

<u>Changes Observed on Air Photos</u>: On the 1930 and 1956 air photos Eucalyptus North, Eucalyptus Tree, and Eucalyptus South were all part of one large vegetation island. To the north, the large island was separated from Cottonwood a SE trending sand tongue, and to the south, it was bordered by a tall NW-SE trending slip face that defined the northern margin of a group of large sand tongues. The vegetation island contained several small clumps of willows in the north, surrounded by dune scrub vegetation, and several larger willow clumps in the south, also surrounded by dune scrub vegetation. A broad NW-SE trending ridge lay between what later became Eucalyptus North and Eucalyptus Tree islands, separating the island flat into a northern and southern section. The ridge may have been an old sand tongue that had become vegetated with dune scrub.

The part of the island that became Eucalyptus North was separated by a narrow NW-SE trending ridge. The ridge, together with the tall south-facing slip face along the southern margin of the sand tongue between Eucalyptus North and Cottonwood, formed a narrow enclosed flat. The flat was elongated in a NW-SE direction, had a moderately tall western ridge with a slip face, and was open to the east.

A number of long, narrow longitudinal ridges extended 500 feet or more to the NW from the Eucalyptus group of islands. The ridges were primarily vegetated with willow, based on the dark color observed on the air photos. Some patches of lighter colored vegetation, interpreted to be dune scrub, were intermixed with the willows. There did not appear to be much change in the extent of the area covered by vegetation between 1930 and 1956. The slip face along the west side of the combined island did not appear taller than about 30 to 40 feet.

By 1970, the topography of the Eucalyptus islands remained essentially the same. The islands continued to be one vegetated mass. Although the extent of vegetation was similar to what it was 14 years earlier, there were many more trails evident in the dune scrub vegetation, and the vegetation on the longitudinal ridges had diminished.

After 1970, a much more distinct slip face formed along the west side of Eucalyptus North. The broad ridge between Eucalyptus North and Eucalyptus Tree was totally denuded and looked more like a sand tongue, with some active dune slip faces forming on it. The loss of vegetation on this ridge cut the previously combined vegetation island into two islands. A new slip face formed along the south side of the sand tongue, but did not encroach far into the north side of Eucalyptus Tree. As the longitudinal ridges to the west and the vegetation on them disappeared, additional sand moved eastward from the ocean toward the Eucalyptus group of islands. Increased amounts of sand also moved along the wide tongue to the south of the Eucalyptus group of islands.

By 1992, the slip face of the tongue along the north side of Eucalyptus North had moved southward into the small elongated flat, filling it with sand, and leaving only the one larger flat. Vegetation along the northwest side of the island retreated noticeably, approximately 150 feet since 1970 (roughly 7 feet per year). Vegetation along the remainder of the west side of the island also retreated, but not nearly as much as the northwest side. Vegetation extended 50 feet or so farther east into the flat.

Between 1992 and 2003, the western edge of Eucalyptus North receded eastward approximately 75 feet (8 feet per year). Also some small flutes began moving toward the island interior. The residual old trails present on the island inside the fence line in 1992 filled in with vegetation by 2003, and vegetation continues to expand eastward, outside the fence line.

Maintenance Projects: We are not aware of any revegetation projects conducted on Eucalyptus North.

Comments: The three flutes (small sand tongues) on the west side of the Eucalyptus North are sites of rapid influx of sand into the island, and should receive immediate attention in terms of revegetation and stabilization. Willows have had a difficult time keeping up with the rate of sand influx on the flutes that have formed since 1992.

The deflation bowl or flat that has formed in the wind shadow on the east side of the island is considerably larger than what lies inside the eastern fence line. Vegetation would probably expand fairly rapidly in any part of the flat that could be fenced off. If the rapid rate of movement of the western slip face cannot be reduced considerably, fencing should be moved east in the flat, and willow should be aggressively planted in the newly expanded area. It would then well established and ready to rapidly climb up the advancing slip faces when they arrive.

Since evidence found in this study indicates that larger islands tend to last longer than smaller ones, rejoining all three of the Eucalyptus islands back into one should be considered. The process of rejoining islands does not appear to be simple or easy in most situations. In this particular situation, where there is a wind gap in the line of tall dunes to the west of the open ride corridor between Eucalyptus North and Eucalyptus Tree, very strong winds and a high rate of sand movement would likely make re-connection here even more difficult.

Suggested Management Options:

- One alternative is to maintain the island on its own.
- Another alternative is to connect Eucalyptus North and Eucalyptus Tree.
- In both alternatives, the three flutes (sand tongues) on the west side of the island should vegetated and stabilized as soon as possible.

If it is decided to maintain Eucalyptus North:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in. If the advancement of the slip face on the west is not reduced substantially from its current rate of eastward movement, then fences on the west and east sides should be moved eastward to allow vegetation of the flat on the east side of the island to proceed as rapidly as possible.
- Currently the fence on the west side is 150 to 200 feet west of the vegetation edge in a very windswept area. CSP should consider monitoring this area, to see if willow along the western vegetation line of the island will expand westward if protected from riding.
- If willow vegetation on the west side of the island does not expand on its own, the area should be planted to help capture and slow down the large amount of sand that appears to blowing toward the west side of the island. Because this area is subject to very strong winds, revegetation may be difficult. Experience from previous revegetation efforts in similar situations also indicates that new vegetation could cause changes in wind behavior, which could cause significant scour adjacent to the newly vegetated area. Experience has also indicates that the revegetated area could well be buried by sand within a few years. This may be acceptable, if it is viewed as having slowed down the advancement of the main slip face bordering the island.
- Willows should also be planted on the patches of bare slip face along the western side to reduce rapid migration eastward.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.

- The expansion of vegetation to the east and south should also be monitored, to determine what acreage is being gained each year and how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- It would be very important to revegetate any flutes or sand tongues that develop along the slip faces as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegete.
- Revegetate the large bare wide topped ridge along the south side of island.

If it is decided to connect Eucalyptus North and Eucalyptus Tree:

- It would likely require a significant effort over several seasons.
- Because the open ride corridor between the two islands is directly downwind from a wind gap in the line of tall dunes to the west, all measures to be conducted would have to take into account how the proposed measure would likely react when subjected to periods of sustained high winds.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Eucalyptus Tree large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

11. EUCALYPTUS TREE

Date of Site Visit: May 15, 2007

Time Spent on in Field:
2:30 - 3:30 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
John Schlosser - CGS

Shown on Figure D-4.

Existing Conditions: Eucalyptus Tree is approximately 600 feet wide (NS), 700 feet long (EW), and is oriented in a more E-W direction than most of the other vegetation islands. Eucalyptus Tree and Eucalyptus South are separated only by a narrow ride corridor, so that the two function more like one island than two separate islands. The unvegetated corridor is oriented EW rather than parallel with the prevailing wind direction of NW-SE, and is narrow enough along most of its length, so that strong winds apparently do not develop in the eastern two thirds of the corridor. The only adverse effect of the ride corridor between the two islands appears to be the removal of vegetation along the high slip face located along the western side of the islands. Strong winds do apparently blow frequently into the northwest side of Eucalyptus South, and these winds carry sand that would have been trapped in vegetation along the slip face if it had been present. Instead it has been piling up in the vegetation on the northwest corner of Eucalyptus South. However, the effects of wind are not as pronounced along the south side of Eucalyptus Tree, where the southern boundary ridge is small or non-existent; nor along the north east side of Eucalyptus South.

Eucalyptus Tree and Eucalyptus South are affected by similar processes, due to similar topographic setting. There is a very large, fairly continuous transverse dune located about 400 to 500 feet to the west of the islands. The dune has a slip face at least 60 to 80 feet high. The presence of this long tall dune has caused a narrow deflation valley to be formed along the base of the tall slip face. A gentle uniform windward slope then extends from the base of the slip face up to the western edge of the vegetation islands, where an irregularly shaped transverse dune has its crest. A fairly continuous slip face has formed along this western island edge, from north of Eucalyptus Tree to well south of Eucalyptus South.

Another shorter transverse or barchanoid dune is located about 125 feet west of the west edge of vegetation on Eucalyptus Tree. This dune is approximately 250 feet long and 25 feet tall. Small groups of pioneer plants have sprung up in the area of this discontinuous, lower slip face. If willows were planted in the small deflation bowl at the base of this slip face, and others like it, the willows would probably slow down the advancing dunes.

There are a number of small willow knobs (hills) along the western edge of the island that extend above the surface of the windward slope and the slip face of the transverse dune that has encountered the west side of the island. The willow knobs have been battered by wind and blowing sand, and numerous roots have been exposed. In some places small, short wind valleys have formed at the windward nose of the willow knobs. One example of a sand blasted willow knob is at sand sample location ET-1 (Appendix B) in the southwest corner of Eucalyptus Tree. Sand ripples near the base of the willow knob were 27 to 30 inches apart with coarse grains on top. Some shell fragments were exposed in the dead willow roots.

Where willow knobs do not extend above the encroaching dune slip face, it is assumed the dune has over-ridden the hills that used to be present. Now sand blows up the bare windward slope to the crest of the slip face, where it then cascades down the slip face to the central flat of the island. In most cases the slip face is vegetated with willow branches sticking out from the slip face surface. In some cases the willow branches manage to stick out of the bare sand surface of the windward slope a few feet west of the crest of the slip face. It is assumed that these willows have recently been buried by the advancing slip face, and it seems unlikely they can survive for long. However, they should be monitored to see whether they can continue to survive, and what effect their presence has on the dune.

The western fence line has recently been moved farther westward than it had been previously, so that there is a wide expanse of bare sand between the fence line and the crest of the slip face/ western edge of vegetation. In the southwest corner of the island, the fence has been almost completely buried where the main slip face crosses the southern fence line, indicating 4 to 5 feet of increased sand depth since this most recent fence was installed. The slip face here is 30 feet tall. Sand ripples indicate the wind direction has been N70W.

Along the western side of the island, narrow flutes of sand extend eastward from the general NS oriented crest line of the slip face. The slip faces coming off the flutes extend 30 to 50 feet down to the floor of the densely vegetated central flat. In the northern part of the western edge of the island, the main slip face has recently buried a pre-existing large flute. The slip face is 25 feet high, completely unvegetated, and it toes out on top of the older sparsely vegetated flute.

The main slip face continues northward across the ride corridor between Eucalyptus Tree and Eucalyptus North and on into Eucalyptus North, as a 40 to 50-foot tall slip face. The northwest corner of the island has experienced an increased rate of sand influx recently, as evidenced by the size and fairly rapid movement of the main slip face in this area. The increase is probably due to the presence of the wind gap in the line of tall dunes just to the northwest of the ride corridor.

The northern boundary ridge is very wide and mostly unvegetated on the top. The interior (south-facing) slip face is about 30 feet tall on the west end, decreasing to 10 feet tall on the east end. It is generally well vegetated with willows. The northern fence line has been recently moved well north of the edge of vegetation, so that a wide area of bare sand has been included in the island.

The southern boundary ridge is small to non-existent, due probably to protection from strong winds provided by having just a narrow ride corridor between this island and Eucalyptus South.

The central flat of the island is fairly large, and well vegetated with a variety of types including willow and eucalyptus in the interior, and lupine and *Juncus* grass along the edges outside the fence line. The CXT bathroom is located on the east side of the island. Sand sample ET-2 was taken just north of the CXT within the vegetated flat.

<u>Changes Observed on Air Photos</u>: On the 1930 and 1956 air photos, Eucalyptus North, Eucalyptus Tree, and Eucalyptus South were part of one large vegetation island. To the north, the large island was separated from Cottonwood by a NW-SE trending sand tongue, and to the south it was bordered by a tall NW-SE trending slip face that defined the northern margin of a group of large sand tongues. The vegetation island contained several small clumps of willows in the north, surrounded by dune scrub vegetation, and several larger willow clumps in the south, also surrounded by dune scrub vegetation. A broad NW-SE trending ridge lay between what later became Eucalyptus North and Eucalyptus Tree islands, separating the large island flat into a northern and southern section. The ridge may have been an old sand tongue that had become vegetated with dune scrub, but there was no high slip face along the west side of this ridge, and no willow growing on the ridge.

A number of long narrow longitudinal ridges extended 500 feet or more to the NW from the Eucalyptus group of islands. The ridges were primarily vegetated with willow, based on the dark color observed on the air photos. Some patches of lighter colored vegetation, interpreted to be dune scrub, were intermixed with the willows.

There did not appear to be much change in amount of area covered by vegetation between 1930 and 1956. The slip face along the west side of the combined island did not appear taller than about 30 to 40 feet.

Between 1956 and 1970, the topography remained essentially the same. The islands continued to be one vegetated mass. Although the extent of the area covered by vegetation was very similar to what it was 14 years earlier, the density of vegetation cover had diminished, especially in the dune scrub areas. There were many more trails evident in the dune scrub vegetation on the broad ridge between Eucalyptus North and Eucalyptus Tree. A wide flat area in the southeast corner of Eucalyptus Tree that had been dune scrub was completely cleared of vegetation, which nearly separated from Eucalyptus South. However, a dense patch of willow growing on the western slip face still connected the two vegetation islands. The vegetation on the longitudinal ridges to the west of the islands had also diminished.

Between1970 and 1992, the broad ridge between Eucalyptus North and Eucalyptus Tree was totally denuded, and started to look more like a sand tongue, with some active dune slip faces forming on it. The loss of vegetation on this ridge cut the previously combined vegetation island into two islands. A new slip face formed along the south side of the new sand tongue between Eucalyptus North and Eucalyptus Tree, but did not encroach far into the north side of Eucalyptus Tree. As the longitudinal ridges to the west and the vegetation on them disappeared, additional sand moved eastward from the ocean toward the Eucalyptus group of islands. In their place was a series of barchan and transverse dunes in an open dune field. Increased amounts of sand also moved along the wide tongue to the south of the Eucalyptus group of islands.

Between 1992 and 2003, the western edge of Eucalyptus Tree appeared to have receded eastward approximately 75 feet (8 feet per year). Also some small flutes began moving in toward the island interior. The residual old trails inside the fence line that were visible on the 1992 air photos had almost completely filled in with vegetation by 2003, and vegetation continued to expand eastward outside the fence line.

Maintenance Projects: "Eucalyptus" 1996/97 was completed in February 1996. The maintenance notes describe the project area as Eucalyptus, therefore it is assumed that the notes refer to Eucalyptus Tree rather than Eucalyptus North. The project area included 2.5 acres west and north of "Eucalyptus". It was noted that after the area "is stabilized the fence will be moved" westward to protect the revegetation project area.

The project included blowing straw over the area; punching in the blown straw with a sheepsfoot roller; then waiting for seasonal rains. Once rains began, the area was hydroseeded, and afterwards rolled or harrowed to make good contact between the applied seed and the ground surface. Monitoring of the site followed for several years.

It was observed that the project slowed down sand movement, but over time the strong winds and blowing sand undid what was done over the course of the following 5 years. The maintenance staff felt that the longevity of the revegetation effort would have been extended if they had planted west to the base of the high slip face, which moves slower. In the case of the regevetation project, 12 to 18 inch slip faces developed between the high slip face and the revegettion project, causing sand to move in more quickly and gradually bury the project vegetation.

Comments: The situation near Eucalyptus Tree is different from other islands to the north of the Eucalyptus group in that a large, fairly continuous 60 to 80 foot tall transverse dune is located 500 feet to the west of the islands. A deep deflation "valley" has formed at the base of the slip face, and a long gentle windward slope extends up from the valley to the top of the transverse dune that forms the western edge of these islands. Strong winds howl up the slope toward the islands.

The flutes on the west side of Eucalyptus Tree should be top priority for revegetation and stabilization. Vegetation naturally tends to expand east into the flat. It has extended beyond the fence line in several places. The flat is larger than what is currently fenced. If fencing were extended to the east it is very likely that the area could be quickly revegetated.

On the west side of the island conditions are much harsher and less conducive to successful revegetation. However the existing willows sticking out of the windward slope, west of the main slip face, should be monitored to determine if willows do naturally expand westward, or if they are just branches of recently buried willow hills in the process of dying out. Willows planted in small deflation bowls may be able to survive inside the fence line in places such as at the base of the slip face of the short transverse/barchanoid dune west of the island. If so they could expand to vegetate the slip face and slow down its eastward movement.

Since evidence found in this study indicates larger islands tend to last longer than smaller ones, rejoining Eucalyptus Tree with Eucalyptus South should be considered.

Because the ride corridor between the two islands is fairly narrow, the reconnection should be easier to do than in other locations. Connecting all three of the Eucalyptus islands back into one should also be considered. However, connecting Eucalyptus North with Eucalyptus Tree is likely to be more difficult. Where there is a wind gap in the line of tall dunes to the west of the open ride corridor between Eucalyptus North and Eucalyptus Tree, very strong winds and a high rate of sand movement through the ride corridor would make reconnection more challenging.

Suggested Management Options:

- One alternative is to maintain Eucalyptus Tree on its own.
- Another alternative is to connect Eucalyptus Tree and Eucalyptus South.
- A third alternative is to connect Eucalyptus Tree and Eucalyptus North.
- A fourth option is to connect Eucalyptus Tree, Eucalyptus North, and Eucalyptus South.
- In all options, the flutes (sand tongues) on the west side of the island should be vegetated and stabilized as soon as possible.

If it is decided to maintain Eucalyptus Tree on its own:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in. If the slip face on the west is not slowed down substantially from its current rate of eastward movement, then fences on the west and east sides should be moved eastward substantially, to allow vegetation of the flat on the east side of the island to proceed as rapidly as possible.
- In an effort to slow down advancement of dune slip faces west of the island, willow could be planted in small deflation bowls at the base of slip faces of even the short dunes such as the one located inside the fence line west of the current vegetation. Also the existing willow branches that stick out of the windward slope west of the main slip face should be monitored to determine if willow can expand westward into such locations, or if the existing willows are merely branches of buried willow hills that are in the process of dying.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Eucalyptus Tree large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.

- It would be very important to revegetate any flutes or sand tongues that develop along the slip faces as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Eucalyptus Tree and Eucalyptus South:

- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Enhance the existing sand ridge and slip face that extends between the two islands. This will be the new western edge of the future re-attached larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. The altered wind patterns may help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Within the flat portion of the closed ride corridor, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Eucalyptus Tree large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

If it is decided to connect Eucalyptus Tree and Eucalyptus North:

- It would likely require a significant effort over several seasons.
- Because the open ride corridor between the two islands is directly downwind from a wind gap in the line of tall dunes to the west, all measures to be conducted would have to take into account how the proposed measure would likely react when subjected to periods of sustained high winds.
- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge along western margin of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.

- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Eucalyptus Tree large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

If it is decided to connect Eucalyptus Tree, Eucalyptus North, and Eucalyptus South:

- See suggested techniques for connecting these islands in the above discussions.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Eucalyptus Tree large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

12. EUCALYPTUS SOUTH

Date of Site Visit: May 15, 2007

Time Spent on in Field:
1:45 - 2:30 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
John Schlosser - CGS

Shown on Figure D-4.

Existing Conditions: Eucalyptus South is approximately 300 feet wide (NS), 450 feet long (EW), and oriented in a NW-SE direction. Eucalyptus South and Eucalyptus Tree are separated by a narrow ride corridor, so that the two function more like one island than two separate islands. The unvegetated corridor is oriented EW rather than parallel with the prevailing wind direction of NW-SE. The corridor is narrow enough along most of its length that strong winds apparently do not develop in the eastern two thirds of the corridor. The only adverse effect of the ride corridor between the two islands appears to be the removal of vegetation along the high slip face located along the western side of the islands. Strong winds apparently blow frequently into the northwest side of Eucalyptus South, and these winds carry sand that would have been trapped in vegetation along the slip face if it had been present. Instead sand has been building up in the vegetation on the northwest corner of Eucalyptus South.

The western edge of the island in general appears to get battered regularly by strong winds and to be overrun by a high rate of sand influx. The wind has a straight run of 500 feet or so up a 5% windward slope from the base of an 80 foot high slip face to the west. The windward slope of the transverse dune (or series of barchanoid dunes) has buried most of the willow hills and knobs on the western side of the island, so that sand is transported directly to the main slip face along the western side of the island. Here it either cascades down the slip face or is pushed out into the vegetation in the form of flutes (small sand tongues). The main slip face is generally well vegetated with willow branches sticking out of the slip face slope. The top surface of each of the flutes is bare sand, but the slip faces extending down from the margins of the flutes are generally vegetated with willow.

The main slip face along the western side of the island curves to the east at the southwest corner of the island. A small willow hill sticks up above the general sand surface just west of main slip face where it makes its curve to the east. The hill is being severely eroded by strong winds. The slip face continues in an easterly direction for a short distance forming the southern boundary ridge of the island. In this southwest corner, the main slip face is bare sand, with no willow vegetation. It extends about 40 feet down to the floor of the central flat of the island.

A short distance east of the southwest corner of the island, the main slip face leaves the southern boundary ridge and bends toward the south, continuing through the southern fence line on toward the group of Tabletop vegetation islands. Sand ripples on the top of the slip face near the southern fence line are 6 inches apart with a wind direction of N75W.

There is a large, broad southern boundary ridge that continues toward the east beyond the point where the main slip face leaves the southern boundary ridge. This broad ridge has developed some new lupine vegetation that does not show up in the 2003 photos used as the base map for field work.

At the northwest corner of the island a large bare sand flute has recently blown in toward the center of the vegetation island. Sand Sample ES-2 (Appendix B) was taken at this location. However, farther east along the northern boundary, the ridge is not as well developed as it normally is on other vegetation islands. This is probably due to the significant protection from the wind that Eucalyptus Tree provides. The ride corridor here appears too narrow to allow significant wind flow down the corridor, which could then allow more of a ridge to develop along the north side of the island.

The fence line along the eastern side of the island has been recently moved out 50 feet or more, to protect extensive new vegetation of *Juncus* grass, lupine, and willow which has pushed out eastward on the flat. The interior portions of the island flat contain large willows, lupine, thistle, ice plant, *Senecio*, Queen Anne's lace, popcorn flower, and Indian paint brush. Sand sample ES-1 was taken from this vegetated flat.

<u>Changes Observed on Air Photos</u>: On the 1930 and 1956 air photos, Eucalyptus North, Eucalyptus Tree, and Eucalyptus South were part of one large vegetation island. To the north, the large island was separated from Cottonwood by a NW-SE trending sand tongue, and to the south it was bordered by a tall NW-SE- trending slip face that defined the northern margin of a group of large sand tongues. The vegetation island contained several small clumps of willows in the north, surrounded by dune scrub vegetation, and several larger willow clumps in the south, also surrounded by dune scrub vegetation. There was a large patch of willows in the SW corner of the large island, where the western slip face intersected with the EW trending slip face of the large sand tongue that formed the southern boundary. This large willow patch has since disappeared, but it was located south of present day Eucalyptus Tree and west of present day Eucalyptus South.

A number of long narrow longitudinal ridges extended 500 feet or more to the NW from the Eucalyptus group of islands. The ridges were primarily vegetated with willow, based on the dark color observed on the air photos. Some patches of lighter colored vegetation, interpreted to be dune scrub, were intermixed with the willows. There did not appear to be much change in amount of area covered by vegetation between 1930 and 1956. The slip face along the west side of the combined island did not appear taller than about 30 to 40 feet.

Between 1956 and 1970, the topography remained essentially the same. The islands continued to be one vegetated mass. Although the extent of the area covered by vegetation was similar to what it was 14 years earlier, the density of vegetation cover diminished, especially in the dune scrub areas. There were many more trails evident in the dune scrub vegetation. A wide flat area in the southeast corner of Eucalyptus Tree that had been dune scrub was completely cleared of vegetation, which nearly separated it from Eucalyptus South. However, a dense patch of willow growing on the western slip face still connected the two vegetation islands. The vegetation on the longitudinal ridges to the west of the islands also diminished.

Between 1970 and 1992, much of the dune scrub vegetation disappeared and the large island was cut into two. A broad open sand area developed between Eucalyptus North and Eucalyptus Tree. The western slip face along Eucalyptus South appeared to move eastward approximately 200 feet (approximately 9 feet per year). By 1992, the large clump of willows that had been present in the southwestern corner of Eucalyptus South had disappeared, apparently overrun by a large slip face.

The slip face on the sand tongue whose margin formed the south side of the island did not move much into the island flat. However, scattered vegetation that had been growing along this same slip face east of the flat in 1970 had all disappeared by 1992. Vegetation in both Eucalyptus Tree and Eucalyptus South appeared to extend east from the fence line into the large flat area east of the islands at least an additional 50 to 100 feet by 1992.

As the longitudinal ridges to the west and the vegetation on them disappeared, additional sand moved eastward from the ocean toward the Eucalyptus group of islands. In their place was a series of barchan and transverse dunes in an open dune field. Increased amounts of sand also moved along the wide tongue to the south of the Eucalyptus group of islands.

Between 1992 and 2007, the western edge of the vegetation on Eucalyptus South became more irregular in shape and more sand tongues formed. It was difficult to tell from comparing photos how much the western slip face had moved. Residual old trails inside the fence line, visible on the 1992 air photos, were almost completely revegetated by 2003 and vegetation had expanded eastward outside the fence line.

Maintenance Projects: We are not aware of any revegetation projects conducted within Eucalyptus South.

Comments: The main slip face in the southwest corner of the island, and the flutes (sand tongues) along the west and northwest sides of the island should be top priority for revegetation and stabilization. Vegetation naturally tends to expand east into the flat, and has extended beyond the fence line in several places. The flat is larger than what is currently fenced. If fencing were extended to the east it is very likely that the area could be quickly revegetated.

On the west side of the island conditions are much harsher and less conducive to successful revegetation. However it would be very beneficial to the long term preservation of vegetation on this island if it were rejoined with Eucalyptus Tree. This would require revegetating the wide gap at the west end of the open ride corridor between the islands .

Since evidence found in this study indicates that larger islands tend to last longer than smaller ones, reconnecting Eucalyptus Tree with Eucalyptus South should be considered. Although the west end of the ride corridor between the islands is in a very windy location with a high rate of sand movement, most of the corridor is fairly narrow and the reconnection should be easier to do than in other locations. Reconnecting all three of the Eucalyptus islands into one should also be considered. However, rejoining Eucalyptus North with Eucalyptus Tree would be considerably more difficult due to the wind gap in the line of tall dunes to the west of the open ride corridor between Eucalyptus North and Eucalyptus Tree.

Suggested Management Options:

- One alternative is to try to maintain the island on its own.
- Another alternative is to rejoin connect Eucalyptus South and Eucalyptus Tree.
- In both alternatives, the main slip face in the southwest corner of the island, and the flutes (sand tongues) on the west and northwest sides of the island should be vegetated and stabilized as soon as possible.

If it is decided to try to maintain Eucalyptus South on its own:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in. If the slip face on the west is not slowed down substantially from its current rate of eastward movement, then fences on the west and east sides should be moved eastward substantially, to allow vegetation of the flat on the east side of the island to proceed as rapidly as possible.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east should also be monitored, to determine what acreage is being gained each year and how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of sand influx to the slip faces could be slowed down by doing revegetation projects west of the main slip face, similar to the project done west of Eucalyptus Tree in 1996/97. It is likely that the project area would be buried by sand within 5 years or so after completion, but it would slow down the eastward movement of sand.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- It would be very important to revegetate any flutes or sand tongues that develop along the slip faces as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegete.

If it is decided to connect Eucalyptus South and Eucalyptus Tree:

- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Enhance the existing sand ridge and slip face that extends between the two islands. This will be the new western edge of the future larger island. This could be done with heavy equipment, or with sand fencing to build up the new

ridge. The altered wind patterns may help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.

- Within the flat portion of the closed ride corridor, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where the former tall slip face of the old larger island used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.
- Allow natural expansion of the vegetation eastward by extending fences to the east. This will require moving the CXT or establishing a fenced corridor around the CXT at Eucalyptus Tree large enough for maintenance truck access and OHV parking, so that use of the CXTs does not interfere with its maintenance.

13. TABLETOP

Date of Site Visit: May 17, 2007

Time Spent on in Field:
2:00 - 4:00 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
John Schlosser - CGS

Shown on Figures D-5 and D-6.

Existing Conditions: This vegetation island is actually a group of islands, most of which are small remnants of formerly much larger individual islands as well as remnants of much more extensive groups of smaller islands. Since the 1963 air photos were taken, the number of islands and the size of the islands have steadily decreased. It appears from the conditions observed in May 2007, and by comparing locations of large transverse dunes on older air photos, that a large volume of sand has been rapidly transported up to, and in many cases right over, many of the islands in this group during the past 40 years.

The western (windward) edges of the islands have been severely sand blasted and eroded by the wind. Where fencing has allowed vegetation on the east side to continue growing, the islands have increased to the east, even though the vegetation decreased to the west. Where islands have not been able to expand to the east, the islands have decreased in size. Many of the islands are no longer protecting a flat area, but are just vegetated ridges poking up above the general sea of moving sand. As succeeding waves of transverse dunes come in from the west, it is expected that many of these islands will eventually be overtopped with sand, as the willows will not be able to keep up with the influx of sand.

The currently existing islands comprise six groups, each with fences around them. In this study, the largest group is referred to as "Main Tabletop". The other smaller groups are referred to as Group 1 through Group 5. Main Tabletop represents the largest vegetated area enclosed by a fence line. It lies approximately 600 feet south of Eucalyptus South. The smaller groups of islands, Group 1 through Group 5, each with their own enclosing fence line, lie between 200 and 1000 feet to the south and to the west of Main Tabletop.

Based on the location of numerous large slip faces as mapped in the field in May 2007, and compared with the location of large slip faces discernible on historic air photos, it appears that the slip faces have moved fairly rapidly in the Tabletop area . For example, slip faces appear to have moved roughly 30 to 80 feet in the 4-year time span between 2003 and 2007 (approximately 7 to 20 feet per year). Where advancing dunes encountered significant vegetation, the rate of eastward movement decreased dramatically. In open sand areas, where the wind is unobstructed, dune advancement occurred at the maximum rate of movement.

Detailed Observations of Individual Vegetation Islands (See Figure D-5 for locations of numbered points and features.)

Main Tabletop: Main Tabletop is approximately 500 feet wide (NS) and 1,000 feet long (EW direction). It is oriented in a NW-SE direction and is shaped like a long skinny hand, with the palm of the hand being the island flat located on the southeast and three long fingers of vegetation extending northwest from the palm. The northern finger (Feature 1 on Figure D-5) is a sparsely vegetated narrow ridge along its western portion. Its eastern portion is bare sand, buried by a large flute (sand tongue). The middle finger (Feature 2 on Figure D-5) is a narrow ridge in its western portion and a vegetated narrow, deep valley in its eastern portion. The southern finger (Feature 3 on Figure D-5) is a partially vegetated broken ridge, which is an extension of the broad southern boundary ridge of the island.

On the northwest side of the island, two small willow clumps extend above the sand, one at either end of a narrow ridge about 300 feet long that forms the western end of the northern finger (Feature 1). There is a wind valley along the northern edge of the ridge. The ridge is separated on the south and east from the rest of the island by a 150 foot wide flute (Feature 4) that has formed from the west side of the island. Sand sample TT-1 (Appendix B) was taken from this location. The willow clump at the windward (NW) tip of the northern finger is severely sand blasted. Multiple dunes with slip faces from 20 to 50 feet high are located upwind (NW) of the willow clump. Conditions are challenging for the willows in terms of maintaining enough vigor to continue occupying the ridge and staying above the oncoming waves of sand.

The large flute or sand tongue (Feature 4), between the northern and middle vegetation fingers, receives frequent strong winds. Its surface is very windswept, with local small "blowouts" eroded into it. According to Nancy LaGrille (personal communication), there had been a revegetation project here a few years ago, which attempted to stabilize the three large flutes (Features 4, 5, and 6). The surface of the tongue had been smoothed, and hay was punched in with a sheepsfoot roller, and later various seeds were sown. At the time of the field visit for this study, most of the surface of the flute supported a sparse cover of tall grass, and short plugs of hay still stuck out of the otherwise bare sand surface. At the western end of the flute, small longitudinal dunes were forming in the wind shadow of short plants, probably dune mint and *Senecio*, which had sprouted from the planted seeds. The small dunes looked similar to small foredunes observed just above the high tide line at the beach. Sand ripples were 4 to 9 inches apart, with a wind direction of N70W. The center of the flute is shaped like a broad trough, with narrow ridges along each side, and with active slip faces below the side ridges. The axis of the trough rises from the western end toward the eastern end. From the SE end, a tall slip face of bare sand cascades down into the island flat.

The north edge of the flute abuts up against the northern finger ridge. To the east of the finger ridge, the edge of the flute has buried a 100-foot section of the northern fence line. The south edge of the flute abuts up against the narrow ridge that is the tip of the middle vegetation finger. There is an old wind valley between the edge of the flute and the ridge. At the eastern end of the ridge, a narrow, deep vegetated valley forms the eastern part of middle vegetation finger. The south edge of the flute forms a slip face that is slowly filling in the narrow valley.

The western portion of the middle vegetation finger (Feature 2) is a narrow ridge about 200 feet long covered with older willows. The vegetation has been sandblasted severely, and wind valleys have been scoured along both sides of the narrow ridge. An advancing slip face has recently encountered the willow ridge, filling the western end of the wind valleys with sand. This has greatly reduced the wind flow down the valleys, so they do not appear to be as actively eroding now as they had been. The wind velocity at this location appears to be severe, probably because it is located a short distance downwind from a local "blow out" bowl that has formed below the large slip face of an advancing transverse dune. In addition to willows, mint, Queen Anne's lace, yellow ice plant, primrose, and heather (?) were observed growing on the ridge.

A large slip face, an extension of the slip face that recently encountered the western tip of the ridge, has recently advanced southeastward, wrapping around the western end of the ridge. This slip face is filling other wind valleys that had previously formed southeast of the ridge. Three narrow and rather short wind valleys had been scoured parallel to the middle finger ridge prior to the advancement of the slip face. One valley lies between the middle finger ridge and another low ridge just to the south that was formed by wind scour of the previously existing surface. A similar third ridge was also eroded, and the second wind valley lies between these two smaller eroded ridges. The third wind valley lies along the south side of the third ridge. All these topographic features (three wind valleys and the two small eroded ridges) are likely to be over-ridden by the advancing slip face in the near future.

Feature 5 is another flute which formed just downwind (SE) of the multiple ridges and wind valleys described above. The flute lies along the south side of the portion of the middle vegetation finger that is a deep narrow vegetated valley. The north edge of the flute has formed a narrow ridge with a slip face of actively moving sand below it, which is filling the narrow valley. The eastern end of this flute is much narrower than the flute on the north side of the middle vegetation finger (Feature 4). There is an active slip face at the eastern end of the flute that cascades down to the central flat of the island, but it is delivering much less sand to the flat than Feature 4. The slip face is partially vegetated with willow, coyote brush, and dune mint. This flute was also part of the revegetation project described above, and had treatment similar to Feature 4. Current conditions are similar to the other flute, with scattered tall grass and remnants of hay plugs sticking out of the otherwise bare sand surface. There has been wind erosion and small "blow outs" of the flute surface. There appears to be less vegetation on this flute in 2007 than there was in the 2003 air photos.

The southern margin of the flute lies along a smaller valley, apparently a remnant of a larger valley. The active slip face along the south edge of the flute is delivering sand to the floor of the narrow valley. The valley lies between the middle and southern vegetation fingers and extends eastward to join the island flat.

The western tip of the southern vegetation finger (Feature 3) is a narrow ridge, vegetated primarily with large, old willow that is getting sand blasted by strong winds. The ridge has a wind valley along its south side, and a narrow unvegetated wind gap on its east side between it and the next willow knob to the east, which is also part of the southern vegetation finger. The eastern end of this second willow knob drops steeply down to the island flat. A complexly shaped southern boundary ridge continues from this second knob all the way to the east end of the island. Along the interior (N-facing) slope of the boundary ridge is a willow-vegetated, 80-foot tall slip face that extends down to the floor of the island flat.

Feature 6 is another flute that formed along the south side of the southern vegetation finger and extends along the top of the broad southern boundary ridge. Although it was part of the recent revegetation project, the wind and volume of new sand blowing in has damaged the revegetation efforts. Portions of the surface of the flute are buried with new sand, including an E-W oriented, 10-foot high slip face (Feature 7) that has recently formed at the eastern end of the flute, between the vegetation island and a large transverse dune located to the west of the island. Sand ripples on the flute surface were 3 to 4 inches apart, with a wind direction of N65W. There is a wind valley along the south edge of the flute, between the flute and the southern fence line. Vegetation, mostly lupine, has significantly increased along the southern fence line in this area since the 2003 air photos were taken.

On the eastern side of the island, a large flat extends well outside the fence line to the northeast. Apparently, large slip faces and sand ridges to the north of the island cause the wind to scour out a flat in this direction instead of the usual southeast direction. The slip face at the eastern end of the flute (Feature 4), between the northern and middle vegetation fingers, continues northward to join the slip face of a transverse dune beyond the northern fence line, in the open ride area. The slip face extends several hundred feet to join a large sand ridge (collection of various dunes) north of the vegetation island.

The slip face that forms the interior slope (N facing slope) of the southern boundary ridge is about 20 feet tall at the eastern end of the island. It bends abruptly to the south at the east end of the island, to join a slip face of a transverse dune that lies just east of Tabletop Group -1. The slip face on the transverse dune is 20 to 25 feet high near Main Tabletop and is 80 feet high just south of Tabletop Group-1.

<u>Tabletop Group 1</u>.The vegetated part of this island is located about 175 feet south of the main block of vegetation in the eastern part of Main Tabletop. The fence lines around the two islands were only 70 feet apart during the field visit in 2007. Group 1 consists of a set of wind blasted willow knobs on the east and a fenced off section of nearly flat, windswept plain to the west of the willow knobs. The willow knobs on the east are about 150 feet wide (NS) and 125 feet long (EW).

The fence line extends about 150 feet west of the willow knobs. There is sparse vegetation within the western part of the island, including a few hardy willows and some pioneer type, low growing plants such as primrose and mint. Small longitudinal dunes similar to foredunes have formed in the windshadow of the pioneer plants.

<u>Tabletop Group 2</u>. The island is located about 400 feet northwest of Group 1 and 200 feet south of the western tip of the southern vegetation finger of Main Tabletop. Group 2 consists of two willow knobs joined in the center, with a small topographic depression on the east side. The vegetated area of the island is about 100 feet wide (NS) and 80 feet long (EW), i.e., more than is shown on the 2003 air photos.

Some of the willows have trunks up to 6 inches in diameter, indicating the windblown willow knobs have been in existence for some time. Willow roots are exposed on the north and west sides; most of the willow looks dead. A transverse dune slip face has recently encountered the west side of the willow knobs which extend about 12 feet above the top of the dune. The transverse dune slip face dies out to the north in the ride area. There is a deep but short wind valley on the south side of island which ends as a small "blow out" bowl just southeast of the island. Other vegetation on the east side of the knobs includes dune mint, yellow ice plant, primrose, willow, and lupine.

Tabletop Group 3. This island is located about 350 feet northwest of Group 2, and about 400 feet west of the western tip of the southern vegetation finger of Main Tabletop. The island is a ridge 200 feet long and 50 feet wide that sticks up above the open blowing sand on either side. Bare gaps between vegetated segments of the ridge appear to be flutes of various ages that were previously blown across the ridge.

The western tip of the island has a large wind valley wrapped around it. There has been erosion of the willows, with many roots exposed. The willows appear old, with 4 to 6 inch diameter trunks. The island stands 25 to 30 feet above the bottom of the wind valley, and the approaching slip face of the large transverse dune to the west is 50 to 60 feet tall. It appears that the height of the approaching slip face has blocked some of the wind that previously impacted the west end of this island. It also appears the island will gradually be buried by the much higher slip face as it migrates east.

Willow roots were observed extending 30 to 35 feet out from the ridge to the fence line on the north side of the island. Sand ripples on the north side were 18 inches apart, with a wind direction of N70W. On the eastern half of the island there are flutes along both sides, with narrow wind valleys between the edges of the flutes and the edges of the vegetated ridge.

Tabletop Group 4 (see Figure 6). This group is about 700 feet south of Main Tabletop, 450 feet south of Group 1, and 225 feet north of Group 5. Group 4 consists of seven small willow knobs with severely windblown and sand blasted willows. The fenced area containing the seven knobs is approximately 130 feet wide (NS) and 280 feet long (EW). However, none of the individual vegetated knobs is more than 30 feet in diameter.

The crest of the transverse dune that recently passed over Group 5 (below) also encountered the western edge of this island group. The crest of the slip face is approximately the same height as the tops of the willow knobs. The slip face is currently filling in the wind valley around the western island. It is likely that entire group of islands will gradually be over topped by this encroaching transverse dune. The slip face has buried the fence on the northwest side. Sand ripples here were 8 inches apart with a wind direction of N60W.

The various slip faces of barchan dunes and small transverse dunes observed in the open ride area between Group 1 and Group 4 varied from 1 to 20 feet in height.

Tabletop Group 5 (see Figure 6). This group is about 1,050 feet south of Main Tabletop, 800 feet south of Group 1, and 225 feet south of Group 4. Group 5 consists of two windblown and sand blasted willow masses on top of a small knoll. The fenced area around the knoll is approximately 70 feet wide (NS) and 110 feet long (EW). The crest of a transverse dune has passed over it recently, and the slip face now lies just east of the island.

Changes Observed on Air Photos: Between 1930 and 1956, the pattern of vegetation was very similar on the air photos and, where there were changes, they were small. Generally, vegetation increased from 1930.

In comparing the 1956 and 1970 photos, topography and vegetation patterns were essentially the same. The principal difference was that, in 1956, there were no OHV trails visible in vegetated places. In 1970, trails were prevalent nearly everywhere, especially in areas of dune scrub vegetation. The edges of vegetation islands also appeared more eroded and irregular from the riding activity along the edges.

In 1956, open sand gaps in the Tabletop area, between the Eucalyptus islands and Pipeline, consisted of three wide sand tongues that bridged almost completely across the large Western valley in this area. The eastern edges of the sand tongues had tall slip faces which had reduced the vegetation previously existing in the Western valley to a narrow string of willow trees lining the long slip face. Only a narrow flat remained along the east side of the sand tongues. However, this narrow flat extended south to join the much larger flat that was present at that time in the eastern part of Pipeline. Several long narrow flats, oriented NW-SE, were located between the edges of the tongues. There were also two small flats along the western edge of the tongues that appeared to be remnants of the previously existing large Western valley. All of these flats were vegetated; the rest of the area covered by sand tongues was bare sand.

In 1970, the area that comprises the Tabletop group of islands (the area between Eucalyptus South and Pipeline) was mostly covered by bare sand. Several large clumps of vegetation existed, but the bulk of the area was unvegetated. There were three large tongues of sand, each measuring about 600 to 800 feet wide (NS) and 1,100 to 1,300 feet long (EW), that occupied what had previously been the large Western valley that lay at the eastern foot of the Western sand ridge (see Geomorphology of Oceano Dunes Area above). From the 1970 photos, it appears the three large tongues had coalesced on their eastern end into a broad ridge oriented NS. A gentle western slope, climbing up from west to east, and a topographically low area existed along the western edge, approximately where the western edge of the previous Western valley had been. Another topographically high sand ridge lay to the west of the low area. This sand ridge was roughly in line with the line of transverse dunes that extended along the west side of vegetation islands to the north and south of this area. It appeared that the large sand tongues had moved through the area much like a sand wave, and some portions of pre-existing land surface were becoming exposed again on the west side as the peak of the sand wave moved on to the east.

In describing changes between 1970 and 1992, it is helpful to give a brief description of conditions existing on and adjacent to the three sand tongues in 1970. The northern sand tongue was located between Eucalyptus South and Main Tabletop. There was a small remnant flat, elongated in an EW direction, located in the western part of the northern tongue. A narrow willow covered ridge in the southeastern part of the tongue would become the northern finger of the Main Tabletop. In 1970, there were also stringers of vegetation along the northern margin of the tongue, and in the small remnant flat.

The middle sand tongue in 1970 contained all the Tabletop islands that continue to exist in 2007. A large area of vegetation, elongated in an EW direction, occupied the northern margin of the tongue. Attached to this vegetation was a small remnant flat in the western part of the tongue that was also vegetated. This combined area of vegetation now forms Main Tabletop and Groups 1, 2, and 3. Along the southeast margin of the tongue, there was vegetation in a small elongated flat and on three short narrow ridges. Remnants of these vegetation clumps are now Groups 4 and 5. There also was a stringer of vegetation present along the eastern slip face of the sand tongue in 1970. There was a broad area on the western side of the tongue that was a topographically low area, but it had no vegetation at that time.

In 1970, the southern tongue contained a large vegetated flat, elongated in an EW direction located in its southwestern quarter. Stringers of vegetation were also present along the slip face at the eastern edge of the sand tongue. The majority of the changes in vegetation, as observed on air photos, occurred between 1970 and 1992. The changes before and after were less dramatic. The following discussion of changes progresses from north to south in the Tabletop area.

The slip face on the east end of the northern sand tongue moved approximately 350 feet eastward by 1992, for a rate of 16 feet per year. The tongue filled in the north end of the remnant flat that had been present along the eastern side of the sand tongues in 1970, burying the vegetation that had been present. The small vegetated flat present in the western part of the tongue in 1970, still remained in 1992, but it was smaller with only scattered clumps of vegetation. This flat and all the vegetation had disappeared by 2003. A train of small barchans was advancing across the western part of the tongue by 1992, and a small but deep depression had developed in the eastern part of the tongue by 1992.

In 1970, the willow ridge that later became the northern finger of Main Tabletop was surrounded by sand. The sand flute (Feature 4 on Figure 5) on the south side of the ridge is part of the northern sand tongue. By 1992, the eastern end of the flute had moved about 180 feet east (8 feet per year), burying the eastern portion of the willow ridge. The flute extension since 1970 also filled in part of the island flat that had existed in 1970.

The Main Tabletop island in 1970 was a continuous cover of vegetation about 1,000 feet long (EW) by 250-300 feet wide (NS). Only the eastern half was located in the long flat that extended in a NS direction from Eucalyptus South to Pipeline. By 1992, the western third of the island had been covered with sand. At least half of the vegetation in the remaining eastern two thirds of the island had also vanished. Most of the dune scrub present in 1970 was covered with a dense network of trails. Since 1992, losses on the west have been balanced by gains on the east side of the island.

There was a small vegetated flat along the southwest side of Main Tabletop that became Tabletop Groups 2 and 3. A small narrow flute pushed into the flat from the west in 1970. By 1992, more sand had moved into the area, forming two rows of small barchans that over-rode some portions of the vegetation and wrapped around the higher vegetated hills. Tabletop Group 3 was reduced to a linear string of willow clumps. Group 2 was greatly reduced to a windblown knob sticking up above the sea of moving sand around it. A set of barchans moved about 250 feet (11 feet per year) to surround Group 2.The small flat was filled on the west side with small barchans, and the eastern part became a large wind valley between the islands. By 2007, Groups 2 and 3 had become smaller. The slip face of the main sand ridge west of Group 3 had grown to 60 feet tall, but had not moved eastward much since 1992 .

In 1970, Tabletop Group 1 consisted of a few knobs of willows sticking up above the moving sand. The slip face of the middle sand tongue was located to the east of Group 1. As of 2007, the group still consists of a wind blasted willow knob with a large slip face to the east of the island.

In 1970, there were two moderate size groups of vegetation clumps located in the crease between the middle and southern sand tongue. There was also a good-sized group of small islands located at the base of the large slip face at the eastern end of the middle tongue. The vegetation along the crease between the two islands occurred on short narrow ridges, and in narrow flats elongated in an EW direction. By 1992, the vegetation on the slip face at the eastern end of the tongue was gone. The groups of vegetation growing along the crease between the two sand tongues had been drastically reduced in size, and were basically just knobs of wind blasted willow sticking above a sea of moving sand. These were in the area that became Group 4 and Group 5. By 2007, they had been reduced in size even more. Some of the islands had been buried, as the waves of barchans continued to move eastward.

In 1970, the southern tongue had advanced the farthest east. There was extensive vegetation at the base of the main slip face, and in the long flat adjacent to the east of the slip face. By 1992, the slip face had advanced and filled in this section of the long valley. All the vegetation had been buried or otherwise had disappeared. An elongated flat was present about 800 feet west of the main slip face of the tongue. There was extensive vegetation present in the flat, and long narrow longitudinal ridges extended westward from the flat. By 1992 the flat was mostly filled in, and most vegetation was gone, reduced to only very small clumps. By 2007 all vegetation in this area had disappeared and the flat was covered with a dune field.

Between 1992 and 2003, a period of 11 years, approximately 60 small vegetation islands in this area disappeared. Most were in the open ride area not protected by fencing. It appears that, in open sand areas to the west of the Tabletop area, the dune slip faces have moved eastward approximately 100 to 150 feet, and possibly up to 200 feet (a rate of 9 to 14, possibly 18 feet per year).

<u>Maintenance Projects:</u> CSP staff, Nancy LaGrille, reported that three sand tongues on Main Tabletop island were the subject of a revegetation project “a few years ago” (approximately2003/ 2004 season). The surface of the sand tongues were smoothed with equipment, straw was blown over the surface, and was punched in using a

sheepsfoot roller. Sometime later, presumably after seasonal rains began, the area was seeded. It is not known if it was hydromulched, or just broadcast seeded.

During the 2007 site visit, sparse cover of tall grass (barley?) and clumps of hay covered most of the sand tongue surfaces. In a few locations, low pioneer vegetation has sprouted, and low narrow dunes were forming downwind of the plants. The area is subject to extremely high winds, and there were numerous small "blow outs" where the wind had scoured a few inches below the prepared seedbed and layer of punched straw. In other areas, the vegetation and straw had been buried at least several inches deep by blowing sand.

Comments: In terms of the outlook for how long individual vegetation islands are likely to survive, Main Tabletop is in the most favorable condition of the Tabletop group of islands. This is because it still contains an island flat on the leeward side, from which vegetation can expand eastward. There is a chance that the eastward expansion can keep pace with the retreat of the western edge of vegetation, and the island can continue to exist for many decades. There are three large, very active flutes (sand tongues) which are currently advancing into the island. The continued advancement of these flutes could reduce the length of time the island survives. To prolong its existence, the flutes should continue to be the focus of revegetation efforts in order to slow down the sand encroachment to a manageable level.

In the bigger picture, Main Tabletop is currently well along in the process that causes vegetation islands to disappear. The island flat is being squeezed closed from three sides. Eventually the flat will become very narrow, as it has already become in the two valleys west of the current island flat. Based on observations of the process elsewhere in the project area and on historic air photos, the narrow flat will either be buried by rapidly advancing slip faces, or will evolve into a narrow willow ridge that sticks up above the surrounding dune field. From that point, the ridge will likely continue as a wind blasted island until a very large dune with a slip face higher than the island advances and buries the ridge. If this scenario is accurate, then Main Tabletop has a life expectancy of only several decades before it disappears.

The other Tabletop Groups are currently only remnants of larger islands or larger groups of islands, which have been decreasing in size over the past 40 years or so. They are willow knobs or narrow ridges surrounded by active dune fields, sticking up into the intense wind that blows across the dunes. They have no associated flat in a wind protected position from which to expand. Their "life expectancy" is low, probably on the order of 10 to 20 years.

Suggested Management Options:

- One alternative is to maintain Main Tabletop on its own, and to allow the other Tabletop islands, Group1 though Group 5, to become open ride area.
- Another alternative is to maintain one or more of the other Tabletop Groups on their own, as well as Main Tabletop, while allowing the other islands to become open ride areas.
- A third alternative is to allow all the Tabletop islands to become open ride area.

If it is decided to maintain Main Tabletop:

- The best long term approach is to allow the island to move gradually to the east. If willow vegetation can get established fast enough, the flat could be expanded to the northeast as well. Fences will have to be moved east and northeast at the same rate as slip faces on the north, west, and south move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being "lost" per year.
- The expansion of vegetation to the east and north should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved ("in" on the west, and "out" on the east).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to maintain any of the Tabletop Group 1 through Group 5:

- The effort to maintain any of these islands will be more difficult than it will be for Main Tabletop, due to the absence of any island flat to use as a base for expansion of vegetation in the downwind direction.
- The best long term approach is to try to construct a flat on the east side of the island. The larger the flat the better. Use the wind as much as possible to help form the flat. This could be done by using equipment to construct a "ridge" along the western side of the new flat, incorporating the existing willow knob or ridge as part of the new western ridge as much as possible. Sand fencing may also be used to help build up the ridge. Since building up a ridge in an area of such strong winds could cause radical changes in the topography, it will be important to carefully monitor conditions as the new sand ridge is formed.
- Once a new flat is constructed it is important to get willow vegetation established quickly – on the flat as well as on the slip face of the western boundary ridge of the flat.
- If a new flat with viable vegetation can be established, then fences will have to be moved east at the same rate as slip faces on the north, west, and south move in.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being "lost" per year.

- The expansion of vegetation to the east should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved ("in" on the west, and "out" on the east).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

14. PIPELINE

Date of Site Visit: February 15, 2007

Time Spent on in Field:
Noon - 2:30 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
Tim Hanson – CSP
John Schlosser - CGS

Shown on Figure D-7.

Existing Conditions: Pipeline has an average width of approximately 700 feet (NS) and an average length of approximately 2,300 feet (EW). It is oriented in a NW-SE direction, with the NW end being the narrowest, and getting wider toward the SE end. The island has a prominent flat, approximately 1,500 feet long, which is greatly elongated in a NW-SE direction. On Figure D-7, it has the shape of a gourd, with the fat end on the east and the long narrow neck pointing to the northwest. The neck portion of the flat is only 80 to 200 feet wide, while the eastern end is 600 feet wide (NS direction). Much of the topographic flat actually lies outside the eastern fence line, and the fence could be moved out as much as 300 feet to the east to take in the rest of the flat.

The flat is bordered on the north, west, and south by tall slip faces belonging to various coalescing dunes and sand tongues. The slip faces range from approximately 20 to 60 feet tall and are generally very well vegetated, mostly with willow.

This island is different than most in that there is an extensive area to the west of the main slip face that is vegetated. The vegetation and the western fence line is 700 to 800 feet west of the main western slip face.

Another unusual feature of Pipeline is that the northern and southern boundary ridges of the island flat are more prominent and extensive than the western boundary ridge. The topography of the island indicates repeated invasion by sand tongues and flutes over many decades. Older tongues and flutes have become vegetated, and younger ones have moved into the island on top of the older ones. The northern and southern boundary ridges appear to have been formed by repeated invasion of long narrow sand tongues. Several long narrow ridges are also present on the windward side of the main slip face. These appear to be remnant margins of older sand tongues. Most of the ridges have well established clumps of willow growing on them.

Currently two well defined sand tongues are present on the island, one in the center of the island which has recently been revegetated, and one in the southeast that continues to be mostly unvegetated. According to Nancy LaGrille (personal communication), the central sand tongue was bare sand in 2003, prior to the latest revegetation efforts. At the time of the site visit in 2007, it was well stabilized with lupine and lesser amounts of other plants such as primrose, *Phacelia*, *Senecio*, spiney iceplant, poison oak, and golden yarrow. A large area between the main slip face and the western fence line, called the “red area”, which had been bare sand, also was revegetated in 2003. At the time of the site visit, it was well vegetated with lupine and a small amount of other plants such as those present on the central sand tongue. It appeared that the vegetation had stabilized the surface of the previously actively advancing sand. Old dune features were still recognizable, but they had been stabilized by the vegetation. Several small barchans and transverse dunes were still actively advancing along the southern fence line, where vegetation was much more scattered.

Prior to January 2003, there were mostly willow clumps present on the NW trending narrow ridges in the center and along the northern side of the vegetation island. It appeared that the willow clumps along the northwest border were severely wind blasted prior to that time. Also prior to 2003, there had been only bare sand between the northern fence line and the willow clumps. At the time of the site visit, the area between willow ridges and the fence line was densely vegetated with lupine. It appears that the willow clumps are not being as badly sand blasted now that the vegetation has become established upwind of the willow ridges.

Changes Observed on Air Photos: Between 1930 and 1956, the pattern of vegetation in both sets of photos is virtually the same. There were no noticeable impacts from OHV activity. Between 1956 and 1970, the pattern of vegetation at Pipeline is also similar. The only changes noted in the 1970 photos are the increased number of trails within the various vegetation clumps on the island and the edges of the clumps are more irregular than they had been, presumably from OHV riding.

In 1970, the vegetation pattern of the island looked somewhat like a “W” on its side, with the three prongs pointing to the NW. The eastern third of the island was a large island flat, and the long narrow prongs were bands of vegetation extending 800 to 1,000 feet or more toward the coast. The prongs were formed by two large sand tongues that had pushed into the vegetation from the west. The northern prong was the widest and longest. The middle prong was narrower and only half as long, and the southern prong was even smaller than the middle. The general pattern of the three vegetation prongs can still be seen on the 2003 air photos, with the same two sand tongues between them. Another large patch of vegetation, approximately 1,500 feet long from east to west and 600 feet wide from north to south, was present in an elongated flat just northwest of Pipeline. Several narrow ridges extended off this vegetation patch toward the strand line. In fact, the ridges extended to where 7.5 Reveg is located today. This large island had disappeared by 1992.

In 1970, the island flat was also larger than it is today. It was connected to the long narrow flat present along the east side of the main slip faces of three large sand tongues that were present between Eucalyptus South and Pipeline. The southern edge of the southern sand tongue formed the northern boundary of Pipeline. A large continuous slip face extended from the eastern edge of the vegetation island westward to the end of the northern prong of vegetation.

The central sand tongue was about 150 feet wide and had pushed about 700 feet into the vegetation from the west, separating the northern prong of vegetation from the middle prong. The middle prong of vegetation consisted of willows growing on the slip face along the south side of the central sand tongue, and on the slip face along the north side of the southern sand tongue. The southern sand tongue, in 1970, was about the same size as the central sand tongue and had pushed into the vegetation island, separating the middle and southern prong of vegetation. The southern prong of vegetation was also growing on the slip faces between two sand tongues. On the north side of the southern prong of vegetation was the southern sand tongue. On the south side of the southern prong of vegetation was a much larger sand tongue, about 800 feet wide, that separated Pipeline from Maidenform Flats. This larger sand tongue formed a tall, continuous slip face along the southern boundary of Pipeline. Slip faces of advancing barchan dunes, which had moved eastward down both the central and southern sand tongues, were also present in 1970 between the vegetation prongs.

In the center of the large sand tongue, half way between Pipeline and Maidenform Flats, there was a large (400 feet long by 100 feet wide) vegetation island on a hill that extended above the surface of the sand tongue and was oriented NW-SE. This large vegetation island had totally disappeared by 1992.

By 1992, the large sand tongue on the north side of Pipeline island had moved eastward, filling in the narrow flat in front of it and burying the large islands of vegetation that had been growing on the slip face and in the flat to the east of the slipface. The thin strands of vegetation on the long narrow ridges extending NW from Pipeline and from the large island that had been just north of Pipeline were gone, except for those that had been enclosed inside the fence at Pipeline. The rest of the vegetation in the main part of Pipeline was intact and had expanded since 1970.

There also appeared to have been significant sand movement along the bare sand tongues bordering the north and south sides of the island, as well into the western side of the island from the barchan dune field to the west. This was evident from the change in position of numerous dune slip faces present in both the 1970 and 1992 sets of photos.

Between 1992 and 2007, vegetation expanded within the fence line, especially on the central sand tongue between the northern and middle vegetation prongs. What had been a bare sand sheet in the western part of the island in 1992 was densely vegetated in 2007.

<u>Maintenance Projects</u>: It was not clear from the maintenance notes exactly where revegetation projects were located on Pipeline. However, the following were noted:

- 1993/94 season: CSP spread and mechanically punched in straw over 2 acres west of the flat part of the island. The straw slowed down sand movement for a couple years, but was driven over by OHVs. Subsequently, the area was filled in with blowing sand.

- Memo of 4/29/94: CSP punched hay west of Pipeline and the “feeder tongue”.

- 1995/96 season: Due to concerns that the bare central sand tongue would cut the island in half, leaving a northern and southern willow ridge, CSP vegetated 5 acres with straw and hydroseed. Work was completed March 1996. This work was completely buried by blowing sand within 3 months. A “lift of sand 18 inches high” marched in from the west and across the top of the planting area. CSP was astounded by how fast the sand moved in. It was like nothing they had encountered before. It was not clear what distance the "lift" of sand had moved in the 3 months, but it must have been considerable since the revegetation project covered 5 acres.

- 1996/97 season: CSP did the same thing as the year before with a bit better results. However, the whole experience led to trying to find a cheaper way to stabilize sand to the west of the islands, to slow down the rate of inundation.

- 1998/99 season: CSP harrowed and broadcast barley seed and fertilizer on two acres of bare sand west of island. They did the same on small patches within the center and on the south side of the island. Also planted approximately 18,000 lupine seedlings. The project was completed in March 1999. A dense stand of grass came up. However, the area was not fenced, so vehicles drove through it and destroyed the grass cover. With the grass cover gone, windblown sand came in and buried the seedlings and grass downwind in the center and on the south side of the island.

- 1999/2000 season: CSP used straw as well as barley seed on 2 acres of bare sand west of the island. On 4 acres in the center of the island, CSP covered the sand with straw, mechanically punched it in, then broadcast barely seed, fertilizer, and native plant seeds. The project was completed in January 2000. The 4 acres inside the island had a good growth of lupine and not much else. The 2 acres west of the island grew and then was pummeled by traffic and wind. The project was covered by sand in one season. Even 0.75 of an acre inside the fence along the west side of the island was covered by sand.

  After these experiences, CSP Maintenance staff formulated a new revegetation plan, i.e., to establish foredunes upwind of the area that was to be revegetated. The foredunes, once established, would create slack areas downwind, which could be planted with willows. CSP felt confident the willows could propagate down wind at the rate of 15 feet per year on their own, or 30 feet per year with intensive management. The goal was to develop new vegetation islands or connect the new willow ridges with existing vegetation island willow ridges. It does not appear that this new revegetation plan was ever attempted.

- 2001/02 season: Certain areas targeted for revegetation immediately west of Pipeline were labeled either "red" or "yellow" zones of concern. Bruce Lund of CSP recommended fencing off two parallel willow ridges, located west of Pipeline. The area between the two ridges had been the target for vegetation projects for the preceding 7 years. However, because it had never been fenced off to prevent open riding, the vegetation projects had always been destroyed in a matter of months.

  The goal this season was for CSP to establish vegetation between the two willow ridges, where it had been bare sand. Straw was blown over the project area and punched in with a sheepsfoot roller. Barley seed, native seed, and fertilizer were applied. Later the area was planted with lupine seedlings and willow. This was the first time CSP tried augering down 10 feet and putting in willow seedlings in long cardboard tubes to get more water and improve their chances for survival.

CSP planned to monitor this project with photo points, and by using GPS to map changes in the vegetated areas, on a yearly basis. The maintenance notes we were provided did not go beyond work done in the 2001/2002 season. However, according to Nancy LaGrille, the "red" area in the western part of Pipeline was aggressively planted in January 2003. This area was densely vegetated in February 2007. Therefore, the project to date appears to have been successful.

Comments: Establishing vegetation on the windswept open sands of the western part of Pipeline is a great success story for revegetation efforts undertaken by the CSP maintenance staff. It is not clear how long lupine and dune scrub type of vegetation can survive on the relatively harsh site that the western side of Pipeline represents. There is nothing to stop large amounts of sand from blowing into the western edge of the vegetation. It does not appear that any type of vegetation other than willow can grow fast enough to prevent sand burial when it is delivered at high rates of influx. Also, it appears that willow is best suited to obtain the water it needs to survive even while growing on active dune slip faces up to 60 and 80 feet high.

It is likely that the dune scrub type vegetation on the west side of the island will need maintenance, to fill in "holes" that develop in the vegetation cover. If willow can be successfully grown on the windy plain on the west side, it would likely perform better than the other vegetation types in slowing down the advance of oncoming dunes.

Pipeline is one of the largest of the vegetation islands in the study area, and is well suited to survive for a long time, even with high rates of sand influx, such as it has experienced in the past 70 years. The northern and southern boundary ridges are beginning to squeeze in on the western part of the island flat, but the eastern part is still very large. It will be important to make sure that willows get established on the flat to continue stabilizing the slip faces of the boundary ridges.

It is also important to keep the two large sand tongues within the island vegetated and stabilized. The vegetation on the central sand tongue should be maintained and the bare southern sand tongue should be vegetated. Because the flat on the east side of the island is much larger than what is currently inside the island fence, the fence line should be pushed eastward to allow the vegetation to continue to expand to keep pace with the "loss" of vegetation on the north, west, and south sides.

Suggested Management Options:

- The only practical option is to maintain the island on its own.
- Vegetation of the two sand tongues should be the highest priority.

If it is decided to continue to maintain Pipeline:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north, west, and south move in.
- The flat on the east side of the island is larger than what is currently inside the island fence. Consider moving the eastern fence line well to the east in the near future, to allow vegetation to expand rapidly become well established to withstand future encroachment of dunes.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- Areas on the west side of the island that have been recently revegetated by CSP should be maintained, so that any “holes” that develop in the vegetation cover are filled in, and any movement of bare sand into the island along the fence lines is slowed down by planting vegetation.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The rate of sand influx to the slip faces could also be reduced by planting and protecting foredune vegetation upwind of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

15. MAIDENFORM FLATS

Date of Site Visit: February 14, 2007

Time Spent on in Field:
9:30 a.m. - 10:30 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Ronnie Glick - CSP
Nancy La Grille – CSP
Tim Hanson – CSP
John Schlosser - CGS

Date of Site Visit: February 15, 2007

Time Spent on in Field:
8:30 a.m. – Noon

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
Tim Hanson – CSP
John Schlosser - CGS

Shown on Figure D-8.

Existing Conditions: For this study, the large well vegetated flat on the south side of Maidenform Flats was considered to be a part of both Maidenform Flats and 40-Acre Woods. The large flat is continuous with vegetation to the north, in Maidenform Flats, and with a broad area of vegetated ridges that extends southeast of the flat into 40-Acre Woods. The open ride area on the west side of the island is open 5 months of the year and closed the other 7 months, during the Plover nesting season. Open ride areas on the other sides of the island are open year-round.

The island (including the large flat on the south side of the island) is roughly 1,700 feet wide (NS) and from 600 to 1,800 feet long (EW), depending on the distance between western and eastern fence lines in various parts of the island. Approximately one quarter of the area inside the island fence line is bare sand.

In plan view, the vegetated parts of the island form a “Z” shape, tilted to the right, so that the top and bottom of the “Z” trend in a NW-SE direction. The western side of the island is severely windblown and has been inundated by repeated waves of dunes. Currently there are three large, bare sand tongues advancing through the center of the island. The topography of the central vegetated part of the island consists of narrow ridges and valleys that appear to be older, stabilized sand tongues. The large southern flat has a tall, horseshoe-shaped slip face bordering it on three sides. The slip faces are generally well vegetated, except in the northwestern portion. The flat is open to the east and extends well beyond the eastern fence line into the open ride area. The portion within the fence line is well vegetated. Another, smaller, narrower flat is present on the north side of the island. It is bordered by a tall barren slip face on the north and an irregular willow covered slip face on the west. The irregularity in the shape of the western border is because it is formed by several small sand tongues or flutes. A broad vegetated ridge borders the flat on the south side, and unlike the large southern flat, this flat is not open to the east. Instead, there is a long broad vegetated ridge on the east, flanked by two narrow windblown valleys.

At the northwestern edge of the island, there are several small willow covered hills, elongated parallel with the prevailing northwesterly wind. The western tip of the most westerly of these willow hills has been contacted by a 25 to 30-foot tall slip face, which is approximately as tall as the willow hill. Currently there is a narrow wind valley between the slip face and the hill. Based on similar situations observed elsewhere in the study area, within a short time the slip face will probably bury the wind valley, and begin burying the western tip of the willow hill. Willows are likely to continue to extend above the surface of the encroaching dune, but there will probably no longer be a hill sticking up above the dune surface, as the dune continues to advance.

Other willow hills in the northwest corner of the island currently do not have a tall dune slip face close by. The hills extend above the gently sloping sand surface located to the west of the hills, and strong winds severely erode the willow hills, exposing roots and sand layer striations. Smaller sand tongues (Features 1 and 2 on Figure D-8) extend southeastward into the interior of the island from the irregular western edge. The main slip face below the western edge is 40 to 60 feet tall and extends down to a dense thicket of willows on the northern flat.

The central part of the main western slip face continues southward just inside the western fence line from the northwest corner of the island. This section of the main western slip face is an actively moving, barren slip face about 40 feet tall. In this area, two large barren sand tongues (Features 3 and 4) extend east from the main slip face well into the island. At the southern end of the central section, the slip face joins the tall horseshoe shaped slip face enclosing the large southern flat.

A large sand tongue (Feature 3 on Figure D-8), about 250 feet wide and 500 feet long, extends southeastward into the island from the main western slip face. The surface of the tongue is depressed, with narrow ridges along its north and south margins. The surface of the tongue also rises moderately steeply (40% slope) from its western end to its eastern end. The western end of the tongue is a deep deflation bowl that has been eroded at the toe of the main western slip face. The bowl is large enough to form a small flat, low enough to be near groundwater and a reasonable location to plant willows. If willows were established, they would help reduce the advance of the barren main western slip face. The eastern end of the tongue is a bare slip face, 20 to 25 feet tall, that has over ridden an older smaller sand tongue (Feature 4).

Sand tongue Feature 4 is 350 feet long and 80 feet wide, extending southeast from the eastern tip of sand tongue Feature 3. The center of the tongue is bare sand and is depressed, with narrow ridges along its margins. Slip faces 10 to 20 feet tall extend from the margins onto the pre-existing surface of now-vegetated small hills and valleys of earlier sand tongues. Vegetation on the sand tongue margins and on the surrounding pre-existing topography is all dune scrub. Willows have not become established in this part of the island. A moss-covered crust covers the ground between larger plants in the dune scrub area.

Feature 5 is another large, barren sand tongue about 275 feet wide and 475 feet long, located just south of sand tongue Feature 3. It has pushed out over the pre-existing topography of small hills and valleys of what appears to be older sand tongues. It has a 25 to 30 foot tall slip face along its margins. The vegetated older surface on the northeast side of the tongue consists of dune scrub, while the vegetation along the southeast has a large component of willow, and also one 30 year old Monterrey pine located south of the eastern tip of the tongue.

An isolated willow hill lies at the western end of the narrow gap between sand tongue Features 3 and 5. It is a small wind blasted remnant of a much larger willow clump that has been mostly buried by the slip faces along the flanks of the advancing sand tongues. Southeast of the willow hill, a narrow valley has formed between the slip faces of the two large sand tongues.

The northern edge of the island lies at the base of a broad high sand ridge that trends in an E-W direction across the entire length of the island. The ridge does not have one unbroken slip face like is present along the north side of many of the other islands. The ridge is composed of multiple faces, and the lower slip face adjacent to the northern fence line is approximately 30 feet tall.

Dune scrub vegetation has been expanding on the east side of the island and is coming through the fence along most of the eastern fence line. The western bulge in the open ride area adjacent to the southern part of the island contains about one third of the area of the southern topographic flat. If the fence could be moved out into the bulge about 300 feet to the east in this area, it would very likely fill in with vegetation in a short time.

<u>Changes Observed on Air Photos</u>: In 1930, the large southern flat was covered with willow which blended into extensive areas of dune scrub vegetation to the north and south. The dune scrub to the north covered the area now occupied by the two large sand tongues in the center of the island. There was a long, very skinny strip of bare sand extending southeast across the island in approximately the location where sand tongue Features 3 and 4 are located today. Based on the 1956 photos, the central area had hilly topography, whereas the willows occupied the large southern flat and a smaller flat in the north.

A large hill covered by dune scrub was present just to the northeast of the current location of the northern flat. The hill apparently provided protection from the wind, and there was a considerably larger flat in this area than there is now. A large patch of willow grew on the western part of the flat, and this willow is still present today, but its western border has been much altered by repeated intrusions of sand tongues. The large vegetated hill located northeast of the island was still present on the 1970 photos, but had disappeared by the time the 1992 photos were taken. The hill is now covered by a dune field.

By 1956, a large sand tongue had moved into the dune scrub area where sand tongue Feature 5 is located today. The long skinny tongue had enlarged in the area where sand tongue Features 3 and 4 are located today, but Feature 3 was not nearly as wide as it is today. Dune scrub vegetation had significantly expanded in the northeastern part of the island.

Comparing 1970 with 1992, 2003, and 2007 air photos, the western, windblown edge of the island has receded to the east by at least 20 feet and locally up to 200 feet, for an overall average of about 100 feet. The rate of retreat over this 37 year time interval is 0.5 to 5 feet per year, with an average of about 3 feet per year. Vegetation on the east side, generally consisting of dune scrub and lupine, has increased significantly over that same time interval. It appears the installation of the fence around the open ride area greatly assisted the revegetation of these areas.

The northern tongue (Feature 3) has gotten significantly wider since 1970. The southern tongue (Feature 5) has pushed eastward about 200 feet since 1970, but the rate has slowed significantly since the 1992 photos. However, it has continued to expand in width. The northern flat has been squeezed mainly from the north by a growing slip face on that side of island, so that the flat is much narrower now (100 to 200 feet wide) and elongated in an E-W direction estimated to be about 600 feet long. The southern flat is slowly filling with sand, mainly along the west side, but also from the north. The southern ridge has remained stationary for the past 35 years.

Maintenance Projects: We are not aware of any revegetation projects that have been undertaken at Maidenform Flats.

Comments: The western edge of the island is downwind from a long stretch of open sand, where the wind blows in directly off the ocean. There is little of the original foredune vegetation remaining upwind from the island. Large amounts of sand have been delivered to the western edge of the island, apparently at a high rate of influx, for decades. There is nothing to indicate that the influx will reduce in the near future. Large sand tongues have nearly cut the central part of the island in two. The vegetation and stabilization of these tongues should be a high priority.

It is highly likely that the western side of the vegetation will continue to be overrun by sand and be pushed to the east. It is important to get vegetation established on the western slip faces, especially willow. It is also important to get willow established on the flats in front of the advancing slip faces so that it will be in position, and in a vigorous condition, to climb the advancing slip face and slow down its advance. This will provide time for vegetation to the east to become established.

If steps are not taken to stabilize and stop the sand tongues coming through the center of island, it is likely that even taller slip faces, up to 40 and 50 feet tall, will move eastward along the route opened by the sand tongues. This has already occurred on the west side of the island. The character of the wind protected flat area on the east side of the island will be dramatically changed if the sand tongues are not stabilized.

Suggested Management Options:

- Maintained Maidenform Flats to provide for its long term existence.
- Vegetation of the sand tongues, especially the two large sand tongues in the center of the island, should be highest priority.

In order to maintain Maidenform Flats:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north, west, and south move in.
- The flat on the south side of the island is larger than what is currently inside the island fence. Consider moving the eastern fence line well to the east in the near future, to allow vegetation to expand rapidly and become well established to with stand future encroachment of dunes.
- The flat on the north side of the island is getting squeezed from the large bare slip face on the north. The slip face should be vegetated, preferably with willow, to slow down its advancement into the flat.
- It is important that willow gets well established in the flats as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- Willow could be planted along the base of the central part of the main western slip face. This area appears to have been scoured deep enough to be near ground water, and the willows would significantly slow down the advancement of the slip face if they could get established.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being "lost" per year.
- The expansion of vegetation to the east should also be monitored, to determine what acreage is being gained each year and how quickly the fences in both areas can be moved ("in" on the west and north, and "out" on the east and south).
- The rate of encroachment of the slip faces could be reduced by planting and protecting foredune vegetation upwind of the island reducing the influx of sand to them.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

16. 40-ACRE WOODS

Date of Site Visit: February 14, 2007

Time Spent on in Field:
8:30 a.m. – 11:30; 1:30-2:30 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Ronnie Glick – CSP
Tim Hanson - CSP
Nancy La Grille – CSP
John Schlosser - CGS
Donn Ristau - Consultant

Meeting in Sacramento

Date of Meeting: March 8, 2007

Time Spent:
10:00- Noon

Participants - Affiliation
Trinda Bedrossian – CGS
Kathleen Considine - CSP
Sheri Rain –CSP
Diona Roja -CSP
John Schlosser - CGS

Date of Site Visit: March 27, 2007

Time Spent on in Field:
9:00 a.m. – 12:00 Noon.

Participants - Affiliation
Trinda Bedrossian – CGS
Ronnie Glick – CSP
John Schlosser - CGS

Date of Site Visit: March 29, 2007

Time Spent on in Field:
Noon – 3:00 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
Jeff Parsons – Archeo Consultant
John Schlosser - CGS

40 –Acre Woods is shown on Figure D-9.

Background: This particular vegetation island was the subject of a separate but related study involving future management of OHV riding opportunities on a portion of this site. CSP requested input from CGS in exploring the feasibility of five main proposals for future management. The area to be evaluated focused on the sparsely vegetated portion in the center of the island, referred to as the “central vegetation belt” in this current report. CGS was asked to evaluate: (1) existing conditions at the site; and (2) how each proposal would impact sand migration into the lake, including how new riding areas and trails would impact erosion.

A preliminary report, entitled “Review of 40-Acre Woods Proposals, Summary of Findings, Oceano Dunes SVRA”, dated April 5, 2007, was prepared for CSP (California Geological Survey, 2007). A more detailed report with supporting documentation was to follow. This section of the current report provides that more detailed supporting documentation.

The recommendations that were made in the previous report have not changed, concerning the various management options being considered by CSP. There is additional information that should be considered prior to making decisions regarding which option to choose. The most important consideration is that any change in vegetation cover or topography brought about in the sparsely vegetated central part of 40-Acre Woods needs to be closely monitored for potentially significant changes in wind patterns. Any recommendations or plans regarding future management of the area may have to be modified due to unforeseen effects from altered wind patterns. Additional items to be considered are included below in the section on "Suggested Management Options".

Existing Conditions: The area that was considered to be part of the 40-Acre Woods vegetation island for this project includes the area bounded on the west by the open ride fence line, on the south by the Oso Flaco Lake access road, on the east by Oso Flaco Lake, and on the north by the fence line along the south side of the Maidenform Flats open ride area. The large willow covered flat on the south side of Maidenform Flats was considered to be a part of both Maidenform Flats and 40-Acre Woods. 40-Acre Woods has a NW-SE alignment, extending approximately 2,350 feet. The width of the island (NS) varies from approximately 2,200 feet on the west end to 1,200 feet on the east end of the island. The island area covered in this study is roughly 90 acres.

The island is comprised of three different NW-SE trending belts of vegetative cover, each of which has its own set of wind and sand transport conditions. The northern belt includes the well vegetated large willow covered flat, on the south side of Maidenform Flats, and the dune scrub covered series of ridges and valleys that extends 1,500 feet to the southeast. This northern belt is approximately 600 feet wide, and is generally higher in elevation than the other two belts.

The central vegetation belt is predominantly open sand, with only local areas of sparse vegetation. Since the belts on either side are vegetated, the wind moves relatively unobstructed through this belt, causing a wind tunnel effect where the surface wind is funneled eastward through the open corridor. Various types of topographic features have formed in the open sand of the central belt, mostly barchans and barchanoid dunes, with some variations of longitudinal dunes. Numerous deflation bowls or "blow outs" have formed immediately downwind of some of the larger barchan slip faces. Sand tongues, and smaller flutes are also common. The topography in this central belt is very dynamic, i.e., capable of changing rapidly and significantly. The belt of open sand is approximately 850 feet wide at the western end, narrowing to 500 feet wide at the eastern end just above Oso Flaco Lake.

The southern vegetation belt is a recently revegetated dune field, which 15 to 20 years ago was open sand similar to what the central belt is today. The topography consists of ridges and valleys, with rounded and smoothed shapes of barchans, longitudinal dunes, and blow out holes. It is currently covered with dense dune scrub vegetation and is approximately 850 feet wide at the western end, narrowing to 250 feet wide at the eastern end. All but the northwest corner of the belt lies downwind from an unbroken complex of large vegetated foredunes with developing willow flats on the lee side of the foredunes. The surface wind that flows over this belt is somewhat reduced compared to the central belt, and the rate of sand influx is drastically reduced from what is delivered to the central belt. The elevation of the southern belt is slightly higher than the central belt.

The open ride area adjacent to the island is open 5 months of the year and closed the other 7 months during the Plover nesting season. The southern boundary of the ODSVRA ride area is located near the west end of the central vegetation belt of the island. Partially vegetated foredunes are located upwind (west) of the island along the shore. The vegetation is fairly continuous between the foredunes and the west end of the southern vegetation belt of the island, however the open ride area is located between the foredunes and the west end of the central and northern belts of the island. The open ride area is bare sand, exposed to the full force of the prevailing northwesterly winds which blow the sand into large transverse dunes. As the transverse dunes approach the island, they break up into groups of large crescent shaped barchanoid dunes. The area containing large barchanoid dunes begins just west of the island and extends into the western part of the island. Slip faces on many of these barchanoid dunes are up to 60 feet tall.

At the easternmost end of the central vegetation belt, large barchan dunes again form, with slip faces 40 to 80 feet tall. Immediately east of the tall slip faces, narrow wind valleys and sand tongues deliver sand to the crest of a 40 to 50 foot tall slip face that cascades down to the marshy flat adjacent to Oso Flaco Lake.

Sand samples were taken at eight locations (FA-1 through FA-8) throughout the island (see Appendix B).

<u>Changes Observed on Air Photos</u>: In 1930, Oso Flaco Lake had a similar shape and dimensions as today, but the two projections of the lake that point toward the northwest were about the same size. Today the northern projection (called the thumb for this report) is much smaller than it was in 1930. The southern projection is of similar dimensions as in 1930, but portions of the western end of the projection have become densely vegetated rather than open water. Also in 1930, the outlet of Oso Flaco Creek flowed directly northwest to the ocean, whereas today it turns to the southwest after leaving the lake.

There was extensive vegetation extending northwest from the western tip of the lake, which joined with the foredunes. Other foredune vegetation located along the shore to the north was less extensive, consisting of short narrow strips (probably growing on small longitudinal dunes). The area between the two westward projections of the lake was bare sand, which extended all the way to the coast. Dune scrub vegetation covered the area north of the lake. The western edge of the dune scrub vegetation went as far as the western tip of the large willow flat on the south side of Maidenform Flats to the western tip of the thumb of the lake.

By 1956, the vegetation along the western tip of the lake had expanded to the north and to the west. Based on the dark color of the vegetation on the photo, it probably is a large patch of willows. The open sand dune field northwest of the lake contained numerous barchans visible on the photos. The western edge of the large area of dune scrub vegetation, located north of the lake, had receded 200 to 300 feet. The topography in the dune scrub area consisted of several long NW-SE trending and NE facing slip faces along the edges of large sand tongues that had become vegetated. Numerous narrow ridges, with the same orientation, also appeared to be related to old sand tongues. This pattern of steep slip faces, broad ridges, and valleys all oriented NW-SE extends northward to the area that today is the dune scrub covered part of the northern vegetation belt. The large willow covered flat on the south side of Maidenform Flats island had a well developed slip face around three sides, with willows climbing up most of the slip faces.

The dune scrub area north of the lake appeared to be used heavily for camping and OHVs. There were 15 to 20 narrow trails visible through the vegetation and four wide patches of bare sand that probably were camping areas. This is the only vegetation island where OHV trails and bare camping areas were visible on the 1956 air photos. The thumb of the lake was about the same size as in 1930.

By 1963, vegetation in the area west and north of the western tip of the lake had expanded, but it still had not expanded north of the location of the present day Oso Flaco Lake access road in the southern vegetation belt. A bare sand barchan dune field still existed between this expanding vegetation and the gradually receding dune scrub vegetation northeast of the lake. The network of OHV trails and large bare camping areas also expanded in this area. The thumb of the lake was about the same size as it had been in the 1930 and 1956 photos.

The 1970 photos indicate vegetation northwest of the western tip of the lake was getting thicker. It also appeared that the longitudinal foredunes were getting longer, thicker, and better vegetated in the area northwest of the lake. The vegetation edge along the north side of this patch had not moved northward much since 1963. It still remained south of the Oso Flaco Lake access road location. The most dramatic changes were north and northeast of the lake in the area that had been covered with dune scrub vegetation. Only one third of the vegetation that had been present in the 1963 photo remained. What had been a relatively intact large block of vegetation with a dense trail network in it became detached small blocks of vegetation in a sea of open sand. The large willow flat on the south side of Maidenform Flats remained intact, although it appeared that the western edge of that vegetation had receded eastward about 150 feet since 1963. The thumb of the lake was drastically reduced in size. Its northwestern tip receded southward about 400 feet, and it became narrower.

By 1992, the northern edge of the patch of dense vegetation that extends northwest from the western tip of the lake was in about the same location as it was in 1970. However, a group of large, well vegetated foredunes had developed along the shore north of this vegetation. The group of foredunes is about 600 feet (N-S) by 800 feet (E-W). Fordunes located north of this group were still narrow, sparsely vegetated strands. A deflation bowl or flat developed downwind of the new foredune complex. It was about 200 to 300 feet wide (E-W) with vegetation growing in it, including willows. A line drawn along the vector of the prevailing wind from the north edge of the new group of foredunes extends southeast to line up with the thumb of Oso Flaco lake.

Nearly all the dune scrub vegetation that once was present in the area north east of the lake was gone by 1992; i.e., the area that today comprises the central vegetation belt was bare sand, and the area that today comprises the southern vegetation belt had not yet been revegetated. A huge expanse of open sand existed upwind of the north side of Oso Flaco Lake. The ridges and valleys that were covered previously with dune scrub were transformed into a barchan dune field once the vegetation was removed. Only a dense stand of willow, present on the tall slip face at the eastern end of the island, slowed the advance of sand toward the lake. The dense willow flat on the south side of Maidenform Flat remained relatively unchanged from 1970. The area southeast from the willow flat, which became part of the northern vegetation belt of today, was only partially vegetated. However, the amount of vegetation had increased from what was present in 1970, probably as a result of the installation of a fence to protect the vegetation from riding.

By 2003, what had been the new group of foredunes on the 1992 photos continued to grow denser vegetation. The foredunes north of the new group also expanded in length, thickness and amount of vegetation. The entire area that comprises the southern vegetation belt, which was bare sand in 1992, was revegetated by 2003. The central vegetation belt, which had also been essentially bare sand in 1992, had scattered small patches of vegetation in 2003, but was still a windblown bare dune field. Vegetation in the willow flat in the southern part of Maidenform Flats had expanded eastward out to the fence line. Vegetation within the northern vegetation belt had filled in and covered essentially the entire belt southeast of the willow flat.

<u>Maintenance Projects:</u> Revegetation projects in 40-Acre Woods included efforts to stabilize the bare sand area that had been located adjacent to the north side of Oso Flaco Lake. The projects included the establishment of foredunes upwind (northwest) of the revegetation area adjacent to the lake.

- 1986/87 season: CSP implemented a revegetation project on 50 acres north of Oso Flaco Lake. The area was covered with straw; then hydroseeded. A heavy duty agriculture-type aluminum pipe irrigation system was installed. Water was supplied with a diesel pump attached to Oso Flaco Lake. The area sprouted well and produced a good grass cover, until strong spring winds came and stripped away the vegetation. The blown out bare sand areas got larger, and caused sections of the irrigation system to collapse. Subsequently, the system was removed. Only patches of *Camisonnia* remained a few years later. The lessons learned were that grass is not tough enough to withstand strong spring winds, and there is no real natural seed bank in the bare sand areas. Seed has to be brought in.

- 1989/90 season: CSP initiated a revegetation project to establish foredunes northwest of Oso Flaco Lake, beginning at the south boundary of the ride area and extending to just north of Oso Flaco Creek mouth. The project size was 30 acres. Bulldozers, front end loaders, and trucks were used to move sand within 0.5 mile to fill in “blow outs” in the existing dunes (some of which were vegetated). Artificial dunes were constructed to stretch between the existing natural dunes. They were 40 feet long, 20 feet wide, by 10 feet high. The area to be treated included some steep and loose sand areas. The area was hydro-mulched with fertilizer and a seed mix which included a huge list of native species. Then straw was spread over the area and punched in. Sand fencing was installed in 10 locations. Single lines were erected between existing dunes, each 40 feet long. Also, at 10 other locations two parallel rows of fencing, 40 feet long and 10 feet apart, were installed. As reported 10 years later, the area became a stable foredune area with good vegetation cover. It caused a huge “slack area” (deflation bowl) to form directly east of the foredune area. It was expected that the “slack area” would fill in with vegetation, as it had done south of the fence line in the Oso Flaco area.

- 1990/91 season: The project location was described as “due south of last year’s foredune work area”. The project consisted of 10 acres, west of Oso Flaco Lake. Equipment (Caterpillar Challenger) was used to level and contour the sand. Then the contoured area was hydroseeded with native plants and fertilizer, and covered with straw that was “crimped in”. Nine years later, it was a “great looking”, well vegetated foredune area. It was part of an area of well vegetated foredunes that extended from the south boundary of the ride area southward to the huge dune stabilized by European beach grass at the mouth of Oso Flaco Creek.

- Memo of 10/29/91: From Dan Blankenship, Ecologist OHV Division to Bill Dall, Tech Services Superintendent, OHV Division regarding “Oso Flaco Revegetation” stated:

    - From talking with Tom Moss (CSP Ecologist at Asilomar State Beach) who has experience with this, you need to stabilize the foredunes in order to slow the sand movement.
    - Sand fencing and revegetation do not go well together; they are mutually exclusive.
    - Use fences in foredunes areas to build dunes where equipment cannot be used. The sand surface of a dune built by fences (and maintained by keeping the fence there) is constantly moving sand, which will not allow plants to become established.
    - Revegetation should be done downwind of fences, at a distance five times the height of the fence. Once sand builds to the top of the fence, the dune shape will remain constant as long as the fence stays in place. Vegetation can then be used to stabilize the dune made by the fence.
    - Tom Moss has had poor success with revegetation that does not have irrigation the first dry season.
    - Tom would not try to stabilize a back dune area where the area upwind consisted of blowing sand, unstabilized by vegetation, because the plants would not be able to keep up with the influx of sand. Based on the above principles, CSP will undertake to stabilize the bare sand area feeding sand into Oso Flaco Lake by starting out in the foredune area.
    - Sand fencing and revegetation had been used in one foredune area during the 1989/90 season, north of the mouth of Oso Flaco Creek. This project was successful but they needed to shore up some of the blow outs with additional sand fencing, and put fencing on the tops of newly created dunes to capture more sand and increase their height.
    - The following plan was formulated. In the 1991/92 season, Phase I (of the multi year project) will use sand fencing just inside the closed area, which is protected by fence from the open ride area. The sand fencing will capture some of the moving sand, and build future dunes. Also, each season, 10 to 20 acres will be revegetated in areas adjacent to the sand fencing. The method of establishing vegetation will be the

following: spread straw over the area; punch in straw with a sheepsfoot roller; then hydroseed. Follow each project with monitoring to keep track of the rate of sand movement, using air photos and ground stakes. Phase II is scheduled to be done 1992/93 season through the 1994/95 season. It will close 18 acres of open ride area located northwest of the lake, which is the source of the sand going into the lake.

- 1991/92 season: Test plots were constructed to observe the results and determine the best way to establish a dune scrub community. The test plot area was northwest of Oso Flaco Lake in bare sand locations and directly downwind from the southern section of foredunes established in 1989/90. The north side of the test plot area abutted the south boundary of the ride area. Variations of different hydroseed methods and mixes, together with different methods of straw mulching were tested. Most of the test plots had blowouts, but the plots that had the straw punched in prior to hydroseeding did better.

- 1991/92 season: A project was undertaken to fix blowouts that had developed in the 1989/90 season foredune project area. Equipment was used to fill and level the blowout holes. The recontoured area was covered with straw, which was then punched in with a sheepsfoot roller, followed by hydroseeding the area with a mixture of fertilizer, seeds, and various other ingredients. The treatment was effective in revegetating the blow out areas, and vegetation was intact when the monitoring report was completed 7 years later.

- 1992/93 season: The goal of the revegetation project for this season was the creation of a coastal dune scrub community on the bare sand sheet downwind of the stabilized foredune area that was established in the 1989/90 season. The area to be revegetated was 10 acres in size, located immediately south of the south boundary fence of the ride area. Eight years later this area was reported to be in stable condition, due primarily to beach primrose.

- 1993/94 season: The revegetation goal this year was to try to vegetate an active sand sheet. Two former projects, the creation of foredunes and the establishment of a coastal dune scrub community immediately downwind of the established foredunes, had been successful to this point. This project was to stabilize the area downwind of the coastal dune scrub project west of the lake. The project wrapped around the north side of the lake. The north edge of the project roughly followed the first dune ridge running parallel to the lake, toward Little Oso Flaco Lake. The 20-acre project area contained very undulating terrain, so some straw spreading and punching had to be done by hand rather than by equipment. After the straw was applied, the area was hydroseeded and “rolled”. The project was completed in February and March 1994. It did well, but had a few blowouts that needed remedial attention.

- Report of 4/29/94: A report given at a ODSVRA staff Vegetation Management meeting indicated that straw punching conducted for the Oso Flaco Lake revegetation projects had not worked well. When the causes for this were investigated it was discovered that it was rice straw that did not work well. Wheat straw performed quite well. The report also indicated that the containerized plants that were used in the revegetation projects had averaged 80% survival. However, those containerized plants planted in bare areas, that did not have the straw and hydromulch treatment, did not do as well.

- 1994/95 season: This 25-acre project continued the treatment of spreading straw, punching it in, followed by hydroseeding. The goal was to increase the buffer between Oso Flaco Lake and the active sand sheet to the north. The terrain covered by this project was rougher than had been done previously and a huge number of plant containers were used. It was completed in April 1995. By 2001, the revegetation efforts had not held up well, largely because the upwind sand sheet to the west (called "the southern end of Boneyard Flats" in the maintenance records) was covered in a high percentage of the project. Maintenance staff concluded that there needed to be a continuous band of vegetation, beginning at the eastern edge of the foredunes and planting progressively downwind to the east. Any bare sand areas upwind of a stabilization project will have an enormous impact on these projects once the strong seasonal winds begin to blow. Staff concluded that where a **well vegetated area can be covered by sand in a matter of weeks, the plants cannot grow quickly enough to establish themselves.**

- 1997/98 season: The boardwalk from the end of the footbridge across the Oso Flaco Lake to the ocean needed sand stabilization to keep sand from burying the boardwalk. The project methodology was the same standard methodology, using punched in straw, and hydroseed. However, the sand stabilization with new vegetation did not last long. People walked on the vegetation and high spring winds eroded the new vegetation.

- 2000/01 season: Six acres along the northern edge of vegetated past project areas needed to be reinforced, so the vegetation planted since 1992 would not be degraded. The planned project was to install jute netting, held by wooden stakes, into blowout areas. Lupine was to be interplanted within the netting. There was no record in the maintenance notes of how this project performed.

Comments: The area between the now vegetated ridge along the north boundary of 40-Acre Woods and Oso Flaco Lake has undergone dramatic and fairly rapid changes in vegetation cover in the 77 year period from 1930 to 2007. Heavy use of the area for camping and OHVs in the 1950s and 1960s eliminated most of the vegetation that had been present in the center of 40-Acre Woods. Portions of the area where vegetation was removed are still bare sand today. Ironically, some of the heaviest vegetation present today lies on what was bare sand in 1930. The area between the northwest shore of Oso Flaco Lake and the ocean was essentially bare sand in 1930, but due to intensive, repeated revegetation efforts by CSP since 1985, this area is now stabilized with vegetation. Foredunes were established along the coast. These captured sand and modified wind flow patterns to the point where massive sand sheets farther east between the foredunes and the lake shore could be revegetated. Much was learned from the numerous revegetation projects in this area.

The central vegetation belt of the island is an open dune field, which (based on observations throughout the study area) is subject to high rates of sand transport and fairly rapid changes in topography. The type of vegetation and topographic conditions that tend to slow down the rate of sand transport are those present in the northern vegetation belt. The northern belt has conditions created by a typical vegetation island, i.e., a high western ridge containing a tall willow vegetated slip face, and a large flat on the east side of the slip face which allows vegetation to expand to the east. As a long term goal, CSP may want to establish similar conditions in the central vegetation belt. An artificially created vegetation island could be formed in two places, one in the western or middle part of the vegetation belt, and one near the east end.

If an artificial vegetation island is to be constructed in the central vegetation belt, consideration must be given to the effect that construction of a large western ridge will have on local wind patterns. The effects of altering the wind patterns must be carefully monitored. Construction of a large ridge might deflect wind to the south or north into the adjacent vegetated areas. The increased wind and sand transport could begin to cause severe erosion and/or burial of the vegetation in these areas.

A typical vegetation island that includes a tall, willow covered slip face on the west side and a flat on the east side appears better suited to withstand high rates of sand influx than areas of low relief that are vegetated only with dune scrub, such as the southern vegetation belt of this island. A barchanoid dune with a 20 to 40 foot tall slip face could move across a low relief dune scrub landscape at a relatively quick pace, while a typical vegetation island would cause the dune to slow down significantly and wrap around the western edge of the island.

The southern vegetation belt of the island is protected from encroachment by barchanoid type dunes, except along its northwest side, because of the continuous cover of vegetation upwind. The central vegetation belt does not have such a continuous windbreak. The central belt could be revegetated at considerable expense and effort, and restored to look something like the southern vegetation band, which would stabilize the sand under the vegetation cover. However, large dunes would still advance in from the west, burying the vegetation. Therefore a different approach than the procedure used to revegetate the southern belt may be required to keep the central belt vegetated.

It may be that the current pattern of vegetation and wind in the 40-Acre Woods area causes the wind to be funneled through the central belt, increasing its speed in that part of the island. If the wind were slowed or blocked in the central vegetation belt by revegetation efforts, then rather than slowing down across the entire 40-Acre Woods vegetation island, the higher speed wind may be focused to a different location in the 40-Acre Woods. The area northwest of Oso Flaco Lake has had a broad open sand corridor in one place or another at least from 1930 through 2007. The open corridor allowed the strong winds coming off the ocean to pass rapidly eastward through the area. The entire north side of the lake has never been completely vegetated during that period of time, so it is unknown what effect a complete vegetation cover would have on wind behavior. It may be that the natural condition is to have an open unvegetated wind corridor somewhere through the area.

In that case, the best that could be done to slow down sand movement toward the lake may be to revegetate the eastern half to three quarters of the central belt with dune scrub, without significantly modifying existing topography. Allow dunes with tall slip faces to advance east across the revegetated land surface. Then go back and revegetate areas west of the slip faces. This area northwest of the lake may require constant maintenance to keep it as vegetated as possible, in order to prevent large amounts of sand from rapidly advancing into the lake.

Any option to leave open ride areas and ride corridors in the central belt will require additional maintenance and revegetation efforts to keep the sand from the central belt from continuing to move east into Oso Flaco Lake. Areas not fenced year round are not likely to stay vegetated. Any ride corridors wider than about 25 to 30 feet, especially if aligned in a NW-SE direction, will likely become wind tunnels and sand transport corridors. They are likely to develop into narrow sand tongues. We have observed throughout the study area that sand tongues have a negative effect on the longevity of vegetation.

The previous report by CGS (2007), "Review of 40-Acre Woods Proposals, Summary of Findings, Oceano Dunes SVRA", dated April 5, 2007, focused on the central vegetation belt of the larger 40-Acre Woods vegetation island considered in this report. Recommendations were provided that dealt with what portions of the central belt should be vegetated. They did not deal with **how** areas to be revegetated should vegetated, or what type of vegetation should be used. Before any option is chosen it will be important to consider the issues mentioned above. The most important is the need to include in any option chosen a plan to carefully monitor changes in wind patterns caused by a proposed project. It is also important to manage the rate of sand transport through the central belt corridor.

Suggested Management Options:

- Maintain the northern and southern vegetation belts of the island to retain a healthy vegetative cover. It is expected that these efforts will be minor in comparison with any efforts required to revegetate the central vegetation belt.
- To manage the central vegetation belt, consider (1) construction of an artificial vegetation island with a high western slip face and an island flat open to the east, vegetated with a large component of willow, or (2) revegetation of the unmodified existing topography with dune scrub vegetation. Either method of revegetation should be done in small sections and accompanied by careful monitoring to observe the effects on wind patterns.

If it is decided to try to revegetate portions of the central vegetation belt of 40-Acre Woods by constructing artificial islands:

- It would likely require a significant effort over several seasons.
- Form a new sand ridge along western margin of the future island. This could be done with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.

- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where a former tall slip face of a large dune used to be, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new island.
- Artificial islands should be located where it is desired to capture large amounts of sand for an extended period of time. The islands would move eastward, but relatively slowly. It appears that the eastern end of the central belt would be a desirable location, to slow down the rate of sand movement just before it reached Oso Flaco Lake. Another possible location would be near the center of the central belt, to form a sand collection location that would likely have a long lifespan since it would have a long distance to move eastward before reaching Oso Flaco Lake.

If it is decided to try to revegetate portions of the central vegetation belt of 40-Acre Woods by establishing dune scrub, without significant modification of existing topography:

- It would likely require a significant effort over several seasons.
- Use the same techniques employed in the southern vegetation belt, and at Pipeline to get dune scrub established.
- This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- It is likely that dunes with large slip faces will advance from the west and eventually bury the vegetation. The freshly buried area “behind” (west of) the slip face will have to be revegetated again. This type of revegetation may require more maintenance in the form of repeated plantings.

17. INDIAN MIDDEN

Date of Site Visit: March 29, 2007

Time Spent on in Field:
9:30 a.m. - 10:30 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
Jeff Parsons – Archeo Consultant
John Schlosser - CGS

Shown on Figure D-10.

Existing Conditions: Indian Midden, along with Indian Midden South, Boy Scout North, and Boy Scout Camp lie within the Middle valley, just to the east of the Middle sand ridge as described in the section on “Geomorphology of Oceano Dunes Area” above. The large Middle sand ridge is the ridge that the Sand Highway follows.Currently, Indian Midden located just north and east of the general open ride area fence, outside the ride area. There is no fence along the north or east sides of the island. The island is approximately 350 feet wide (NS), 1,150 feet long (EW), and is skewed in a NW-SE direction parallel with the prevailing winds.

A large transverse or barchanoid dune with an approximately 80 foot tall slip face has encountered the western edge of the island. The slip face wraps around the western tip of the island before bending back to a more linear NS orientation. The southern arm of the slip face extends south about 50 feet along the southwestern edge of the island before bending toward the south and heading across the open ride area to join the large slip face on the western side of Boyscout North. The northern arm of the slip face extends in a northeast direction away from the western tip of the island, making a gradual bend to the north, rather than a sharp bend like the southern arm does.

The western ridge of the island is a separate feature from the tall slip face of the encroaching transverse dune. A deep wind valley has formed between the encroaching slip face and the horseshoe shaped western ridge. The floor of the wind valley is 10 feet wide, and it extends approximately 200 feet to both the north and south sides of the island. The western ridge of Indian Midden also has a slip face on its eastern flank that extends approximately 70 feet to the island flat. The steep slope on the western flank of the ridge, which faces the wind valley, is about 60 feet tall.

Vegetation on the western part of the island is thick and composed almost exclusively of willow. It covers the western half of the island flat, the entire western ridge, and much of the wind valley and the tall slip face of the encroaching dune. Sand Sample IM-1 (Appendix B) was taken on the east side of the vegetated flat.

A smaller barchanoid or transverse dune, with a shorter slip face, approximately 15 to 20 feet tall, is advancing westward toward the crest of the larger dune. The shorter slip face is located 20 to 75 feet west of the crest of the taller slip face, and it has encountered and wrapped around a small willow hill that sticks up out of the sand about 75 feet west of taller slip face. Most of the nearly flat surface between the crest of the taller dune and the toe of the shorter dune is bare sand. Only a few scattered clumps of willow branches extend through the sand surface.

A wide, low ridge extends along the north side of the island flat, separating the vegetation island from a large shell midden to the north. Currently, the midden is downwind of the strong winds that come out of the wind valley on the northwest side of the island. It appears that the sand cover is being blown off the midden mound, gradually exposing more of it.

A smaller ridge has formed along the south side of the island. The top of the ridge is vegetated with lupine, and the south fence line is at the toe of the ridge. The open ride corridor between Indian Midden and Indian Midden South is only 60 to 75 feet wide, but it is sufficiently wide to allow strong winds to be funneled through the gap. Sand ridges have built up along the sides of the corridor, similar to those seen along the sides of sand tongues.

Indian Midden has a somewhat different topography than the "typical" vegetation island, in that the flat on the eastern side of the tall western ridge does not open out onto a large deflation bowl, as would be expected. Instead, a large, wide longitudinal ridge is located downwind from the island. The longitudinal ridge is 300 feet long by 180 feet wide, with a narrower portion that extends another 200 feet downwind. The hill rises 50 to 60 feet above the elevation of the island flat, almost as high as the western ridge. It is densely covered with lupine, mock heather, poison oak, and other brushy species, which appear to make up a "climax" type of vegetation community. Sand sample IM-2 was taken on southeast corner of this ridge.

<u>Changes Observed on Air Photos</u>: Based on the 1930 and 1949 photos, Indian Midden and Indian Midden South did not exist as vegetation islands during the 1930s and 40s. No vegetation or shell exposure was visible on the photos in the locations where these islands are today. Other nearby islands, such as Boy Scout North, were plainly visible on sets of photos. From the pattern of dune slip faces visible on the photos it was obvious that the large Middle sand ridge and Middle valley were prominent topographic features that were present in this area as far back as at least the 1930s. They were located in approximately the same locations as they are today.

By 1956, Indian Midden had grown into a dense clump of willows, approximately 200 feet long (NS) and 100 feet wide (EW). This is remarkable growth, considering there was no vegetation visible on the photos just 7 years prior to this. There is a large transverse dune slip face located at the western edge of the vegetation. Most likely the willows had grown up from a deflation bowl that had formed downwind from the tall slip face of the dune. Willows present in Boy Scout North did not appear to grow in coverage the way they had at Indian Midden, i.e. Boy Scout North stayed approximately the same size from 1930 to 1963.

There was no midden visible on the 1956 photos. A small patch of shell midden, approximately 50 feet in diameter, was exposed on the 1963 photo. The emerging vegetation island was a short distance southwest of the exposed midden. Apparently, the local wind patterns had been altered so that sand covering the midden was beginning blow away. Perhaps the approaching dune from the west had gotten close enough and large enough to alter the wind. Also the growth of the dense clump of willow associated with the dune may have contributed to the change in wind pattern.

The area to the south of the island, where Indian Midden South is today, was still an open sand dune field in 1963. Only a “speck” of vegetation, less than half the size of the exposed midden, had emerged on the broad hill several hundred feet southeast of the existing willow clump. The rest of the area between the willow clump and the small speck of new vegetation was open sand. All of this area is vegetated today.

By 1970, a well developed, high slip face was present along the western side of the island, and a well defined flat had developed just east of the slip face. The slip face was well covered with willows, and spotty vegetation was spreading out onto the flat. There still was no vegetation present to the southeast of the flat for a distance of approximately 400 feet. The vegetation on the hill to the east had expanded, but there was no vegetation in the area where Indian Midden South is today.

In 1992, a tall, well developed slip face reamined present along the west side of the island. A wavy line of barchanoid dunes extended south from the west side of Indian Midden the northwest side of Boy Scout North. A short distance east of the wavy line of dunes, Indian Midden South emerged, with a small horseshoe shaped western ridge/slip face. It consisted of isolated clumps of willows covering an area about 200 feet long (NS) and 100 feet wide (EW). In a fashion similar to Indian Midden, Indian Midden South appeared and grew to this size between 1970 and 1992.

The island flat on Indian Midden doubled in size, with vegetation covering about half the flat. The hill to the east of the flat had considerably more vegetation on it than it did in 1970, and the dimensions of the hill continued to grow. As the expanding vegetation trapped more sand, the hill grew taller and wider. Comparing the 1992 photos with later photos, this sand trapping effect has continued, since the island continues to grow in a downwind direction. The area of shell midden exposed also increased to approximately 150 feet by 200 feet.

The most significant changes from 1992 to present are the substantial increases in vegetative cover on the island flat, on the hill to the east of the flat, and on the adjacent Indian Midden South.

Maintenance Projects: We are not aware of any revegetation projects conducted on this island.

Comments: None.

Suggested Management Options:

- One alternative is to maintain the island on its own.
- Another alternative is to connect Indian Midden and Indian Midden South

If it is decided to maintain Indian Midden island:

- The best long term approach is to allow the island to move gradually to the east in response to the natural processes. Since the island lies outside the ODSVRA ride area, fences will not have to be moved on the east to accommodate expansion of vegetation in that direction.

- It is important that willow stays well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Indian Midden and Indian Midden South:

- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge in the current ride corridor between the two islands, by extending the tall slip face at the southwest corner of Indian Midden southeastward to connect with the slip face along the south western margin of Indian Midden South. This could be accomplished with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where a former slip face had been, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.

18. INDIAN MIDDEN SOUTH

Date of Site Visit: March 29, 2007

Time Spent on in Field:
10:30 a.m. - 11:00 a.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
Jeff Parsons – Archeo Consultant
John Schlosser - CGS

Shown on Figure D-10.

Existing Conditions: Indian Midden South is approximately 350 feet long (NS), 150 feet wide (EW) and is skewed strongly in a NW-SE direction so that the western and southern ridges are essentially one long west to southwest trending ridge. There is a large slip face, along entire western side, that wraps around to the northern side of the island as well. Sand sample IMS-1 (Appendix B) was taken from the top of the western slip face. From about the middle of the western side of the island, a large slip face bends southward away from the main slip face. The slip face continues south to intersect with the main slip face on the north side of Boy Scout North. Another slip face trends southwesterly from near the northwest corner of the fence line around the island. This slip face also continues southward to intersect with the main slip face near Boy Scout North.

Two other long slip faces are present within approximately 300 feet west of the island. Both extend northward to form the slip faces immediately west of Indian Midden. The open ride corridor between Indian Midden and Indian Midden South is approximately 70 feet wide. The corridor between Indian Midden South and BoyScout North is approximately 225 feet wide at its narrowest spot. Riders going west, up to the top of the sand ridge to the Sand Highway, cross several transverse dune scarps between Indian Midden South and the top of the ridge.

Indian Midden South has a narrow flat enclosed within the tight horseshoe alignment of slip faces. The flat is open to the east, where there is a large deflation valley. Some dune scrub vegetation extends out to the east. Willows grow in the flat and up the adjacent slip faces. Sand sample IMS-2 was taken on the southeast side of the flat.

The open ride corridor on the north side of the island appears to act like a sand tongue, with windblown sand building up along the northern ridge. The western side is withblown, and several slip faces are advancing toward the island from the west. It does not appear that this island will be able to maintain its size for long. It likely will be overrun by a high rate of influx of sand from the north and west. The island flat will be squeezed smaller, unless the vegetation is allowed to expand fairly rapidly to the east into what is now open ride area.

Changes Observed on Air Photos: Based on the 1930 and 1949 photos, Indian Midden and Indian Midden South did not exist during the 1930s and 40s. No vegetation is visible on the photos in the locations where these islands are today. Other nearby islands, such as Boy Scout North, were plainly visible on both sets of photos. Vegetation at the site of Indian Midden South did not appear until sometime between 1970 (when there was no island present on the air photos) and 1992 (when there was finally some vegetation present). From the pattern of dune slip faces visible on the photos, the large Middle sand ridge and Middle valley were prominent topographic features present in this area as far back as at least the 1930s. They were located in approximately the same locations as they are today.

By 1956, vegetation had appeared at the Indian Midden island site, but the area of Indian Midden South continued to be open dune field through at least 1970.

By 1992, a tall, well developed slip face continued to be present along the west side of Indian Midden. A wavy line of barchanoid dunes extended south from the west side of Indian Midden to the northwest side of Boy Scout North. A short distance east of the wavy line of dunes, Indian Midden South emerged, with a small horseshoe shaped western ridge/slip face. It consisted of isolated clumps of willows covering an area about 200 feet long (NS) and 100 feet wide (EW). In a fashion similar to Indian Midden, which had appeared from bare sand earlier, Indian Midden South appeared and grew to this size between 1970 and 1992.

Between 1992 and 2007, the most significant changes in Indian Midden South are the development of a small island flat and a substantial increase in vegetation.

Maintenance Projects: We are not aware of any revegetation projects conducted on this island.

Comments: Indian Midden South is relatively small, and there appears to be a large amount of sand moving toward the island from the west at a high rate of transport. Unless the island is allowed to expand rapidly to the east into what is now open ride area, it will not likely survive over the long term.

Suggested Management Options:

- One alternative is to allow Indian Midden South to become open ride area.
- Another alternative is to try to maintain Indian Midden South on its own.
- A third alternative is to connect Indian Midden South and Indian Midden.

If it is decided to maintain Indian Midden South:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to know what acreage is being gained each year, and to know how quickly the fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making a wind gap on the south side with heavy equipment. This would have to be closely monitored to

observe what effects the wind diversion would have on other parts of this island and the adjacent Boy Scout North.

- If any flutes or sand tongues develop along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

If it is decided to connect Indian Midden South and Indian Midden :

- Start by connecting fences between the two islands to keep traffic out of the current ride corridor.
- Form a new sand ridge in the current ride corridor between the two islands, by extending the tall slip face at the southwest corner of Indian Midden southeastward to connect with the slip face along the south western margin of Indian Midden South. This could be accomplished with heavy equipment, or with sand fencing to build up the new ridge. It is likely that the altered wind patterns would help to excavate a deflation bowl downwind of the constructed ridge line. This area should be closely monitored to observe exactly what effect the altered wind pattern has.
- Form a “flat” downwind of the new sand ridge, either with heavy equipment, and/or ideally with the help of the altered wind patterns. Within the flat, establish willows and other vegetation as soon as possible.
- It may be possible to get willows growing up the slip face of the newly formed sand ridge, if sand layering in the location is favorable. If the newly formed ridge is located where a former slip face had been, it is likely that relict steeply dipping sand layering is still present. The steeply dipping layering is a favorable location to provide water to vegetation. Willows planted deep enough in these locations would have an increased chance of surviving, and would have a “head start” in stabilizing the sand ridge that will become the western side of the new enlarged island.

19. BOY SCOUT NORTH

Date of Site Visit: May 16, 2007

Time Spent on in Field:
1:45 - 3:15 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Clint Sherman – CSP (MS work)
John Schlosser - CGS

Shown on Figure D-10.

Existing Conditions: Boy Scout North, along with Indian Midden, Indian Midden South, and Boy Scout Camp lie within the Middle valley, just to the east of the Middle sand ridge as described in the section on “Geomorphology of Oceano Dunes area” above. The Sand Highway follows this massive Middle sand ridge.

Boy Scout North is approximately 425 feet wide (NS) and 700 feet long (EW) and is skewed to a NW-SE alignment parallel with the prevailing winds. In general, the island is a typical vegetation island with a high western ridge and gradually lowering northern and southern boundary ridges, and a central flat that is open to the east. However, the western and northern boundaries of this island are not topographically simple, as some of the islands are. Instead, these are irregularly shaped boundaries, with various types of dune features of different shapes and sizes. There are multiple generations of these dune features which have formed and then gone dormant in response to changing wind conditions. The wind conditions have been altered over time as nearby dunes have changed location, shape and size.

There is a fairly linear (oriented approximately NS), large transverse dune with a 25 to 30 foot high slip face located approximately 70 feet west of the island. It appears that, in the past, other similar sized transverse dunes have encountered the western edge of the island and the slip faces have wrapped around the island, as the dune continued to move eastward.

As observed in the field, there are numerous dune slip faces on and adjacent to the island. These appear to be segments of transverse or barchanoid dunes which have encountered the western edge of the island in the past, and have wrapped around the island and continued advancing to the east. These slip face features have been numbered in the text and are shown on Figure D-10. Three slip faces extend north from the northern boundary of the island. The easternmost of these (Feature 1) is a 5 foot tall, short (in length) slip face ending just north of the northern fence line. The next slip face to the west (Feature #2) is 10 to15 feet tall and extends from the middle of the northern boundary across the open ride corridor to the southwestern boundary of Indian Midden South. Farther to the west is a large 30 to 40 foot tall slip face (Feature #3) that extends from the northwest corner of the island to the northwest corner of Indian Midden South.

The long transverse dune slip face (Feature 7) just west of the island is 25 to 30 feet tall. There are three slip faces that extend south from the southern boundary of the island. The easternmost of these (Feature 4) is a 5 foot tall slip face that extends south into the dune field between Boy Scout North and Boy Scout Camp. The next slip face to the west (Feature 5) is 20 feet tall and separates from the southern boundary slip face as it extends south away from the island. The next slip face (Feature 6) is 15 to 20 feet tall and separates from the main island slip face near the southwest corner of the island and heads south into the adjacent dune field.

The main island slip face is continuous along the north, west, and south sides of the island. It was not given a number for this report. The main slip face varies in height from 5 feet to 80 feet. The southern boundary ridge has a single interior (north-facing) slip face which toes out on the central flat. The height of the interior slope of the southern ridge gets progressively lower from west to east. There are three distinct steps in the ridgeline where the various numbered slip faces, identified above, separate from the main slip face and head south. The first step in the ridgeline is approximately one third of the way from the west side of the island to the east, where slip face Feature 6 curves away from the ridge and continues off to the south. The second step is about two thirds of the way from the west side of the island to the east, where slip face Feature 5 leaves the main slip face and heads south. The last step is near the eastern side of the island, and is only 5 feet high, where slip face Feature 4 separates from the ridge and heads south, while the ridgeline continues a short distance to the east and then blends into the flat.

The southwestern edge of the island has a steep slip face about 80 feet high, which toes out on the central flat. This southwestern portion of the main island slip face has fairly simple topography. The windward slope abuts the crest of the slip face, with no intervening wind valley. Wind ripples just west of the crest of the slip face in this area were 3 to 7 inches apart with a wind direction of S85E to EW. The center of the western edge of the island has been overrun by a large sand tongue that extends eastward about 150 to 200 feet. It has a partially vegetated, long slip face about 60 to 70 feet tall. Sand sample BSN-1 (Appendix B) was taken from the top of this face.

The northwestern edge of the island has much more complex topography than the southwestern edge. The current fence line in this area is 150 to 200 feet west of the edge of vegetation. It appears the prevailing wind from the NW is deflected so that is comes from the west in this portion of the island, and the concentrated wind flow has eroded an old wind valley at the NW corner of the island. Once the wind gets around the NW corner of the island it appears to turn back to its original prevailing NW direction. Numerous changes in the topography and wind speed along the northern edge of the island in the recent past are indicated by the multiple older wind valleys and slip faces, which have become dormant and vegetated, and the younger, actively eroding wind valleys and actively depositing slip faces that have been imprinted upon the older features.

In the northwest corner of the island, a localized 30 foot deep “blowout” depression has formed just downwind (east) of the large transverse dune (Feature 7). Immediately east of the blowout bowl is a fresh 30 to 40 foot high slip face (Feature 3), which is filling a previously eroded wind valley along the NW side of the island. The old wind valley had formed a high north facing (reverse face) slope along the northern boundary ridge. Erosion along the old wind valley appears to be much less active now than it had been in the recent past, due to the buildup of the large slip face (Feature 3), which has changed the wind direction and speed in this local area.

The eastern end of the northern ridge consists of two parallel low sand ridges, 5 to 7 feet high and 5 to 10 feet wide, that have become completely vegetated. The ridges appear to have formed when the old valley was more active, and they probably were located along the south edge of the old wind valley. The younger ridge is positioned about 25 feet north of the older ridge. Relative age assignment was based on the amount and type of vegetation growing on the ridges.

Two slip faces oriented approximately N-S are located in the lower (eastern) end of the old wind valley. The eastern slip face (Feature 1) is older than the western face. It is well vegetated and has been modified by being overridden by several narrow flutes, which have also become well vegetated. The western of the two slip faces (Feature 2) is the younger. Its southern end intersects with the northern boundary ridge at a point where a new sand tongue has recently been deposited. The sand tongue pushed its way into the vegetation and buried pre-existing topography.

The northern fence has been buried where the large slip face (Feature #3) intersects it. The old northern fence has also been buried where two other slip faces (Features 1 and 2) intersect it. At the time of the field visit, only 6 inches of the wire fencing was sticking above the sand surface. The new fence line located about 50 feet to the north had not been buried. There has been considerable influx of new sand into the northern part of the vegetation island. Because the wind direction and velocity have been altered by the growing transverse dune to the west, it is difficult to predict where wind erosion will occur and where deposition will occur in the short term.

Vegetation growing on the flat consists of willow, Juncus grass, ambrosia, beach burr, dune mint, Queen Anne's lace, mock heather, wax myrtle, and coyote brush. Sand sample BSN-2 was taken in the southeast corner of the flat. The taller slip faces, along the west side of the island and along the western portions of the north and south sides of the island, were at least partially covered with willow.

Changes Observed on Air Photos: As indicated from the pattern of dune slip faces visible on the 1930 and 1949 photos, the large Middle sand ridge and Middle valley were prominent topographic features that present in this area as far back as at least the 1930s. They were located in approximately the same locations as they are today.

In 1930, Boy Scout North was an isolated island in the middle of the transverse and barchaniod dunes. It was obvious on the air photos that the island was impacted by wave after wave of transverse and barchanoid dunes over the years. However, its shape and size appeared to change very little between 1930 and 1970. By 1992, the vegetation had expanded more to the east than it had previously, and by 2007, it had expanded even more to the east. The changes in vegetation pattern observed over the years involved a gradual "erosion" of the vegetation edge along the west and northwest sides of the island and a filling in of vegetation to the east and southeast.

Maintenance Projects: Maintenance and vegetation enhancement efforts on this island appear to have been limited to moving the fence line out regularly to protect new vegetation that has come in naturally. There may have been some planting of native species here, but there was no evidence of larger scale projects in the records.

Comments: It does not appear practical to try to attach Boy Scout North to Indian Midden South and Indian Midden. As long as the island is allowed to expand to the east at the same rate as vegetation is buried on the north and west sides of the island, it should remain viable for many decades.

Suggested Management Options:

- Continue to maintain Boy Scout North on its own.

If it is decided to maintain Boy Scout North:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved southeast at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- The advancement of the slip faces, both at the top and at the toe should be monitored, to determine how much vegetation acreage is being "lost" per year.
- The expansion of vegetation to the east and south should also be monitored, to determine what acreage is being gained each year and how quickly the fences in both areas can be moved ("in" on the west and north, and "out" on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- The two sand tongues on the north and west sides of the island should be quickly revegetated.
- If any other flutes or sand tongues develop in the future along the slip faces it would be very important to revegetate them as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

20. BOY SCOUT CAMP

Date of Site Visit: May 16, 2007

Time Spent on in Field:
9:15 a.m. - 1:08 p.m.

Participants - Affiliation
Trinda Bedrossian – CGS
Nancy La Grille – CSP
Tim Hanson – CSP
John Schlosser - CGS
Clint Sherman - CSP

Shown on Figure D-11.

Existing Conditions: Boy Scout Camp, along with Indian Midden, Indian Midden South, and Boy Scout North lie within the Middle valley, just to the east of the Middle sand ridge as described in the section on “Geomorphology of Oceano Dunes area” above. The Sand Highway follows this massive Middle sand ridge.

Boy Scout Camp is approximately 2,200 feet long (NS) and an average of 600 feet wide (EW). It is crescent-shaped, with the northern and southern tips of the island elongated toward the east. Other vegetated “islands”, adjacent to but not part of Boy Scout Camp, are fenced off and lie outside the ODSVRA ride area. Three of the adjacent islands are NW-SE trending ridges located to the east of Boy Scout Camp. The northern of the three ridges is located to the east of the northeastern tip of the island. It is fairly small, and does not extend far to the east. The southern of the three ridges is located east of the southeast tip of Boy Scout Camp and is part of a much larger area of vegetation that extends well to the east. The ridge that lies east of the center of the island is also part of a much larger area of vegetation extending well to the east. Another skinny vegetated ridge lies just south of Boy Scout Camp. The ridge extends east to a much larger vegetated area.

There are three broad lobes of open sand between the three ridges that lie east of Boy Scout Camp. The northern sand lobe lies between the northern and central ridges to the east. The central open sand lobe lies between the central and southern ridges to the east, and the southern lobe lies between the southern ridge to the east of the island and the skinny ridge south of the island. The western end of these three open sand lobes is the low end of the lobe. The surface of each lobe rises toward the east at an inclination of 20 to 30%. Each lobe ends approximately 1,000 feet to the east at the crest of a tall barren slip face. Each lobe is part of the open ride area.

There is a series of short transverse and barchanoid dunes advancing from the west. Where similar dunes have already encountered the western edge of the island, a large continuous slip face has formed. The slip face is very tall, and is only sparsely vegetated from crest to the toe. It is not clear why there are not more willow-covered small hills along the crest of western slip face, or why the slip face is not more densely vegetated with willows. Perhaps the rate of sand influx is too great for the willows to keep pace and the slip face has buried most pre-existing willow vegetation that was present. The toe of the tall western slip face rests on the large island flat.

The flat is elongated in a NS direction, rather than being more equi-dimensional like a square or circle, such as is the case with most of the other vegetation islands. The flat is enclosed like the other islands, with a high sand ridge built up on the north, west, and south sides of the flat. The northern and southern boundary ridges for this island are much longer than they typically are for other vegetation islands. These ridges extend downwind (southeasterly) over 1,000 feet, well beyond the eastern edge of the flat. The boundary ridges are also much broader and higher than most other vegetation islands. They appear to be part of a set of large longitudinal dunes that formed in this area before the most recent set of large transverse dunes advanced into the area. There is another broad longitudinal ridge located between the northern and southern boundary ridges, extending downwind in a southeasterly direction from the middle of the eastern side of the island. Review of air photos of this island and adjacent area from the 1950s to present indicates that the three longitudinal ridges discussed above were largely unvegetated in the early 1950s, and progressively became more vegetated up to the present time.

As observed in the field, the western edge of the island has a long continuous slip face between 80 and 140 feet tall. There are multiple short transverse and barchanoid dunes advancing toward the main western slip face from the east. These advancing slip faces are generally between 10 and 30 feet tall. Due to their shorter slip face, they migrate to the east much faster than the main slip face. The result is that there is a series of slip faces moving up the windward slopes of the larger dunes to the east.

As the faster moving slip faces approach the slower moving slip faces, they change the wind pattern, so that sand no longer pours down the face of the larger slip face. Instead, the actively transported sand moving eastward up the windward slope of the smaller dune pours down the smaller dune’s slip face, which toes out on the windward slope of the larger dune. In one such location on the southern part of the western main slip face, a younger 20 to 25 foot tall slip face has been advancing from the west, burying the old windward slope of the older slip face, so that only a 10 foot wide bench now remains between the toe of the new slip face and the crest of the old slip face. The older 80 foot tall slip face has willow branches sticking out of it. The bench also has willow branches sticking out of it, but there is no vegetation on the new slip face or its associated windward slope. This vegetation pattern indicates that the willow is having difficulty keeping pace with the high rate of sand influx occurring on the younger dune. However, it can keep up with the slower rate of sand influx occurring on the larger dune slip face, which for now is in the wind shadow of the approaching smaller dune.

There are only two sets of small willow covered hills located west of the main western slip face. One set of hills is in the far northwest corner of the fenced island. It has been inundated with successive waves of small dunes with shorter slip faces. The amount of vegetation in 2007 looked less than what was present on the 2003 air photos that were used for Figure D-11. The other set of willows extending above the main western slip face is in the southern part of the western ridge. The clump of willow hills has a wind valley around them, and a short slip face has advanced up to the western edge of the clump. The slip face wraps around the willow clump and joins the main slip face a short distance on either side of the willow clump. Sand ripples in this area face northeast. Wind direction at time of field visit was N30W. Sand ripples on the open windward slope between the two willow clumps were 5 inches apart, with a wind direction of S65W to EW.

Generally, along the western ridge, the windward slope abuts the crest of the main slip face without encountering any willows. Most of the slip face is not vegetated. It may be that the rate of sand influx is greater than the rate the willow can grow to keep itself above the encroaching sand. Near the southwest corner of the island, a few hundred feet east of the sharp bend in the fence line, where the fence is positioned almost at the crest of the slip face, the wind does not appear to blow as hard across the crest as it does farther north. Lupine is growing well here on the top of the slip face and, in fact, has moved out onto the windward slope, beyond the fence line. This may be an area where the fence line can be moved out to the west to protect the new vegetation and encourage the island to grow to the southwest.

The broad southern boundary ridge area is composed of a series of SE trending ridges and intervening shallow valleys. A narrow ridge, that is a continuation of the southern end of the tall western slip face, wraps around the south edge of the island and trends eastward about 500 feet to join a low broad ridge that is the largest of the ridges in the southern ridge area. The low broad ridge extends from the southern end of the island flat almost 1,000 feet southeastward to the narrow ride corridor through a gap in the ridge line. The ridge continues southeast of the ride corridor, but is not part of Boy Scout Camp. Two more valleys and ridges are present north of the low broad ridge. Vegetation has extended beyond the fence line on the southern side of the south ridge area.

At the SE tip of the island, near the ride corridor in the ridge line gap, sand ripples were 24 to 40 inches apart, and the wind direction was E-W to S80W. On the north side of the southern ridge area, the fence line has recently (since 2003) been moved northward about 150 feet to protect an area where vegetation had begun expanding beyond the old fence line. Vegetation inside the recently protected area has expanded since 2003. Plants growing in the newly fenced area and in the flat to the west include Indian paint brush, lupine, *Senecio*, dune mint, Queen Anne's lace, beach primrose, wall flower, *Phacelia*, *Juncus* grass, blackberry, poison oak, ice plant, coyote brush, mock heather, willow, Monterrey pine, and wax myrtle.

The island flat is densely vegetated with a huge variety of plants. The ridge to the east of the center part of the island has become covered with dune scrub type vegetation, and may have joined together with Boy Scout Camp island were it not for the fenced narrow ride corridor between the two islands. At the southern end of the ride corridor a small seasonal creek crosses the road from the eastern island into the flat of Boy Scout Camp. Sand samples BSC-1 and BSC-2 (Appendix B) were taken along the east and northeast sides of the flat.

From the sharp dogleg turn in the ride corridor between Boy Scout Camp and the ridge to the east, everything on the north side of the fence line is considered part of the broad northern ridge area. The topography in this area is complex, with numerous hills, ridges, and valleys, most of which trend NW-SE. The vegetation is dune scrub, with little or no willow present.

There is a broad valley zone between the two largest ridges in this area. It lies between the main northern ridge located along the northern edge of the island and a parallel large ridge located in the center of the area. The western half of the valley zone has been filled with a large sand tongue with multiple slip faces. The sand tongue has the appearance from the east of a cascading river of sand coming down from the tall western slip face into the vegetation.

A 20 to 30 foot tall EW trending slip face has formed along the northern ridge. It extends from the northeast tip of the island, where the sand has buried all but the upper foot of the fence line along the ride corridor, to the main western slip face. The slip face along the northern ridge appears to be advancing rapidly. It is burying the dune scrub vegetation present in the area, including ice plant, *Abronia*, lupine, *Senecio*, and mock heather. The area appears to be more vegetated than it was in the 2003 air photo, but there is not much tall vegetation like willow to stop the advancing slip face.

The large sand tongue filling the broad valley in the northern part of the island appears to be very active. There is no vegetation on the tongue, and there is evidence of strong wind flow and local erosion along the sides of the tongue. It has three main slip faces between the western fence line and the terminus of the tongue, each oriented perpendicular to the direction of the wind and each about 20 feet tall. There is another large slip face located just west of the western fence line, which may soon move onto the vegetation island. Sand sample BSC-3 was taken on top of this slip face. Sand ripples on the tongue between the lower two slip faces were 2 to 4 inches apart, with a wind direction of E-W.

<u>Changes Observed on Air Photos</u>: Based on the pattern of dune slip faces visible on the photos, the large Middle sand ridge and Middle valley were prominent topographic features that were present in this area as far back as at least the 1930s. They were located in approximately the same locations as they are today.

The vegetation in Boy Scout Camp in 1930 was not as extensive as it is today. The island had the crescent shape, but was not as accentuated because the northern and southern tips did not extend as far to the east as they do now. Large clumps of willow, which appear as a darker color on the photos, were visible in the central part of the island, while dune scrub dominated the northern and southern ridge areas. The vegetation to the east of the island was not nearly as extensive as today either, and the ridge to the east of the center part of the island had only a few small clumps of vegetation marking the beginnings of the dune scrub that would eventually cover it.

By 1956, the willow and other vegetation in the central flat had expanded some. The dune scrub on the northern and southern ridges had expanded substantially, and extended several hundred feet farther east than it had been in 1930. The dune scrub on the hill to the east of Boy Scout Camp had also expanded. Also evident on the photos was a prominent western ridge/slip face, partially vegetated with willows. The majority of the tall western slip face was bare sand. A large slip face oriented E-W was present along the northeast side of the island. Just to the east of the island this same slip face curved to the north and extended well to the north. The slip face appeared to be the leading edge of a large sand tongue. The three longitudinal hills to the east of the island were evident on the photos, even though they were only sparsely vegetated at this time.

By 1970, vegetation had expanded on the south and east side of the island, and on the hills to the east of the island. A dense network of riding trails was visible within the vegetation cover. Many trails went from the flat on the east side, up and over the high slip face on the west. It appeared that the western slip face had grown some and had moved a short distance eastward into the island flat. The flat had also enlarged to the east, even though vegetation had not moved eastward onto the newly expanded part of the flat. Since 1956, the northwest part of the island lost the most vegetation due to several large sand tongues moving in and burying previously existing vegetation. In the southern and southeastern part of the island, a series of small linear ridges, oriented parallel with the prevailing winds, were vegetated with dune scrub.

By 1992, vegetation had filled in within the flat. Many of the previously visible riding trails were covered by plants. Along the western edge of the island, the willow vegetation had been “eroded” by either burial or sand blasting along the tall western slip face. The sand tongue in the northwest corner of the island continued to move into the island. Vegetation on the hill to the east of the center of the island had significantly expanded since 1970, and vegetation also expanded to a lesser degree on the other hills east of the island. The western slip face was very prominent on the photos, although it did not appear to have moved very far eastward from its location on the 1970 photos. The northern and southern ridges of the island were noticeably larger than in 1970, as was the hill east of the central part of the island. Numerous short transverse dunes or barchanoid dunes were observed with slip faces oriented in a NE-SW direction. The northeast end of these short transverse dunes intersected with the main slip face of the island, while the southwestern part trailed off into the open sand area to the west. There appeared to be a high rate of sand influx to the western side of the island.

Between 1992 and 2003, there were some relatively minor changes in the amount of vegetation cover, with the largest being the continued incursion of sand tongues and flutes into the vegetation on the north side of the island. Another significant change from 2003 to 2007 was the quick growth of vegetation in the southeast part of the island in the area where the fence had been moved out into the ride area.

<u>Maintenance Projects</u>: Maintenance and vegetation enhancement efforts on Boy Scout Camp and adjacent islands appear to have been limited to moving the fence line out in selected areas to protect new naturally growing vegetation. There may have been some planting of native species here, but there was no evidence of larger scale projects in the record. Nevertheless, the area has generally increased in vegetative cover in the last 20 years or so.

<u>Comments</u>: Boy Scout Camp has been fairly stable in location and configuration since the 1930s and 40s, probably because the very high western slip face is so tall that it can move only very slowly to the east. However, much of the slip face remains bare sand. Enhancing the existing willow, and planting new willow at the base and on the face of the slip face, would help ensure the eastward advance of the main slip face continues to be slow.

The north side of island has a large sand tongue, with three slip faces, actively moving into the island. The northern boundary ridge has an EW oriented slip face which is actively advancing south over the dune scrub vegetation. There is little or no willow growing along the north side of the island.

<u>Suggested Management Options</u>:

- The best long term approach is to allow the island to move gradually to the east and south. Fences will have to be moved along the southern and eastern fence lines at the same rate as slip faces on the north and west move in.
- It is important that willow gets well established in the flat as well as on the slip faces so it can continue to slow down the advance of the slip faces.
- In particular it is important to plant lots of willows at the toe and on the lower slope of northern slip face, to help slow down the advancement of the northern slip face.
- It may be possible to get willows established high on the western slip face by planting them on the benches formed where advancing slip faces from smaller dunes encroach upon the main western slip face. Once the smaller dune has gotten close enough, the bench between the two dunes will be in the wind shadow of the smaller dune for some period of time. It would not be subjected to strong winds for that time period. Willows could be planted by augering down 10 to 20 feet and inserting willows in cardboard tubes, as has been suggested by CSP Maintenance Staff. It would be a good location to see if willows could take advantage of the water stored in the steeply dipping layers of the slip face. Sand fences could be installed near the top of the smaller dune to build it higher and slow down its advance, in order to give more time for vegetation on bench to get established.
- The broad ridge located east of the center part of the island could become the northern side of the island in the future, if the northern part is overrun with sand, so at some point it would be wise to get willow established on it to help slow down advancing slip faces.
- The advancement of the slip faces, both at the top and at the toe, should be monitored to determine how much vegetation acreage is being “lost” per year.
- The expansion of vegetation to the east and south should also be monitored, to determine the acreage being gained each year and how quickly fences in both areas can be moved (“in” on the west and north, and “out” on the east and south).
- The rate of encroachment of the slip faces could be reduced by reducing the influx of sand to them. This could be achieved by mechanically diverting wind around the island, away from the slip faces, by making wind gaps with heavy equipment. This would have to be closely monitored to observe what effects the wind diversion would have on other parts of the island.
- It is very important to vegetate the large sand tongue in the northwest part of the island.
- In the future, any flutes or sand tongues that develop along the slip faces should revegetated as quickly as possible.
- To help revegetate a sand tongue, sand fencing could be placed on the upwind end of the sand tongue to build up a hill of sand high enough to change the wind pattern. Once the sand tongue is in the wind shadow it will be easier to revegetate.

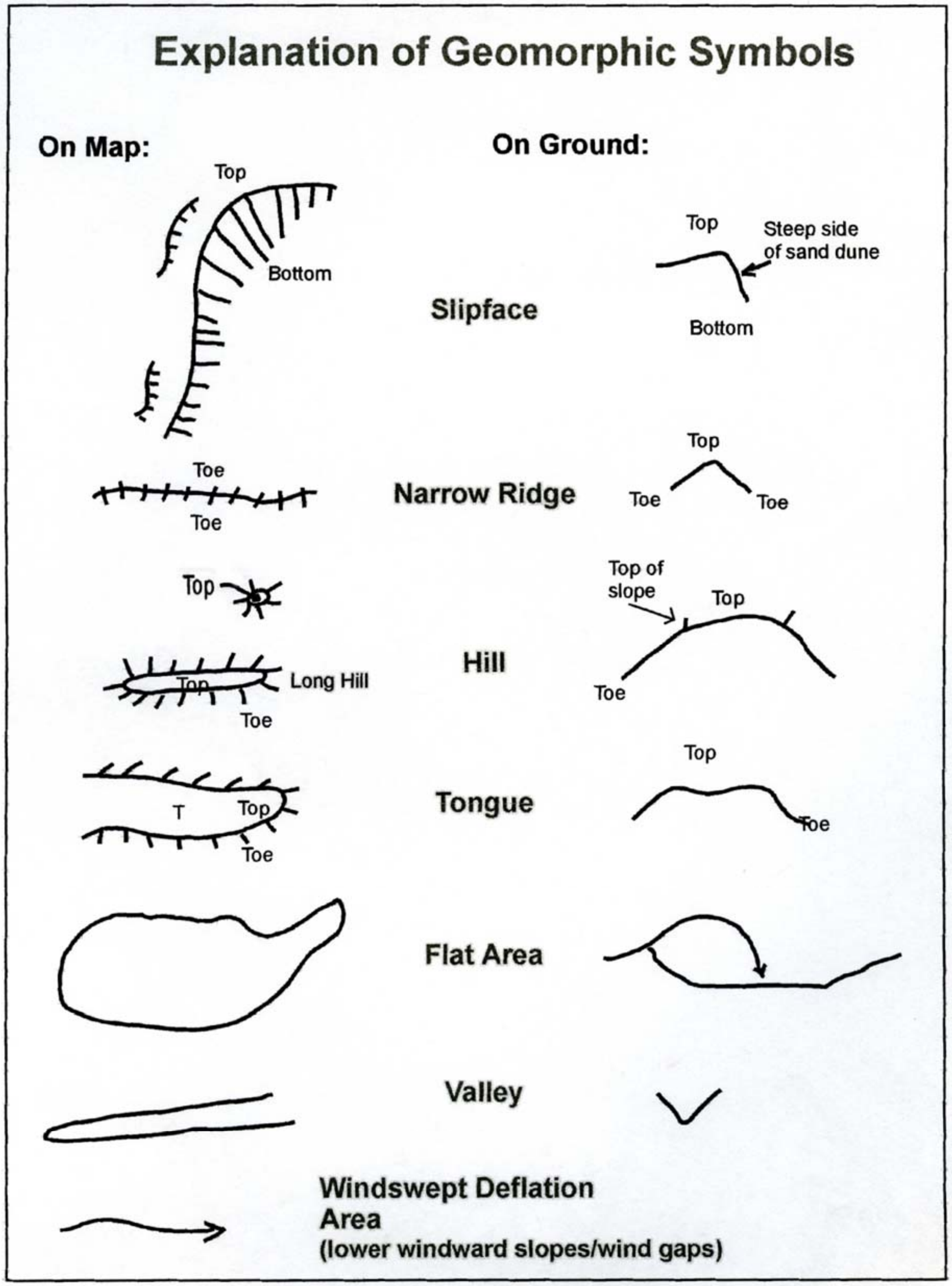
Explanation of Geomorphic Symbols
On Map:
On Ground:
Top
Bottom
Slipface
Top
Steep side of sand dune
Bottom
Toe
Toe
Narrow Ridge
Top
Toe
Toe
Top
Top of slope
Top
Hill
Top
Long Hill
Toe
Toe
T
Top
Toe
Tongue
Top
Toe
Flat Area
Valley
Windswept Deflation Area
(lower windward slopes/wind gaps)

Figure D-1 Moymell, Worm Valley, and Pavilion Hill Vegetation Islands

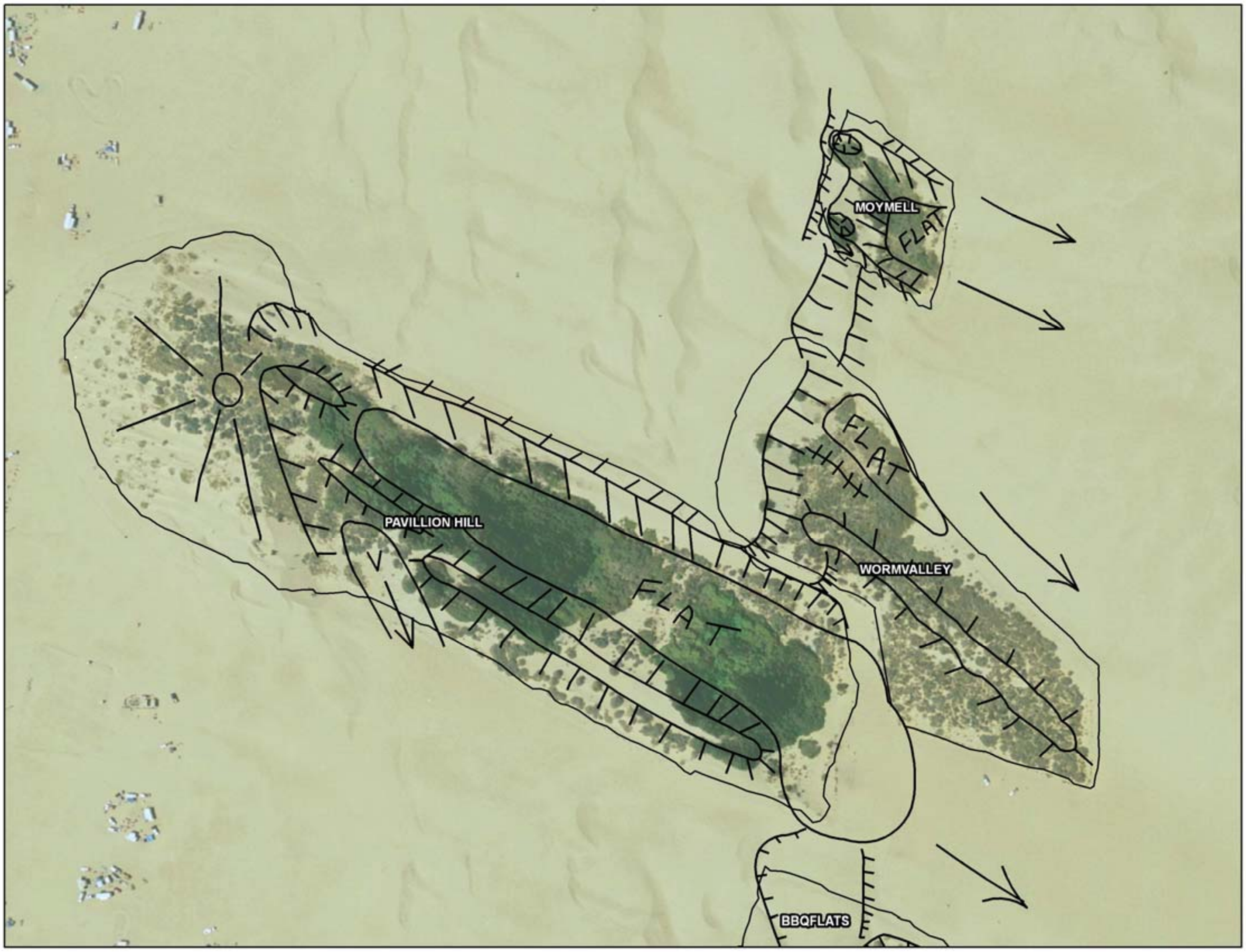

Figure D-2 Barbeque Flats and BBQ Flats South Vegetation Islands

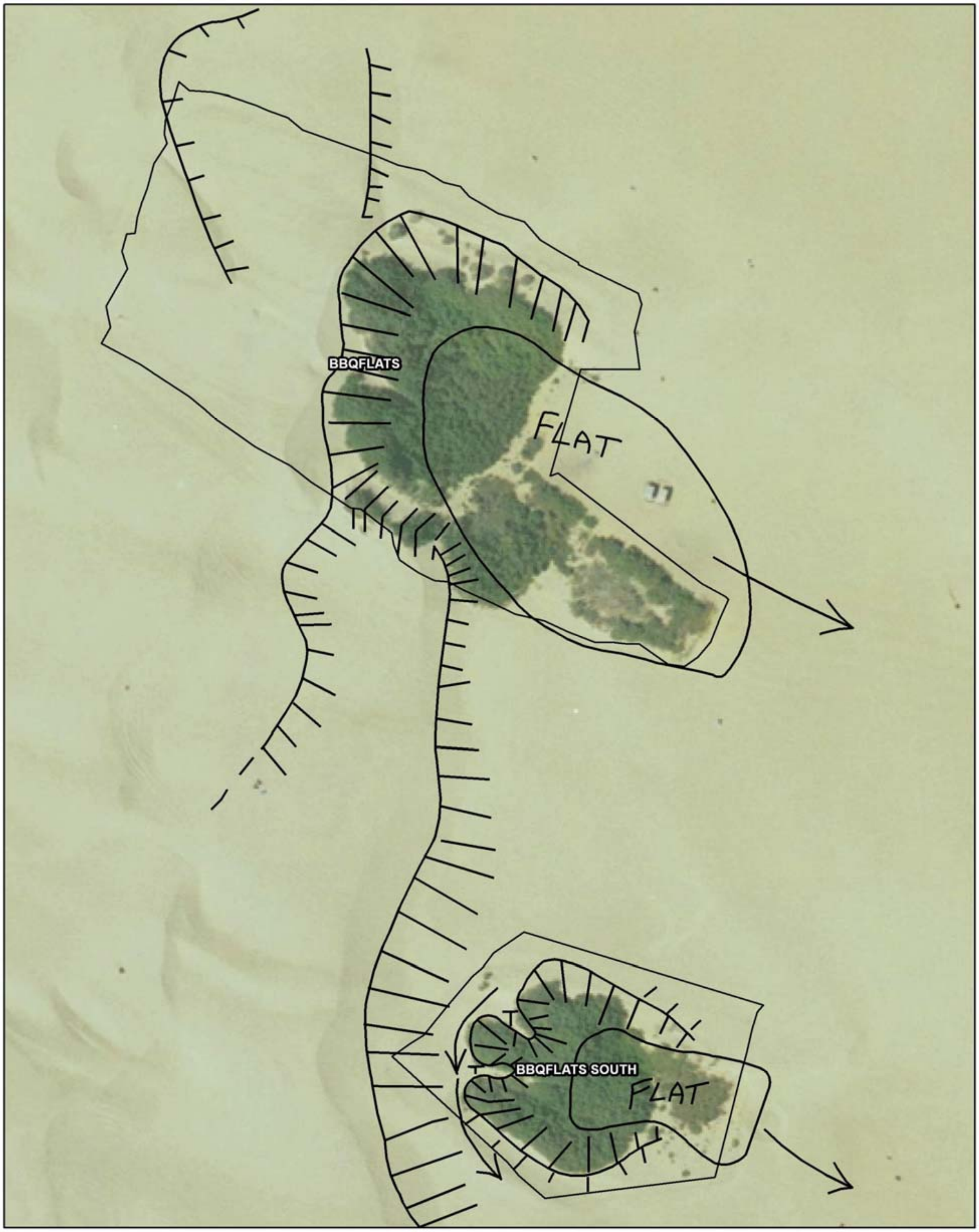

Figure D-3 Heather, Acacia, and Cottonwood Vegetation Islands

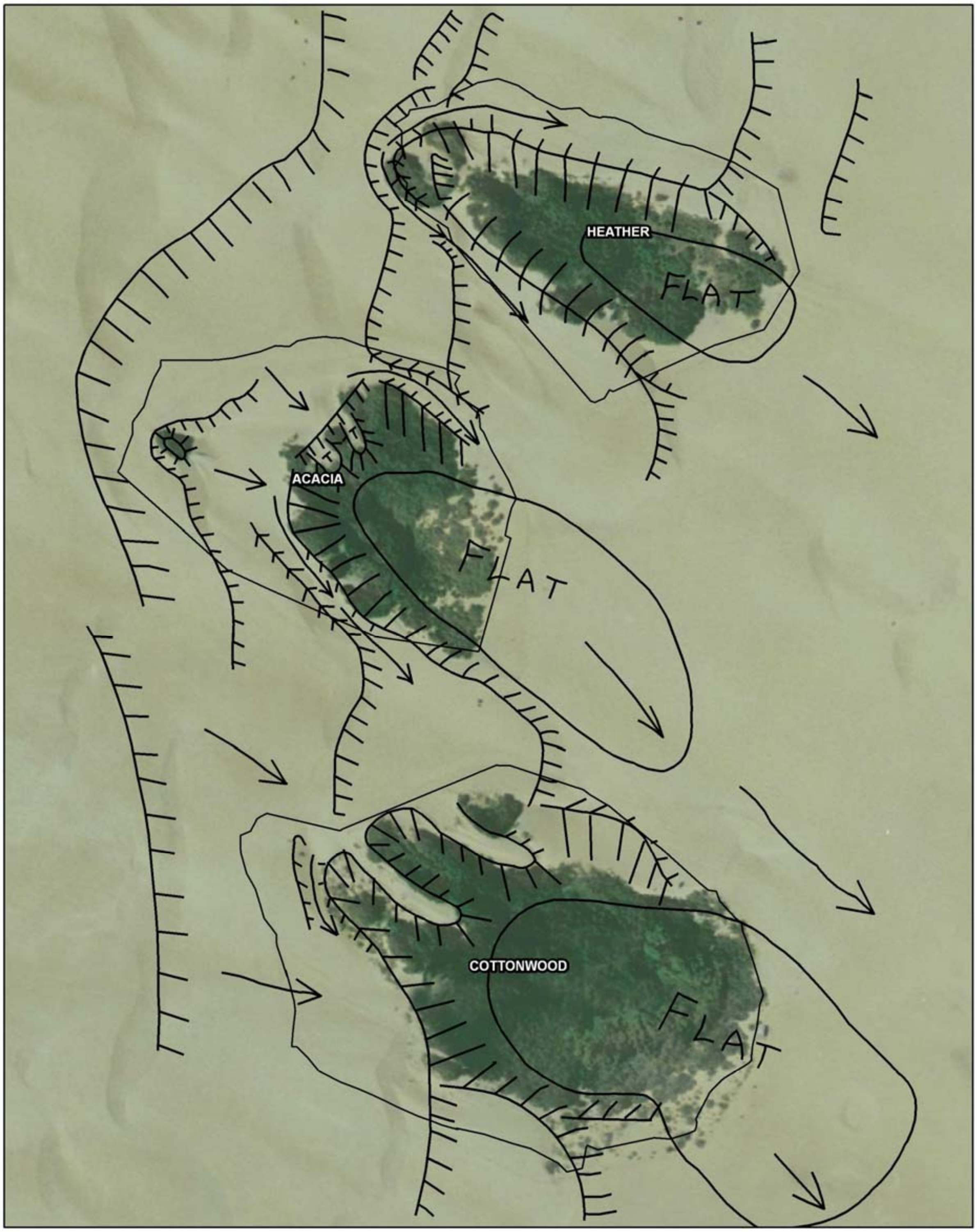

Figure D-4 Eucalyptus North, Eucalyptus Tree, and Eucalyptus South Vegetation Islands

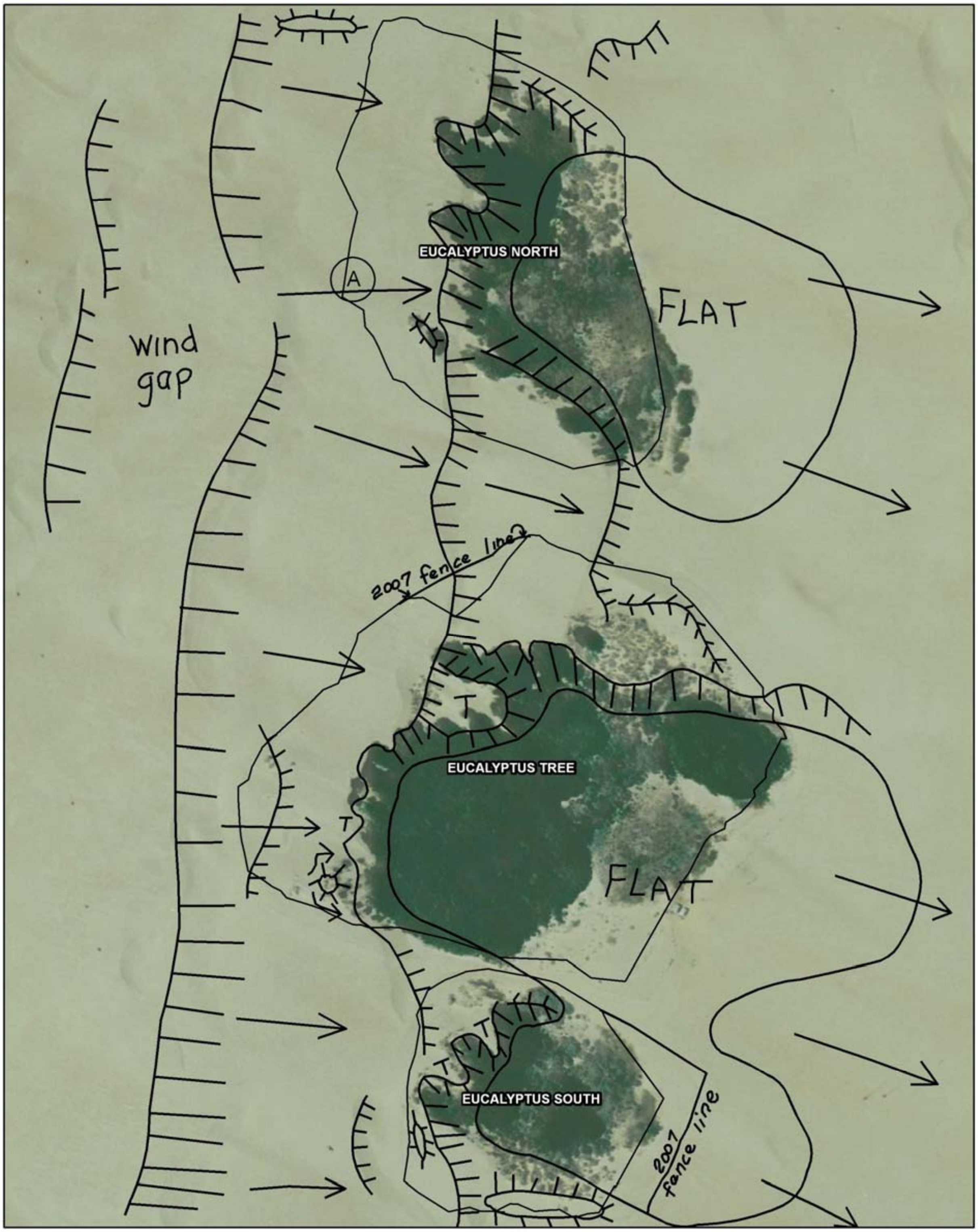

Figure D-5 Main Tabletop, and Tabletop Groups-1, -2, and -3 Vegetation Islands

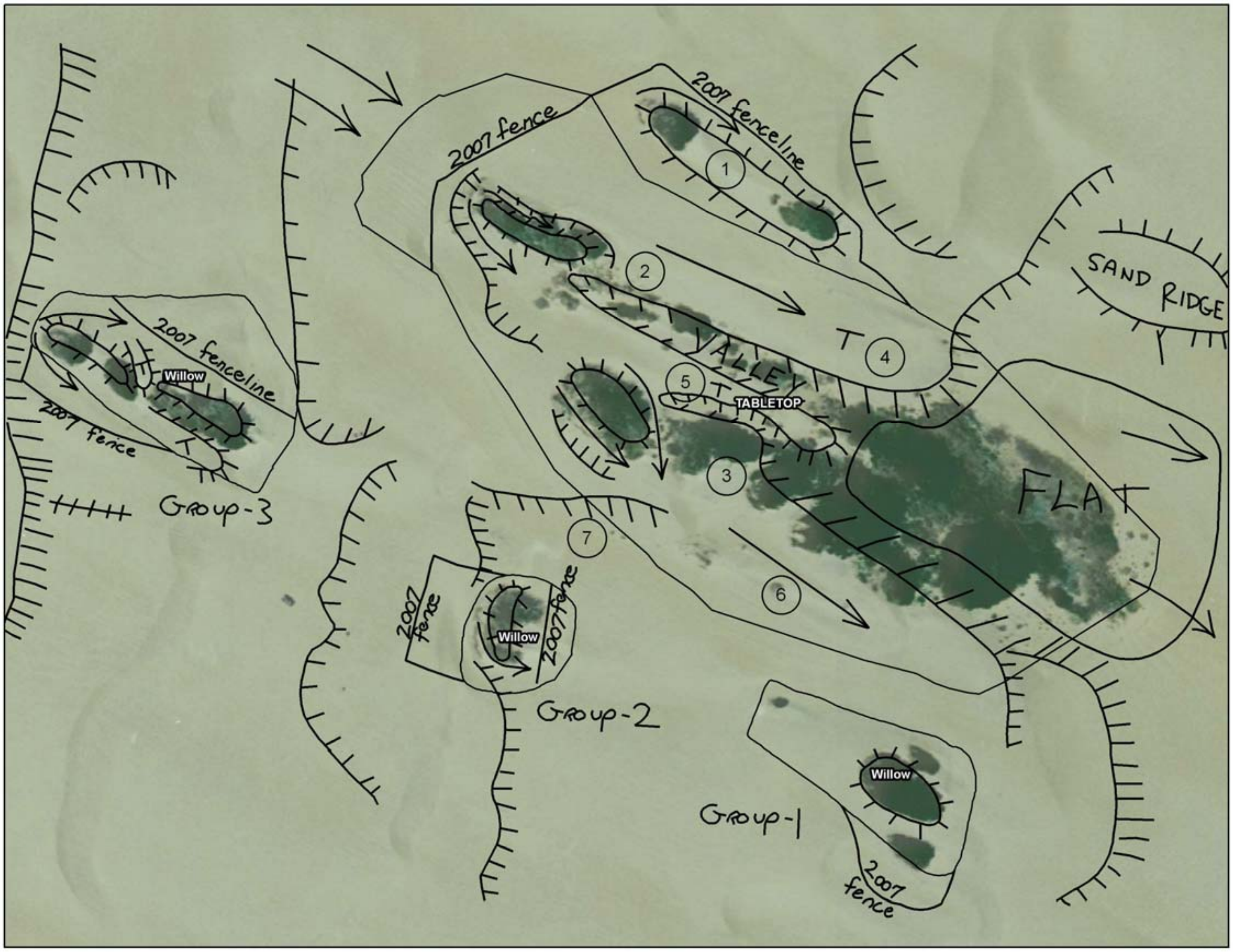

Figure D-6 Main Tabletop, Tabletop Groups-1 through -5, and 7.5 Reveg Vegetation Islands

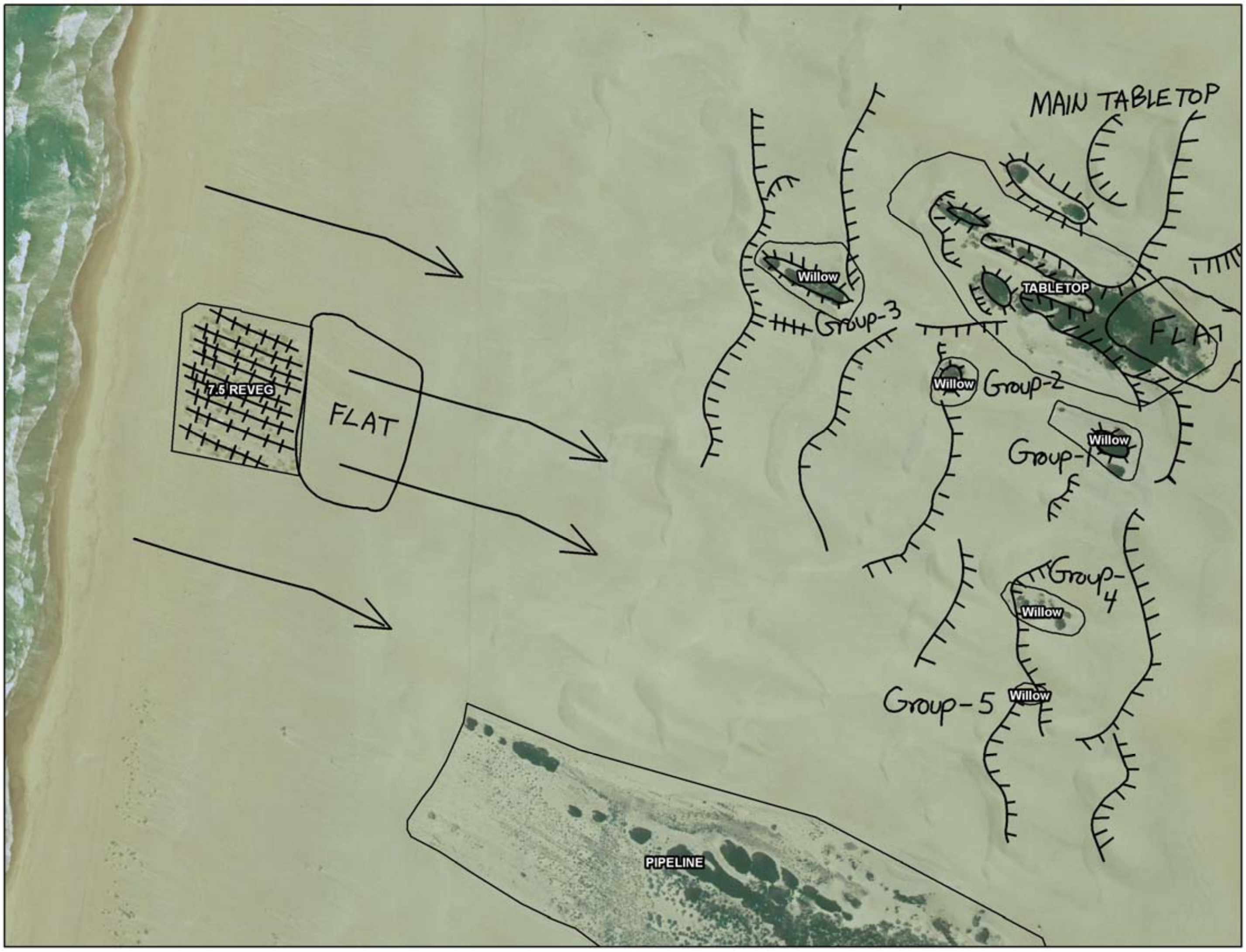

Figure D-7 Pipeline Vegetation Island

Figure D-8 Maidenform Flats Vegetation Island

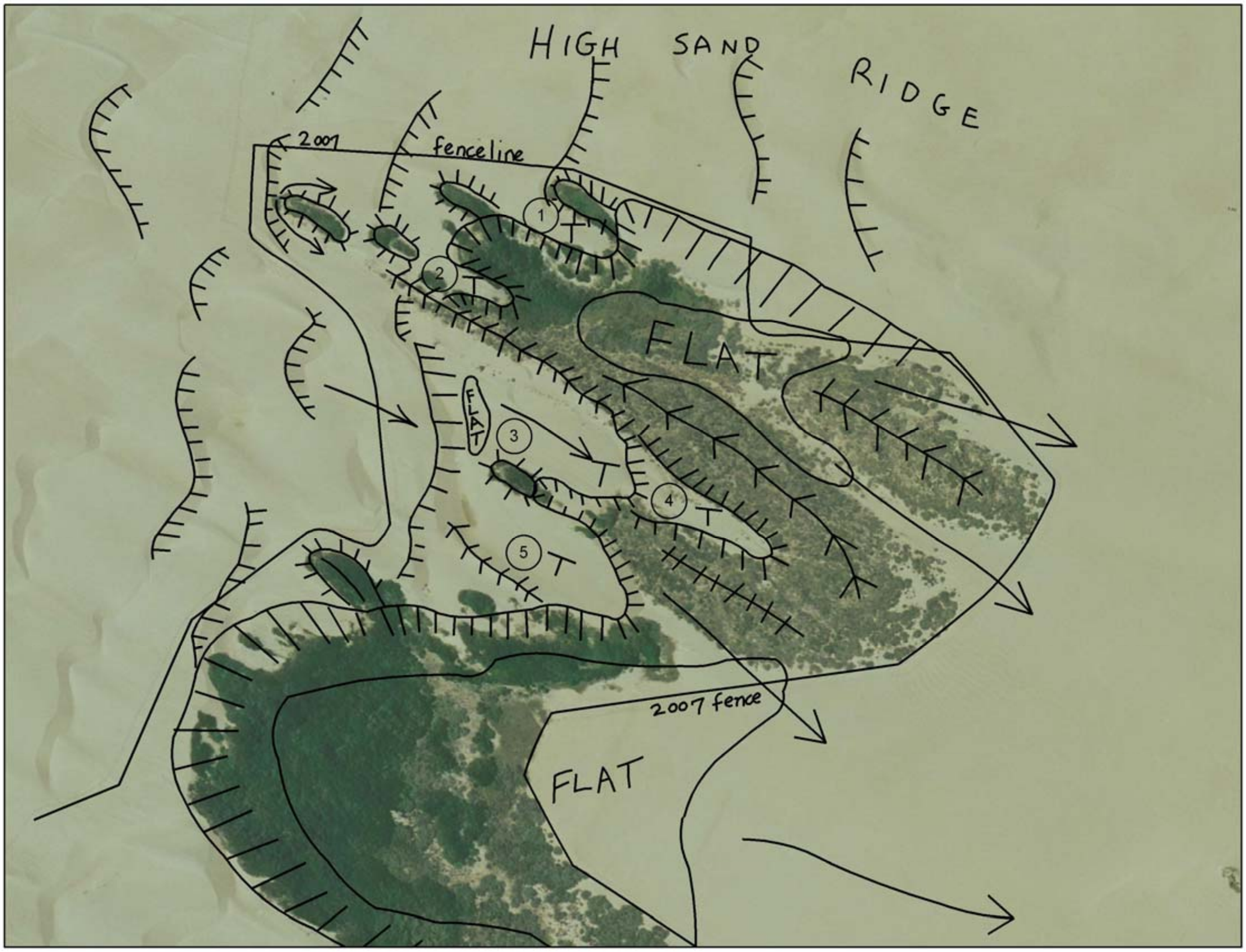

Figure D-9 40-Acre Woods Vegetation Island

Figure D-10 Indian Midden, Indian Midden South, and Boy Scout North Vegetation Islands

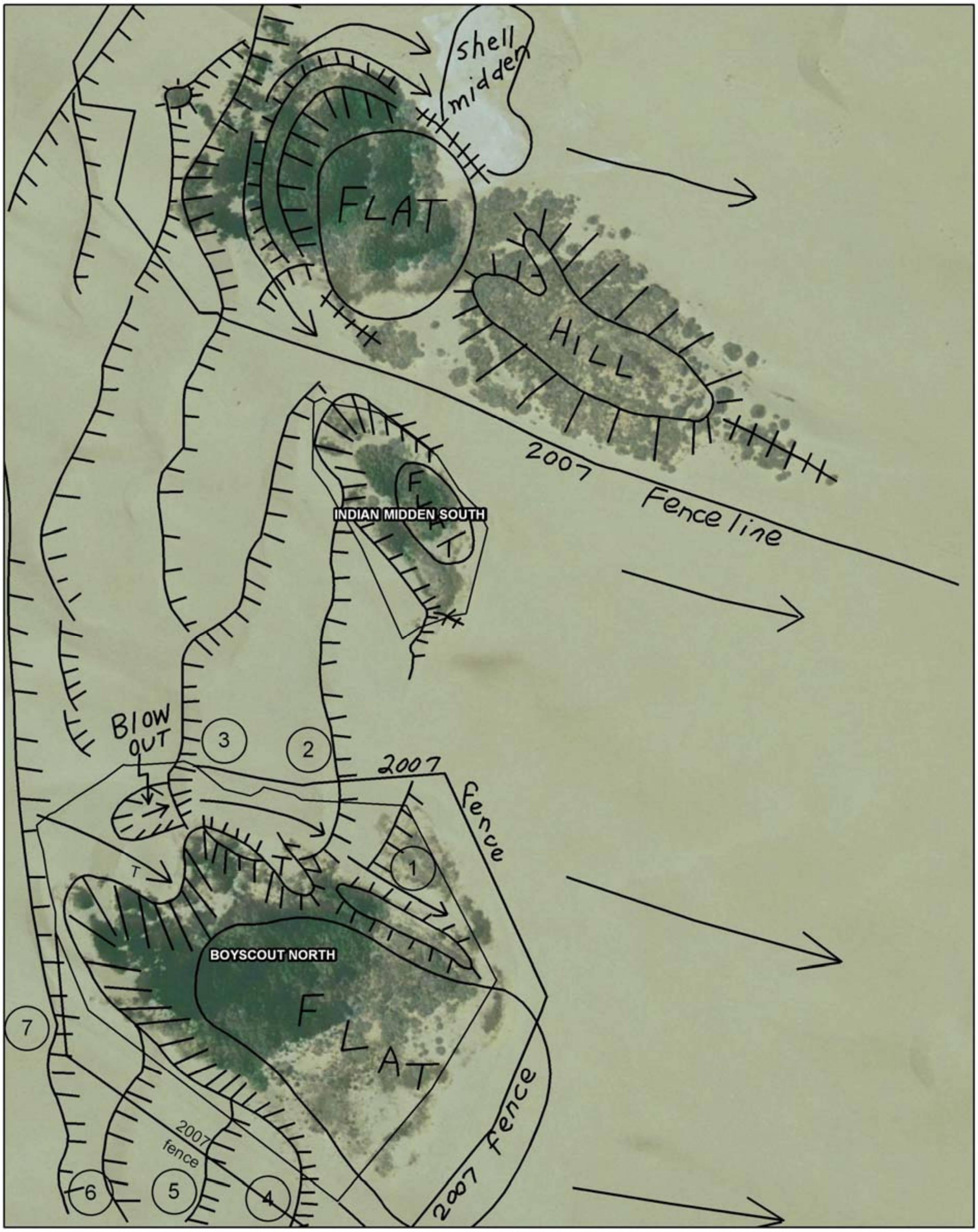

Figure D-11 Boy Scout Camp Vegetation Island

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APPENDIX – E

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