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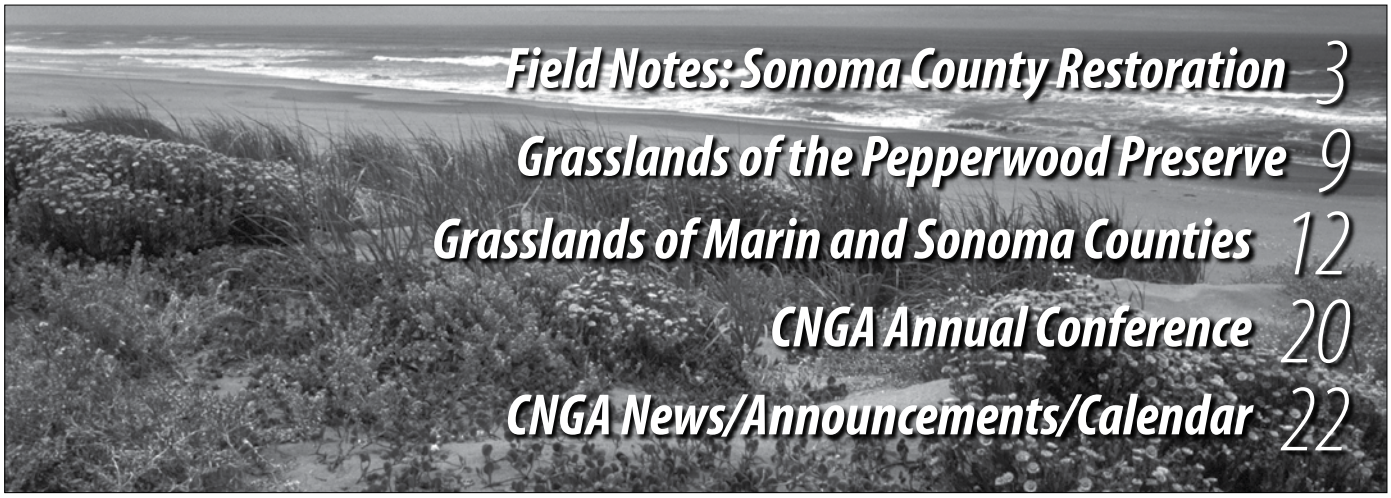

Restoring the Grasslands of Northern California's Coastal Dunes

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Photos: Andrea J. Pickart

Fig. 1. The native dune grasses *Leymus mollis* and *Poa macrantha* mix with forbs, including *Abronia latifolia* (yellow sand verbena) and *Lathyrus littoralis* (beach pea), on the foredune at the Lanphere Dunes Unit, Humboldt Bay National Wildlife Refuge.

Although few people associate California grasslands with coastal dunes, there exists a globally endangered vegetation type known as "foredune grassland" (Fig. 1) that occurs only on dunes of the Pacific Coast of North America. The characteristic species of this community is the native dune grass *Leymus mollis* (Fig. 2), but beach bluegrass (*Poa macrantha* and *P. douglasii*) can be common to dominant, and associated species include a number of forbs, such as *Abronia latifolia, Lathyrus littoralis, Erigeron glaucus, Eriogonum latifolium,* and *Calystegia soldanella* (Pickart and Barbour 2007).

Foredune grasslands are so called because *Leymus mollis* is generally confined to the upper beach and the first rise, or "foredune." Typically, foredune grassland is found on relatively high-energy sandy coastlines, on ocean beaches. Calmer (bay-facing) and more brackish shorelines sometimes support stands of *L. mollis* but may also be colonized by *Leymus* × *vancouverensis,* a hybrid of *L. mollis* and *L. triticoides.* Until the introduction and spread of European beachgrass (*Ammophila arenaria*), *L. mollis* was the dominant grass of northern California's foredunes (Barbour et al. 1976). Over the past century, European beachgrass (and to the north, American beachgrass, *A. breviligulata,* which is native to the East Coast and Great Lakes) displaced native

Fig. 2. Flowering *Leymus mollis* at the Lanphere Dunes.

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dune grass over much of our coastline (Wiedemann 1998, Seabloom and Wiedemann 1994). The Lanphere Dunes at what is now Humboldt Bay National Wildlife

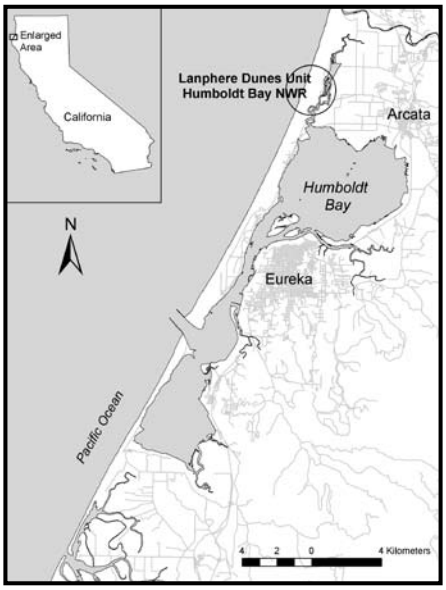

Fig. 3. Location of the Lanphere Dunes Unit on Humboldt Bay, California.

Refuge (Fig. 3) and Abbott's Lagoon at Point Reyes National Seashore were two of only a few remaining healthy populations south of Alaska in the 1980s (Barbour and Johnson 1988). Since then, many dune systems have been restored, allowing this unique community to slowly reclaim part of its former range.

Floristically, foredune grasslands are probably an association within one or more forb-characterized herbaceous dune alliances known collectively as "dune mat" (Pickart and Barbour 2007). In northern California, dune mat occurs on semi-stable nearshore dunes or backdune blowouts, and forest communities develop on stabilized backdunes. From Bodega Bay south, backdunes are characterized by dune scrub communities (a mixture of herbs and shrubs), and dune mat is restricted to a relatively narrow band near the ocean. The classification of California's dune vegetation is still undergoing refinement in the National Vegetation Classification System (Grossman et al. 1998) and its state analog, the "Manual of California Vegetation" (Sawyer and Keeler Wolf 1995), now under revision. Several recent classification and mapping efforts will soon enlarge our understanding.

The coastal dune environment is a harsh place for plant establishment. In addition to the summer drought shared by all Mediterranean climates, coastal dunes are subjected to salt spray, high winds, a shifting substrate, porous soils, and high solar radiation. The herbaceous plants of semi-stable dunes have many adaptations for survival in this environment. Dicots commonly exhibit foliar succulence and/or pubescence to prevent water loss, and many have deep and/or starchy taproots to access and store water. Grasses rely instead on leaf-rolling, exposing the underside of the leaf, which is typically waxy and does not bear stomata through which transpiration takes place (Danin 1996). Both monocots and dicots tend to form arbuscular mycorrhizal associations that increase phosphorous uptake, alleviating the effects of drought (Pickart and Sawyer 1998). Many dune plants are also asexual reproducers. This allows them to spread in an environment hostile to seed germination and emergence. In addition, some species, including *L. mollis,* produce horizontal and vertical rhizomes that allow the plant to grow up through accumulating sand. Nutrients, sparse in the porous dune sands, are provided through salt spray, with the macronutrients nitrogen, phosphorous, and potassium most limiting (Barbour et al. 1985). Nitrogen can be supplemented through the decomposition of wrack deposited by occasional washover (Holton et al. 1991), and probably (although this remains unstudied and undocumented on our dunes) through rhizosphere (immediately surrounding the roots of plants) and epiphytic (living on the surface of plants) bacteria.

The differential ability of plants to overcome the limiting environmental stresses of dunes lies behind the story of European beachgrass invasion. Superior nitrogen allocation in *Ammophila* allows it to outcompete *Leymus* in California dunes (Pavlik 1983a,b). *Ammophila* is able to tightly roll its leaves, reducing drought stress more efficiently than *Leymus,* and diverting energy to reproduction instead. *Ammophila* invests more in vertical growth, with each genet (vegetative clone) forming a separate hummock or "nebka" (Danin 1996), these merging into a tightly packed hummocky topography and near-vertical foredune face (Fig. 4). In contrast, *Leymus* allocates more

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Fig. 4. A steep foredune built by tightly packed ramets (individual members of a clone) of European beachgrass (*Ammophila arenaria*) on the North Spit of Humboldt Bay, California.

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energy to horizontal tillering, producing sparser vegetation and gentler topography (Fig. 5). *Ammophila* requires regular inputs of fresh sand to maintain vigor, apparently as an escape from soil pathogens (Van der Putten and Peters 1997). Although no similar studies have been conducted for *Leymus*, the species clearly loses vigor in stabilized dunes and even more so than beachgrass is limited to the zone of fresh sand deposition.

The superior sand-trapping ability of *A. arenaria* has resulted in geomorphologic as well as ecological impacts to our west coast dunes. A low, hummocky foredune predominated along most of our coastline before Euro-American settlement (Barbour and Johnson 1988, Wiedemann 1998). The steep, continuous foredune ridge built by *Ammophila* has had repercussions for both plants and animals. Sand flow to the region behind the foredune is slowed, reducing one form of abiotic stress. Disturbance is an ecosystem driver in the nearshore dunes, keeping the environment patchy and resulting in high species diversity. Reduced disturbance can accelerate natural succession and may even facilitate other invasive species. Impacts of beachgrass on animals are mixed. Studies in other regions have shown that beachgrass invasion lowers invertebrate diversity (Webb et al. 2000), whereas research conducted at the Lanphere Dunes has suggested that there are actually benefits to small mammals and their avian predators due to increased cover (Thompson et al. 2000, Schut 2002). However, the threatened western snowy plover (*Charadrius alexandrinus nivosus*) has suffered as its preferred habitat of sparsely vegetated dunes has continued to shrink (U.S. Fish and Wildlife Service 2007).

The loss of diversity associated with beachgrass invasion was first brought to light in the 1970s (Breckon and Barbour 1974), and by the early 1980s the first *Ammophila* eradication/dune restoration project was born at the Lanphere Dunes (then a preserve of The Nature Conservancy, and now a unit of Humboldt Bay National Wildlife Refuge). Early experiments revealed that repeated manual removal was the most effective treatment of those studied (VanHook 1983), causing depletion of stored carbohydrates while preventing photosynthesis. By 1992 a large-scale project was begun, and by 1996 over 4 hectares of beachgrass had been effectively eradicated from the Lanphere Dunes and restored to dune mat and foredune grassland (Figs. 6a–b). As predicted by small-scale field experiments, dune vegetation recruits quickly from nearby sources, and no revegetation is needed (Pickart and Sawyer 1998). Annually, a one-day "*Ammophila* Sweep" is conducted by a dozen refuge staff and partners who fan out over approximately 40 hectares of dunes to look for fresh starts or overlooked plants.

Long-term monitoring at the Lanphere Dunes has borne out the success of this technique, with restored dunes now as diverse as those that were never invaded. In fact, the physical disruption associated with manual or mechanical removal can reset succession, increasing the abundance of early successional species, including the endangered beach layia (*Layia carnosa*) (Pickart and Sawyer 1998). Native dune grass thrives under disturbance, which mimics the effects of storm waves and high winds. If nearby sources are not present, *Leymus* can be introduced, as it was at the Bureau of Land Management's Manila Dunes adjacent to Humboldt Bay National Wildlife Refuge (Wheeler 2004). Culms (stems) with rhizome fragments were harvested from a dense nearby colony and transplanted the same day (Fig. 7), or "heeled in." Heeling in the culms on-site can reduce desiccation and mortality during transplantation. In this method, the culms are dug into a trench and their roots and rhizomes covered with sand to reduce moisture loss and allow for a longer transplant period. Mortality rates for heeled-in plants have ranged from 53 to 88 percent (Pickart and Sawyer 1998).

That first restoration project at Lanphere Dunes relied primarily on paid labor from the California Conservation Corps, but spawned numerous projects along the Humboldt County coastline that have been more volunteer driven. The Friends of the Dunes, formed as an arm of The Nature

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Fig. 5. A more gently sloping foredune created by the loosely spaced ramets (individual members of a clone) of *Leymus mollis* at the Lanphere Dunes.

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Conservancy in 1982, participated in these early efforts, and went on to become a nonprofit organization with a highly successful volunteer-based restoration program that has brought about significant community investment in the local dune system. During the 25 years since restoration began, other successful methods of control have been developed, including combinations of heavy equipment (Fig. 8), burning (Fig. 9), and herbicide application (Hyland and Holloran 2005). Although these methods are less costly, some agencies and NGOs in Humboldt County and elsewhere continue to use manual labor as a means of educating and investing the public, building a local restoration economy, and avoiding impacts of herbicides.

Today dune restoration projects take place all along our coast, some with the goal of restoring native foredune grassland. At the Lanphere Dunes, areas once covered with monotypic stands of European beachgrass now boast mixed stands of native grasses and brilliant wildflowers (Fig. 10).

For information on how to visit the Lanphere Dunes, contact Humboldt Bay National Wildlife Refuge (http://www.fws.gov/humboldtbay) or attend a tour sponsored by Friends of the Dunes (http://friendsofthedunes.org). The dunes are most spectacular in summer, and wildflowers peak from June through August.

Fig. 6a. An *Ammophila*-dominated foredune at the Lanphere Dunes in February 1992, prior to restoration (members of the California Conservation Corps are beginning the removal process).

Fig. 6b. The same location in July 2001, five years after restoration work was completed.

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Literature Cited

Barbour, M.G., and A.F. Johnson. 1988. Beach and dune. Pages 223–261 in M.G. Barbour and J. Major, eds., Terrestrial vegetation of California. California Native Plant Society Special Publication No. 9. Sacramento, CA.

Barbour, M.G., T.M. De Jong, and A.F. Johnson. 1976. Synecology of beach vegetation along the Pacific Coast of the United States of America: a first approximation. Journal of Biogeography 3:55–69.

Barbour, M.G., T.M. De Jong, and B.M. Pavlik. 1985. Marine beach and dune plant communities. Pages 296–322 in B.F. Chabot and H.A. Mooney, eds., Physiological ecology of North American plant communities. Chapman and Hall, New York.

Breckon, G.J., and M.G. Barbour. 1974. Review of North American Pacific Coast beach vegetation. Madroño 22:333–360.

Danin, A. 1996. Plants of desert dunes. Springer, New York.

Grossman, D.H., D. Faber-Langendoen, A.S. Weakley, M. Anderson, P. Bourgeron, R. Crawford, K. Goodin, S. Landaal, K. Metzler, K. Patterson, M. Pyne, M. Reid, and L. Sneddon. 1998. International classification of ecological communities: Terrestrial vegetation of the United States. Volume 1. The National Vegetation Classification System: development, status, and applications. Arlington, VA.

Holton, B.H., M.G. Barbour, and S.N. Martens. 1991. Some aspects of the nitrogen cycle in a Californian strand ecosystem. Madroño 38:170–184.

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Hyland, T., and P. Holloran. 2005. Controlling European beachgrass (*Ammophila arenaria*) using prescribed burns and herbicide. Page 29 in G. Skurka, ed., Proceedings of the California Invasive Plant Council Symposium, Vol. 9.

Pavlik, B.M. 1983a. Nutrient and productivity relations of the dune grasses *Ammophila arenaria* and *Elymus mollis* (I): Blade photosynthesis and nitrogen use efficiency in the laboratory and field. Oecologia 57:227–32.

———. 1983b. Nutrient and productivity relations of the dune grasses *Ammophila arenaria* and *Elymus mollis* (II): Growth and patterns of dry matter and nitrogen allocation as influenced by nitrogen supply. Oecologia 57:233–38.

Pickart, A.J., and M.G. Barbour. 2007. Beach and dune. Pages 155–179 in M.G. Barbour, T. Keeler-Wolf, and A.A. Schoenherr, eds., Terrestrial vegetation of California, 3d edn. University of California Press, Berkeley.

Pickart, A.J., and J.O. Sawyer. 1998. Ecology and restoration of northern California coastal dunes. California Native Plant Society, Sacramento.

Sawyer, J.O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento.

Schut, S. 2002. Predator composition of coastal dune habitat with and without *Ammophila arenaria.* Unpublished document, Department of Wildlife Management, Humboldt State University, Arcata, CA.

Seabloom, E.W., and A.M. Wiedemann. 1994. Distribution and effects of *Ammophila breviligulata* Fern. (American beachgrass) on the foredunes of the Washington coast. Journal of Coastal Research 10:178–188.

Thompson, J., K.L. Bruce, C. Miles, and S. Schut. 2000. Small mammal diversity and abundance in non-native and restored coastal dune habitat. Unpublished report, Department of Wildlife Management, Humboldt State University, Arcata, CA.

U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Pacific Coast population of the western snowy plover (*Charadrius alexandrinus nivosus*). Vol. 1. Recovery Plan. USFWS, Sacramento, CA.

Van der Putten, W.H., and B.A.M. Peters. 1997. How soil-borne pathogens may affect plant competition. Ecology 78:1785–1795.

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Fig. 7. Culms of *Leymus mollis* planted on the foredune at the Bureau of Land Management's Manila Dunes.

Fig. 8. Bulldozers removing *Ammophila arenaria* for a western snowy plover habitat restoration project at the South Spit, managed by the Bureau of Land Management (beachgrass was first burned to reduce biomass).

Fig. 9. Charred remains of *Ammophila arenaria* at MacKerricher State Park. In one method of control, beachgrass is burned to stimulate regrowth, then treated with herbicide.

Grasslands of the Pepperwood Preserve

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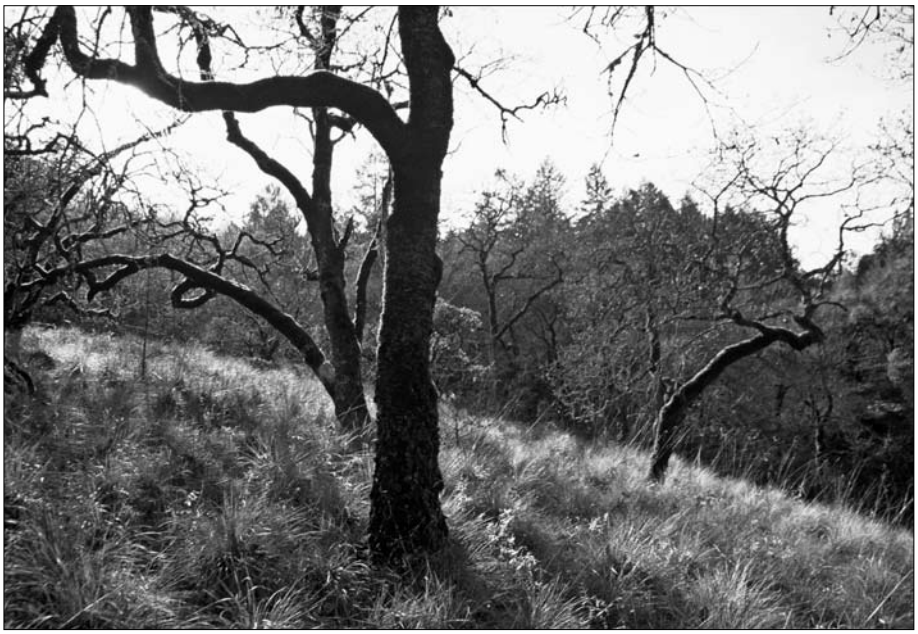
Shawn Brumbaugh, Instructor, Santa Rosa Junior College Life Sciences Department, and Stewardship Coordinator, Pepperwood Preserve

A close look at the grasslands of the Pepperwood Preserve in northeastern Sonoma County is as much a historical journey as it is an ecological one. The successional uses of this land have left a legacy for those with the interest to discern its past. What may first appear to be untouched wildland has actually been shaped by a diversity of uses.

For centuries before the arrival of Euro-Americans, the Wappo people burned these hills regularly to maximize the quality and quantity of plant material they prized for food and textiles. Fire control efforts over the last century have limited the frequency of wildland fires while increasing their intensity. A reduction in fires has increased the survival rate of Douglas fir saplings. Impressive groves of Oregon oak, underlain with beautiful stands of California fescue (*Festuca californica)*, give way as Douglas firs quickly outcompete the mature oaks for sunlight. Eventually the oaks die, and the oak woodland becomes a fir forest. Douglas fir removal has become an important management tool to favor the oak woodland in the absence of wildfire.

Photos: Greg Damron, Outreach Coordinator , Pepperwood Preserve



California fescue under deciduous Oregon oak.

Woodcutting, charcoal production, and agriculture in the early settlement period (1865–1910) resulted in the deforestation

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Fig. 10. Restored foredune grassland at the Lanphere Dunes Unit, Humboldt Bay National Wildlife Refuge.

Van Hook, S.S. 1983. A study of European beachgrass, *Ammophila arenaria* (L). Link: Control methods and a management plan for the Lanphere-Christensen Dunes Preserve. Unpublished document. The Nature Conservancy, Arcata, CA.

Webb, C.E., I. Oliver, and A.J. Pik. 2000. Does coastal foredune stabilization with *Ammophila arenaria* restore plant and arthropod communities in southeastern Australia? Restoration Ecology 8:283–288.

Wheeler, J. 2004. Final programmatic report for the Humboldt Bay dunes native grass revegetation NFWF project # 2003-0029-017 for the time period of August 1, 2003–April 30, 2004. Unpublished document, U.S. Bureau of Land Management, Arcata Field Office, Arcata, CA.

Wiedemann, A. 1998. Coastal foredune development, Oregon, USA. Journal of Coastal Research, Special Issue No. 26:45–51.