This document is part of a collection of Ecological Integrity Assessments addressing 67 of Washington's 99 Ecological Systems. These documents were prepared by the Washington Natural Heritage Program with funding provided by the Washington Department of Fish and Wildlife.

Ecological Integrity Assessment:
North Pacific Maritime Coastal Sand Dune and Strand

Ecological Summary

The North Pacific Maritime Coastal Sand Dune and Strand system occurs along the northern Pacific Coast, from south-central Alaska to the central Oregon coast (roughly Coos Bay) (Weidemann 1984). Coastal dunes comprise forty-five percent of the Oregon and Washington coastline. In Washington, this large patch system is located along the Pacific coast most abundantly on the Washington coast south of the Copalis River and in scattered small locations along the Strait of Juan de Fuca and in the Puget Sound. Pacific Northwest coastal dunes are dynamic, transgressive, wind-controlled systems in their natural condition (citations in Zarnetske and others 2010). Coastal dunes include beach strand (not the beach itself but sparsely or densely vegetated areas behind the beach), foredunes, sand spits, and active to stabile backdunes and sandsheets. Coastal dunes often front portions of inlets and tidal marshes. These communities are dependent upon long shore drift and wind. Most of these are spits or berms behind sandy beaches. In their natural state these are dominated by short to medium-tall grasses, sedges, or forbs, often with abundant bare sandy or gravelly surface exposed.

Coastal dune vegetation typically includes herbaceous, succulent, shrubs and tree species with varying degrees of tolerance for salt spray, wind and sand abrasion, and substrate stability. Dune succession is highly variable, so species composition can vary significantly among occurrences and add significantly to the overall species richness of an locale (Peinado and other 2007). Beach strands and low dunes may have *Ambrosia chamissonis*, *Abronia latifolia*, *Cakile maritime* and *C. edentula*. Dunes can be dominated by grasses, *Leymus arenarius* (= *Elymus arenarius*), *Festuca rubra*, *Leymus mollis*, or various forbs adapted to salty dry conditions. *Gaultheria shallon* and *Vaccinium ovatum* are major shrub species. Forested portions of dunes are included within this system and are characterized in Washington by *Pinus contorta* var. *contorta* early in succession, *Picea sitchensis* somewhat later in the sere, and in some seres *Tsuga heterophylla*. Characteristic Pacific Northwest coastal dune species include *Abronia latifolia*, *Abronia umbellata* ssp. *breviflora*, *Ambrosia chamissonis*, *Calystegia soldanella*, *Camissonia cheiranthifolia*, *Leymus mollis*, *Lathyrus japonicas*, *Polygonum paronychia*, and *Tanacetum camphoratum* (Zarnetske and other 2007). The mosaic of sparse to dense vegetation development in dune systems is driven by sand deposition, erosion, and lateral movement (Weidemann 1984). Disturbance processes include dune blowouts caused by wind and occasional wave overwash during storm tidal surges.

Beachgrasses, *Ammophila arenaria* and *A. breviligulata* have been extensively planted for stabilization purposes and has spread for over 125 years (Weidemann 1996). Unstabilized sand is now a relatively rare condition primarily because of the effects of the introduction of this species. The physical form of dunes has also been altered by *Ammophila arenaria* from more sparsely vegetated, hummocky foredunes to a higher, steeper foredune that decreases sand flow to interior dunes (Weidemann 1984, Pickart 1997). It shortens the stabilization time, and drastically alters natural succession. Forests are probably forming at a greater rate than they did in the past because of increased stabilization. Zarnetske and others (2010) summarize *Ammophila* impact as having changed Pacific Northwest coastal dunes from open, sparsely vegetated and low-lying, mobile systems to large, continuous, and highly stable, foredunes. Exotic species, especially *Anthoxanthum odoratum* and *Holcus lanatus*, are now nearly ubiquitous components of herb-dominated communities (Zarnetske and others 2010). The spread of such species may be related to past livestock grazing in many areas. *Cytisus scoparius* and *Ulex europaeus* are aggressive exotic shrub invaders that were planted for stabilization and have spread widely

The North Pacific Maritime Coastal Sand Dune and Strand system is located in coastal active or stabilized dunes and sandsheets. Late-sere forests, dominating stabilized dune systems where active dune processes are nearly absent and that compositionally represent the adjacent forest matrix system, are excluded from this dune system. Interdunal wetlands occur commonly within the matrix of this system and sometimes are extensive in deflation plains or old dune troughs, but are considered part of the North Pacific Maritime Interdunal Coastal Wetland ecological system and are not part of this upland system.

Stressors

The stressors described below are those primarily associated with the loss of extent and degradation of the ecological integrity of existing occurrences. The stressors are the cause of the system shifting away from its natural range of variability. In other words, type, intensity, and duration of these stressors is what moves a system's ecological integrity rank away from the expected, natural condition (e.g. A rank) toward degraded integrity ranks (i.e. B, C, or D).

Currently, the major threats to the sand dune ecological system in Washington are stabilization by invasive species, off-road vehicle (ORVs) use, intentional sand dune stabilization, road construction, and conversion to residential lots. The exotic *Ammophila arenaria* has been extensively planted for stabilization purposes and has also spread widely on its own for over 125 years (Weidemann 1996) and the eastern North American native *A. breviligulata* has been planted and spreading the Long Beach peninsula (Seabloom and Weidemann 1994). Once they form dominant communities, the physical form and natural processes of dunes have been altered and altering the native species of foredunes (Pavlik 1983) although Wiedemann and Pickart (1996) concluded that *Ammophila* will not significantly alter the natural stabilization-rejuvenation cycles. *Ammophila* is now so widespread on the west coast of the U. S. that its eradication is not

practical unless a more economic means of control is found. Another consequence is that forests form at a greater rate than in the past. Other exotic species, especially sweet *Anthoxanthum odoratum* and *Holcus lanatus* are now a constant component of herb-dominated communities. The spread of such species may be related to past livestock grazing in many areas. *Cytisus scoparius* and *Ulex europaeus* are aggressive invasive exotic shrub that were planted for stabilization and have since spread widely. Off-road vehicle use has resulted in complete destruction of native herbaceous communities in some areas. Over aggressive control of *Ammophila* may not allow natural processes to re-establish.

Conceptual Ecological Model

The general relationships among the key ecological attributes associated with natural range of variability of the North Pacific Maritime Coastal Sand Dune and Strand Ecological System are presented in Figure 1.

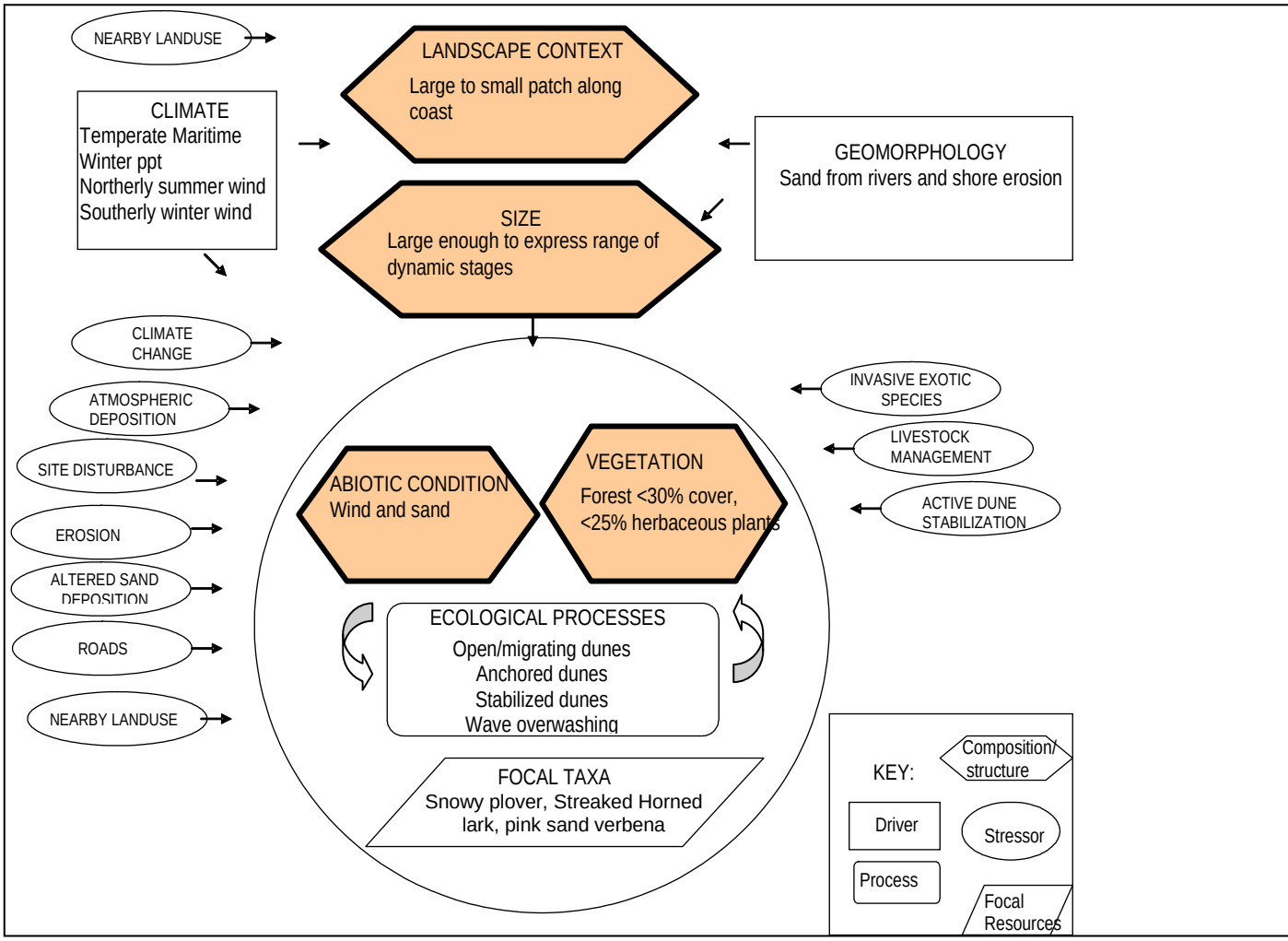

Figure 1. Conceptual Ecological Model for North Pacific Maritime Coastal Sand Dune and Strand Ecological System.

Ecological Integrity Assessments

The assessment of ecological integrity can be done at three levels of intensity depending on the purpose and design of the data collection effort. The three-level approach is intended to provide increasing accuracy of ecological integrity assessment, recognizing that not all conservation and management decisions need equal levels of accuracy. The three-level approach also allows users to choose their assessment based in part on the level of classification that is available or targeted. If classification is limited to the level of forests vs. wetlands vs. grasslands, the use of remote sensing metrics may be sufficient. If very specific, fine-scale forest, wetland, and grassland types are the classification target then one has the flexibility to decide to use any of the three levels, depending on the need of the assessment. In other words, there is no presumption that a fine-level of classification requires a fine-level of ecological integrity assessment.

Because the purpose is the same for all three levels of assessment (to measure the status of ecological integrity of a site) it is important that the Level 1 assessment use the same kinds of metrics and major attributes as used at Levels 2 and 3. Level 1 assessments rely almost entirely on Geographic Information Systems (GIS) and remote sensing data to obtain information about landscape integrity and the distribution and abundance of ecological types in the landscape or watershed. Level 2 assessments use relatively rapid field-based metrics that are a combination of qualitative and narrative-based rating with quantitative or semi-quantitative ratings. Field observations are required for many metrics, and observations will typically require professional expertise and judgment. Level 3 assessments require more rigorous, intensive field-based methods and metrics that provide higher-resolution information on the integrity of occurrences. They often use quantitative, plot-based protocols coupled with a sampling design to provide data for detailed metrics.

Although the three levels can be integrated into a monitoring framework, each level is developed as a stand-alone method for assessing ecological integrity. **When conducting an ecological integrity assessment, one need only complete a single level that is appropriate to the study at hand.** Typically only one level may be needed, desirable, or cost effective. But for this reason it is very important that each level provide a comparable approach to assessing integrity, else the ratings and ranks will not achieve comparable information if multiple levels are used.

Level 1 EIA

A generalized Level 1 EIA is provided in Rocchio and Crawford (2009). Please refer to that document for the list of metrics applicable to this ecological system.

Level 2 EIA

The following tables display the metrics chosen to measure most of the key ecological attributes in the conceptual ecological model above. The EIA is used to assess the ecological condition of an assessment area, which may be the same as the element occurrence or a subset of that occurrence based on abrupt changes in condition or on artificial boundaries such as management areas**. Unless otherwise noted, metric ratings apply to both Level 2 and Level 3 EIAs. The difference between the two is that a Level 3 EIA will use more intensive and precise methods to determine metric ratings.** To calculate ranks, each metric is ranked in the field according the ranking categories listed below. Then, the rank and point total for each metric is entered into the EIA Scorecard and multiplied by the weight factor associated with each metric resulting in a metric 'score'. Metric scores within a key ecological attribute are then summed to arrive at a score (or rank). These are then tallied in the same way to arrive at an overall ecological integrity score.

Table 1. North Pacific Maritime Coastal Sand Dune and Strand Ecological Integrity Assessment Scorecard Level 2 EIA

Metric	Justification	Rank			
		A (5 pts.)	B (4 pts.)	C (3 pts.)	D (1 pts.)
Rank Factor: LANDSCAPE CONTEXT					
Key Ecological Attribute: *Edge Effects*					
Edge Length	The intactness of the edge can be important to biotic and abiotic aspects of the site.	75 – 100% of edge is bordered by natural communities	50 – 74% of edge is bordered by natural communities	25 – 49% of edge is bordered by natural communities	< 25% of edge is bordered by natural communities
Edge Width		Average width of edge is at least 100 m.	Average width of edge is 75-100 m.	Average width of edge is 25-75 m.	Average width of edge is <25 m.
Edge Condition		>95% cover native vegetation, <5% cover of non-native plants, intact soils	75–95% cover of native vegetation, 5–25% cover of non-native plants, intact or moderately disrupted soils	25–50% cover of non-native plants, moderate or extensive soil disruption	>50% cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils
Key Ecological Attribute: *Landscape Structure*					
Connectivity	Intact areas have a continuous corridor of natural or semi-natural vegetation	Intact: Embedded in 90-100% natural habitat; connectivity is expected to be high.	Variegated: Embedded in 60-90% natural or semi-habitat; habitat connectivity is generally high, but lower for species sensitive to habitat modification;	Fragmented: Embedded in 20-60% natural or semi-natural habitat; connectivity is generally low, but varies with mobility of species and arrangement on landscape.	Relictual: Embedded in < 20% natural or semi-natural habitat; connectivity is essentially absent
Landscape Condition Model Index	The intensity and types of land uses in the surrounding landscape can affect ecological integrity.	Landscape Condition Model Index > 0.8		Landscape Condition Model Index 0.65 – 0.79	Landscape Condition Model Index < 0.65

Rank Factor: CONDITION					
Key Ecological Attribute: *Vegetation Composition*					
Relative Cover of Native Plant Species	Native species dominate this system; non-natives increase with human impacts.	Cover of native plants = relative 95-100%.	Cover of native plants relative 80-95%.	Cover of native plants relative 50 to 79%.	Cover of native plants < relative 50%.
Absolute Cover of Invasive Species	Invasive species can inflict a wide range of ecological impacts.	None present.	Invasive species present, but sporadic (<3% cover).	Invasive species prevalent (3–10% absolute cover).	Invasive species abundant (>10% absolute cover).
***Ammophila* species Abundance**	*Ammophila* dominated foredunes decreases sand supply to backdune areas, further stabilization, soil formation, and decline in native dune fauna and flora, (Wiedemann and Pickart 2004).	None present.	Present	Small patches not stabilizing dunes	Large Patches stabilizing dunes
Species Composition Note: Once developed, the Floristic Quality Assessment index could used here instead.	The overall composition of native species can shift when exposed to stressors.	Species diversity/abundance at or near reference standard conditions. Native species sensitive to anthropogenic degradation are present, functional groups indicative of anthropogenic disturbance (ruderal or "weedy" species) are absent to minor, and full range of diagnostic / indicator species are present.	Species diversity/abundance close to reference standard condition. Some native species reflective of past anthropogenic degradation present. Some indicator/ diagnostic species may be absent.	Species diversity/abundance is different from reference standard condition in, but still largely composed of native species characteristic of the type. This may include ruderal ("weedy") species. Many indicator/diagnostic species may be absent.	Vegetation severely altered from reference standard. Expected strata are absent or dominated by ruderal ("weedy") species, or comprised of planted stands of non-characteristic species, or unnaturally dominated by a single species. Most or all indicator/diagnostic species are absent.
Key Ecological Attribute: *Natural Disturbance Regimes*					
Sand Dynamics	Sand dune systems are dependent on the ability for a mosaic of non- vegetated shifting sands and sparsely vegetated sand dunes or swales to freely shift.	Dunes systems composed mostly of sparsely vegetated open/migrating, native anchored and native stabilized stages.	Presence of open/migrating and native anchored stages and exotic-stabilized replacing native stabilized on less than 50% of total area (areas stabilized by raised ground water may contribute here)	Presence of open/migrating and native anchored stages and exotic stabilized on over 50% of total area OR open/migrating or native anchored stage present and exotic-stabilized on less than 50% of total area (areas stabilized by raised ground water may contribute here)	Open/migrating or native anchored stages absent and exotic-stabilized replacing native stabilized on over 50% of total area. (areas stabilized by raised ground water may contribute here)
Key Ecological Attribute: *Physicochemical*					

Soil Surface Condition	Soil disturbance can result in erosion thereby negatively affecting many ecological processes; the amount of bare ground varies naturally with site type.	Bare soil areas are limited to naturally caused disturbances such as burrowing or game trails	Some bare soil due to human causes but the extent and impact is minimal. The depth of disturbance is limited to only a few inches	Bare soil areas due to human causes are common. There may be disturbance/compaction to several inches. ORVs or other machinery may have left some shallow ruts.	Bare soil areas substantially & contribute to long-lasting impacts. Deep ruts from ORVs or machinery may be present, or trails are widespread.
Rank Factor: SIZE					
Key Ecological Attribute: *Size*					
Relative Size	Indicates the proportion lost due to stressors.	Site is at or minimally reduced from natural extent (>95% remains)	Occurrence is only modestly reduced from its original natural extent (80-95% remains)	Occurrence is substantially reduced from its original natural extent (50-80% remains)	Occurrence is severely reduced from its original natural extent (<50% remains)
Absolute Size	Sand dune systems are composed of a mosaic of open/migrating, anchored and stabilized functional stages with sufficient internal variability capturing characteristic biophysical gradients and natural geomorphic disturbance.	>5 mi/8 km long	1.25-5 mi/2-8 km long	0.3-1.25 mi/0.5-2 km long	<0.3 mi/0.5 km long

Level 3 EIA
Level 3 metrics would include more quantitative measures of the metrics listed above. In addition, further consideration might be given to:

- Quantitative measurements of nutrient status (Pavlik 1983)

Triggers or Management Assessment Points
Ecological triggers or conditions under which management activities need to be reassessed are shown in the table below. Since the Ecological Integrity rankings are based on hypothesized thresholds, they are used to indicate where triggers might occur. Specific details about how these triggers translate for each metric can be found by referencing the values or descriptions for the appropriate rank provided in the Table above.

Table 2. Triggers for Level 2 & 3 EIA

Key Ecological Attribute or Metric	Trigger	Action
Any metric (except Connectivity)	▪ C rank ▪ Shift from A to B rank ▪ negative trend within the B rating (Level 3)	Level 2 triggers: conduct Level 3 assessment; make appropriate short-term management changes to ensure no further degradation Level 3 triggers: make appropriate management adjustments to ensure no additional degradation occurs. Continue monitoring using Level 3.
Any Key Ecological Attribute	▪ any metric has a C rank ▪ > ½ of all metrics are ranked B ▪ negative trend within the B rating (Level 3)	Level 2 triggers: conduct Level 3 assessment; make appropriate short-term management changes to ensure no further degradation Level 3 triggers: make appropriate management adjustments to ensure no additional degradation occurs. Continue monitoring using Level 3.

Protocol for Integrating Metric Ranks
If desired, the user may wish to integrate the ratings of the individual metrics and produce an overall score for the three rank factor categories: (1) Landscape Context; (2) Condition; and (3) Size. These rank factor rankings can then be combined into an Overall Ecological Integrity Rank. This enables one to report scores or ranks from the various hierarchical scales of the assessment depending on which best meets the user's objectives. Please see Table 5 in Rocchio and Crawford (2009) for specifics about the protocol for integrating or 'rolling-up' metric ratings.

Supporting documents for the EIAs can be found at:
http://www1.dnr.wa.gov/nhp/refdesk/communities/eia.html

Documentation about Ecological Systems can be found at:
http://www1.dnr.wa.gov/nhp/refdesk/communities/ecol_systems.html

References

Gilbert, M., N. Parameter, and B. Ripley. 2008. The growth responses of coastal dune species are determined by nutrient limitation and sand burial. Oecologia 156:169–178.

Johnson, D.H. and T.A. O'Neil. 2001. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.

NatureServe Explorer. 2007. Descriptions of Ecological Systems for the State of Washington. Data current as of October 06, 2007. NatureServe, Arlington, VA. [http://www.natureserve.org/explorer/index.htm]

Pavlik,B.M., 1983. Nutrient and productivity relations of the dune grasses *Ammophila arenaria* and *Elymus mollis.* 3. Spatial aspects of clonal expansion with reference to rhizome growth and dispersal of buds. Bulletin of the Torrey Botanical Club. 110:271-279.

Peinado, M., J.L. Aguirre, J. Delgadillo, and M.A. Macıas. 2007. Zonobiomes, zonoecotones and azonal vegetation all on the Pacific Coast of North America. Plant Ecology. 191:221-252.

Pickart, A. J. 1997. Control of European Beachgrass (Ammophila arenaria) on the West Coast of the United States. California Exotic Pest Plant Council Symposium proceedings.

Rocchio, F.J. and R.C. Crawford. 2009. Monitoring Desired Ecological Conditions on Washington State Wildlife Areas Using an Ecological Integrity Assessment Framework. Report to Washington Department of Fish and Wildlife Olympia, WA.

Seabloom, EW. and Wiedemann, A.M., 1994. Distribution and effects of *Ammophila breviligulata* Fern. (American beachgrass) on the foredunes of the Washington coast. *Journal of Coastal Research,* 10(1), 178-188.

Slauson, K., D. Boianno, S. Green, and N. Soucy. 1998. Ecological Integrity Assessment of The North Coastal Basin Draft Report Legacy, The Landscape Connection. Arcata, California.

Wiedemann A. M. and A. J. Pickart, 1996. The Ammophila problem on the Northwest Coast of North America. Landscape and Urban Planning 34(3):287-299.

Zarnetske, P. L., E. W. Seabloom, and S. D. Hacker. 2010. Non-target effects of invasive species management: beachgrass, birds, and bulldozers in coastal dunes. Ecosphere 1(5):13.

Authorship: Rex Crawford Washington Natural Heritage
February 25, 2011