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 Intertidal Freshwater Wetland

Ecological Summary

The North Pacific Intertidal Freshwater Wetland ecological system is a tidally-influenced freshwater wetland occurring in small patches along the coastal margins and intertidal zones of the Pacific Northwest coast from Cook Inlet, Alaska, south to the central coast of Oregon (NatureServe 2007). In Washington, it occurs in narrow strips to more extensive patches along tidally-influenced portions of rivers along Washington's coastal margin and Columbia River. Substrates vary along the tidally-influenced but non-marine portions of rivers. This environment results when a heavier saltwater "wedge," pushes under freshwater. Freshwater then backs-up in rivers and sloughs spilling over on to adjacent floodplains. Overflow water is typically less than 0.5 parts per thousand salts (Kunze 1994). Related topography is created by river flooding events of sediments and large woody debris deposition and daily scouring and reworking by tidal action. Vegetation structure and composition varies and depend on substrate characteristics, elevation, and tidal flooding regime of particular sites. The vegetation is complex and includes tree-, shrub- and herbaceous-dominated patches. Little detailed vegetation data collection has occurred in this type. Existing studies indicate dominant species include *Picea sitchensis, Alnus rubra* trees, *Cornus sericea*, *Rubus spectabilis*, *Salix sitchensis* shrubs and herbaceous plants such as *Carex lyngbyei, Myriophyllum hippuroides, Typha angustifolia, Athyrium filix-femina*, and *Carex obnupta*.

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).

Historic and contemporary land use practices have impacted hydrologic, geomorphic, and biotic structure and function of tidal areas in Washington. Hydrological alterations, especially those which alter tidal exchange, would have a negative effect on ecological processes and species composition. Natural sedimentation from the watershed changes elevation and the influence of tidally flooded areas. Reservoirs, water diversions, ditches, roads, and human land uses in the contributing watershed can also have a substantial impact on the hydrological regime. Channel flow and tidal inundation are disrupted by construction of jetties, dikes, and dams. Direct alteration of hydrology (i.e., channeling, draining, damming) or indirect alteration (i.e., roading or removing vegetation on adjacent slopes) results in changes in amount and pattern of wetland

habitat. Where the alteration is long term, wetland systems may reestablish to reflect new hydrology, e.g., cattail is an aggressive invader. Timber harvesting changes stand structure, wildlife habitat, site topography. Human land uses both within the wetland as well as in adjacent upland areas have reduced connectivity between wetland patches and upland areas. Land uses in contributing the watershed have the potential to contribute excess nutrients into to the system which could lead to the establishment of non-native species and/or dominance of native increasing species. The invasive weeds, for example *Phalaris arundinacea, Polygonum sachalinense,* and *Rubus armenicus* are problems in these freshwater wetlands. Non-native plants or animals, which can have wide-ranging impacts, also tend to increase with these stressors. Although most wetlands receive regulatory protection at the national, state, and county level, many have been and continued to be filled, drained, grazed, and farmed extensively (Chappell 2000). Additionally, these regulations only pertain to the filling of these wetlands and do not regulate alterations in ecological conditions of these sites.

Conceptual Ecological Model

The general relationships among the key ecological attributes associated with this system are presented in Figure 1.

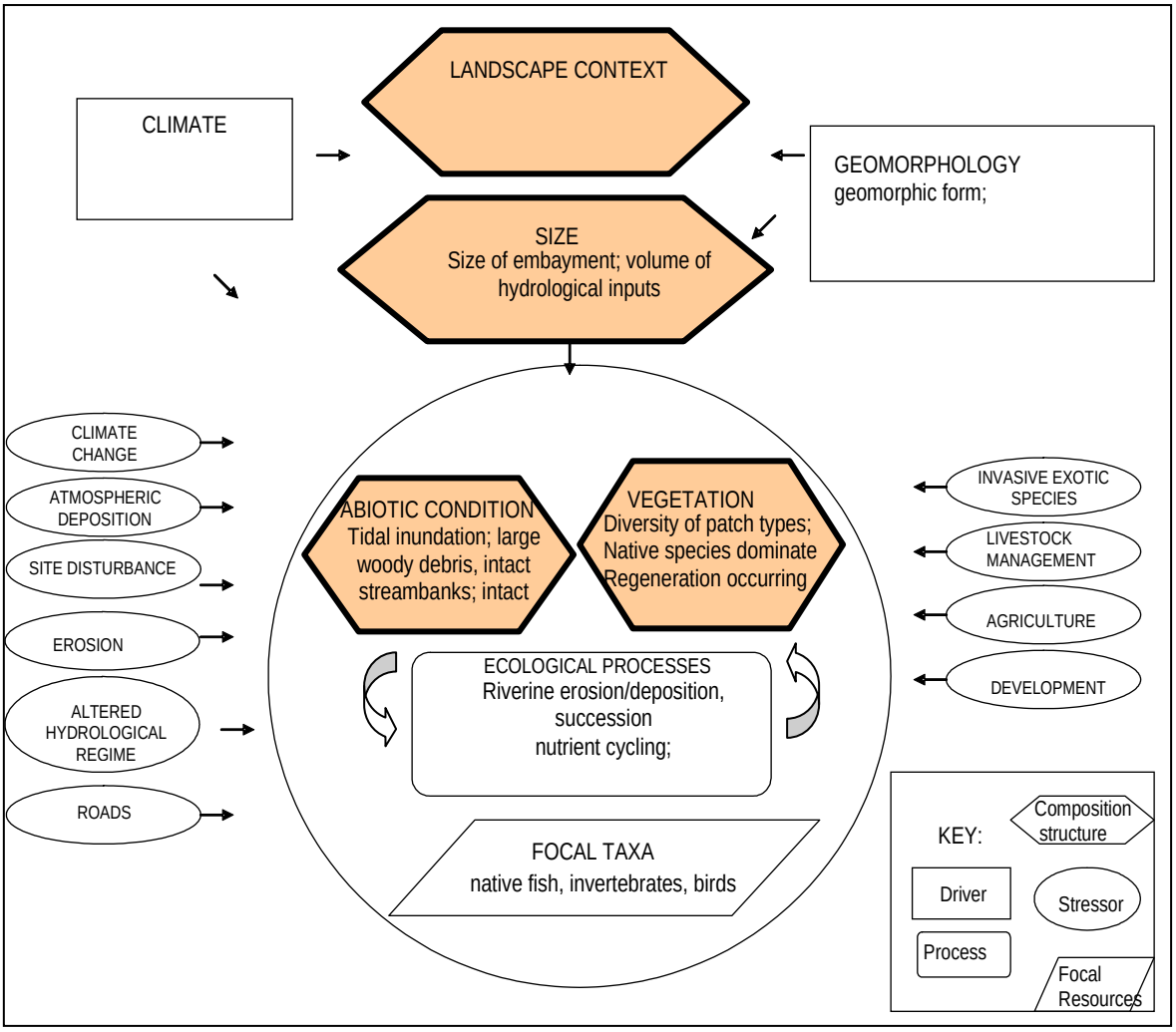

Figure 1. Conceptual Ecological Model for North Pacific Intertidal Freshwater Wetland

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 Intertidal Freshwater Wetland 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: *Buffer*					
Buffer Length	The buffer can be important to biotic and abiotic aspects of the wetland. Buffer Width Slope Multiplier 5-14% -->1.3; 15-40%-->1.4; >40%-->1.5	Buffer is > 75 – 100% of occurrence perimeter.	Buffer is > 50 – 74% of occurrence perimeter.	Buffer is 25 – 49% of occurrence perimeter	Buffer is < 25% of occurrence perimeter.
Buffer Width		Average buffer width of occurrence is > 200 m, adjusted for slope.	Average buffer width is 100 – 199 m, after adjusting for slope.	Average buffer width is 50 – 99 m, after adjusting for slope.	Average buffer width is < 49 m, after adjusting for slope.
Buffer Condition		Abundant (>95%) cover native vegetation, little or no (<5%) cover of non-native plants, intact soils, AND little or no trash or refuse.	Substantial (75–95%) cover of native vegetation, low (5–25%) cover of non-native plants, intact or moderately disrupted soils; minor intensity of human visitation or recreation.	Moderate (25–50%) cover of non-native plants, moderate or extensive soil disruption; moderate intensity of human visitation or recreation.	Dominant (>50%) cover of non-native plants, barren ground, highly compacted or otherwise disrupted soils, moderate or greater intensity of human visitation or recreation, no buffer at all.
Key Ecological Attribute: *Landscape Structure*					

Watershed Connectivity	The types of land cover/uses in the contributing watershed has a significant affect on ecological processes (May 2002)	Landscape of contributing watershed primarily natural land cover; no connectivity barriers and no regional flood control dams upstream; <5% of contributing watershed urban or agricultural land cover types; few to no recent (<20 years) clearcut (<10% of the landscape)	5-20% of contributing watershed urban or agricultural land cover types; connectivity mostly retained; heavily managed forest landscape with many tree plantations (<50% of watershed in recent clearcuts)	20-50% of contributing watershed urban or agricultural land cover types; limited connectivity; heavily managed forest landscape with many tree plantations (<50% of watershed in recent clearcuts)	>50% of contributing watershed urban or agricultural land cover types; limited connectivity largely disrupted; one or more regional flood control dams upstream.
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 Native Plant Species	Native species dominate this system; non-natives increase with human impacts.	Cover of native plants 95-100%.	Cover of native plants 80-95%.	Cover of native plants 50 to 79%.	Cover of native plants <50%.
Absolute Cover of Invasive Species	Invasive species can inflict a wide range of ecological impacts. Early detection is critical. *Phalaris arundinacea* and *Polygonum sahalinense*, are examples.	None present.	Invasive species present, but sporadic (<3% cover).	Invasive species prevalent (3–10% absolute cover).	Invasive species abundant (>10% absolute cover).
Relative Cover of Native Increasers	Some stressors such as grazing can shift or homogenize native composition toward species tolerant of stressors.	Absent or incidental	<10% cover	10-20% cover	>20% cover
Species Composition Note: Once developed, the Floristic Quality Assessment index could be 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: *Vegetation Structure*						
Canopy structure	Intact riparian areas should have a diversity of tree age classes.		Average tree cover generally > 25%; mixed age. Mature cottonwood and/or conifers present; Trees are of sufficient size to provide future LWD to stream or floodplain.		Somewhat homogeneous in density and age, AND canopy cover >90% OR <25%	Canopy extremely homogeneous, sparse, or absent (<10% cover).
Regeneration of Woody Species	Regeneration of woody species is expected in riparian areas with intact hydrology		Saplings/seedlings of native woody species (cottonwood/willow) present in expected amount; Obvious regeneration.	Saplings/seedlings of native woody species (cottonwood/willow) present but less than expected; Some seedling/saplings present.	Saplings/seedlings of native woody species (cottonwood/willow) present but in low abundance; Little regeneration by native species.	No reproduction of native woody species
Large Woody Debris	Large woody debris (LWD) in the stream channel is very important for channel formation, fish habitat, habitat heterogeneity, and sediment/ hydrological processes (NMFS 1996, Fox 2001)	Bank-full Width 0-6 m	(piece = >10cm diameter and ? 2 m in length; key piece >38 pieces		26-38	<26
		>6-30 m	>63 pieces		29-63	<29
		>30-100 m	>208 pieces		57-208	<57
Patch Diversity and Connectivity	When hydrological processes are intact, a diversity of seral patch and habitat types are present within this system. The patches are well connected without interruption from anthropogenic land cover/use.		Heterogeneous mix of well connected patch types. Mature conifer, mature deciduous (cottonwood, alder, or maple)/conifer mixed, or mature cottonwood (alder) patches present along with early seral stands of trees, wetland shrub and emergent vegetation patches.	Expected patch diversity present but connectivity between patches is becoming fragmented. OR less diversity than expected, especially of mature stands of trees.	Patch diversity is low and becoming homogeneous; few if any mature stands of trees present. Many patches isolated due to fragmentation within the riparian system.	Mostly dominated by one patch type. No mature conifer or deciduous tree patches present. Patch is isolated due to fragmentation within the riparian system.
Key Ecological Attribute: *Hydrology*						
Water Source	Anthropogenic sources of water can have detrimental effects on the hydrological regime		Source is natural or naturally lacks water in the growing season. No indication of direct artificial water sources	Source is mostly natural, but site directly receives occasional or small amounts of inflow from anthropogenic sources	Source is primarily urban runoff, direct irrigation, pumped water, artificially impounded water, or other artificial hydrology	Water flow has been substantially diminished by human activity
Channel Stability	Alteration in hydrology or sediment loads or some onsite stressors can degrade channel stability		Natural channel; no evidence of severe aggradation or degradation;	Most of the channel has some aggradation or degradation, none of which is severe	Evidence of severe aggradation or degradation of most of the channel	Concrete, or artificially hardened, channels through most of the site

Streambank Stability	Stable streambanks are indicative of intact hydrological and sediment regimes (Henshaw and Booth 2000).	Stable Perennial vegetation to waterline; no raw or undercut banks (some erosion on outside of banks normal); no recently exposed roots; no recent tree falls	Slightly Stable Perennial vegetation to waterline in most places; minor erosion and/or bank undercutting; recently exposed tree roots rare but present	Moderately Unstable Perennial vegetation to waterline sparse (mainly scoured or removed by lateral erosion); bank held in place by hard points (trees, boulders) and eroded back elsewhere; extensive erosion and bank undercutting; recently exposed tree roots and fine root hairs common	Completely Unstable No perennial vegetation to waterline; banks only held by hard points; severe erosion of both banks; recently exposed tree roots common; tree falls and/or severely undercut trees common
Hydroperiod (Tidal)	A change in the hydroperiod of a tidal wetland (i.e., a change in the tidal prism) can be inferred from changes in channel morphology and drainage network density (Collins 2008, Adamus 2006)	Area subject to the full tidal prism of freshwater, with two daily tidal minima and maxima.	Tidal prism of freshwater, reduced, or muted, although two daily minima and maxima are observed.	Tidal prism of freshwater, muted with tidal fluctuations evident only in relation to extreme daily highs or spring tides.	Tidal prism of freshwater, muted plus there is inadequate drainage, such that the marsh plain tends to remain flooded during low tide.
Hydrological Connectivity (Tidal)	Tidal and floodwater should have access to the floodplain. Stressors resulting in entrenchment affect hydrological connectivity (EPA 2006)	Average tidal channel sinuosity >4.0; absence of channelization. Marsh receives unimpeded tidal flooding. Total absence of tide gates, flaps, dikes culverts, or human-made channels.	Average tidal channel sinuosity = 2.5–3.9. Marsh receives essentially unimpeded tidal flooding, with few tidal channels blocked by dikes or tide gates, and human-made channels are few. Culvert, if present, is of large diameter and does not significantly change tidal flow, as evidenced by similar vegetation on either side of the culvert.	Average tidal channel sinuosity = 1.0–2.4. Marsh channels are frequently blocked by dikes or tide gates. Tidal flooding is somewhat impeded by small culvert size, as evidenced by obvious differences in vegetation on either side of the culvert.	Average tidal channel sinuosity <1.0. Tidal channels are extensively blocked by dikes and tide gates; evidence of extensive human channelization. Tidal flooding is totally or almost totally impeded by tidal gates or obstructed culverts.
Hydrological Connectivity (Riverine)	Tidal inundation and floodwater should have access to the floodplain. Stressors resulting in entrenchment affect hydrological connectivity	**LEVEL 2:** Completely connected to floodplain (backwater sloughs and channels)	Minimally disconnected from floodplain by dikes, tide gates, elevated culverts, etc	Moderately disconnected from floodplain by dikes, tide gates, elevated culverts, etc.	Extensively disconnected from floodplain by dikes, tide gates, elevated culverts, etc.
		LEVEL 3: Unconfined: Entrenchment ratio > 4.0; Confined: Entrenchment ratio > 1.4	Unconfined: Entrenchment ratio 1.4 – 2.2; Confined: Entrenchment ratio 1.0 – 1.4	Unconfined: Entrenchment ratio < 1.4; Confined: Entrenchment ratio < 1.0	
Key Ecological Attribute: *Physicochemical*					
Soil Surface Condition	Soil disturbance can result in erosion thereby negatively affecting many ecological processes	Bare soil areas are limited to naturally caused disturbances such as low tide exposure, flood deposition 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 and does not show evidence of ponding or channeling water.	Bare soil areas due to human causes are common. There may be pugging due to livestock resulting in several inches of soil disturbance. ORVs or other machinery may have left some shallow ruts.	Bare soil areas substantially & contribute to altered hydrology or other long-lasting impacts. Deep ruts from ORVs or machinery may be present, or livestock pugging and/or trails are widespread. Water will be channeled or ponded.

Water Quality	Excess nutrients, sediments, or other pollutant have an adverse affect on natural water quality	No evidence of degraded water quality. Water is clear; no strong green tint or sheen.	Some negative water quality indicators are present, but limited to small and localized areas. Water may have a minimal greenish tint or cloudiness, or sheen.	Negative indicators or wetland species that respond to high nutrient levels are common. Water may have a moderate greenish tint, sheen or other turbidity with common algae.	Widespread evidence of negative indicators. Algae mats may be extensive. Water may have a strong greenish tint, sheen or turbidity. Bottom difficult to see during due to surface algal mats and other vegetation blocking light to the bottom.
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	Occurrences of this size may have relatively high species diversity and are well buffered from edge effects.	> 200 ac/80 ha	75-200 ac/30-80 ha	5-75 ac/2-30	< 5 ac/2 ha

Level 3 EIA
Level 3 metrics would include more quantitative measures of the metrics listed above. In addition, the following metrics should be considered in a Level 3 EIA (Carlisle 1998):

- Nitrate/Nitrite
- Ammonia
- Phosphorus
- Total Suspended Solids
- Fecal coliform
- Salinity

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

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