

**Regional Alternatives Analysis for Port Marine Cargo
Development in the Lower Columbia River Using
Fish and Wildlife Habitat Redundancy Indexes for Comparisons**

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Draft Regional Alternatives Analysis for Port Marine Cargo Development in the Lower Columbia River Using Fish and Wildlife Habitat Redundancy Indexes for Comparisons

This report is intended to provide a rudimentary analysis for siting alternative port marine cargo facilities in a specific region (area of interest) in the lower Columbia River. Neither the methods nor products of this report are intended to satisfy the minimum requirements of a legally mandated regional alternatives analysis. They do, however, generally illustrate the potential range of adverse environmental impacts by future port development in a limited area of interest.

Problem

If adequate alternative analyses are not completed and used to inform marine cargo facility siting decisions, the least environmentally damaging practicable alternative may not be selected. The Port of Portland and the City of Portland are moving forward with a West Hayden Island preferred alternative without doing an adequate environmental review of the other regional alternatives. This action could lead Federal action agencies charged with National Environmental Policy Act (NEPA) responsibilities to find the West Hayden Island alternative pre-decisional and to find that the project's range of alternatives do not meet NEPA standards.

Purpose of the Report

This report is intended to provide a simplified inventory of areas in the lower Columbia River region that are likely candidates for bulk marine cargo expansion sites based on port ownership and industrial or marine cargo zoning. It provides a fish and wildlife habitat score for each of the alternative marine cargo sites identified using a species/habitat interaction metric called a redundancy index (Johnson and O'Neil 2001). Sites that have higher redundancy indexes are considered to have a higher risk of conflict between marine cargo development and fish and wildlife habitat than those with lower redundancy indexes.

This report will be placed in the public record and hopefully serve as an early red flag warning for the need of an adequate regional alternatives analysis to inform future port development in the lower Columbia River.

Area of Interest

The location of existing port facilities and infrastructure proximate to the major river shipping channels are the primary criteria used for selecting the area of interest. A four-mile radius centered around the confluence of the Columbia and the Willamette Rivers, including the majority of the port owned properties near the major shipping channels and docking facilities, is judged to contain the most likely alternative marine cargo development sites. This is considered the area of interest (AOI) of the report.

Credits

Access to data used in the project was made possible by the Lower Estuary Partnership, Portland Audubon Society, Portland State University, Northwest Habitat Institute, and the U.S. Army

Corps of Engineers. Bald eagle nest coordinates were provided by Frank Isaacs (Biologist, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon, pers. comm. 2012). All maps, tables, and figures were created by the author.

Methods

This report is a description of the geographic information system workflow used by the author to complete the intended alternatives analysis. Geoprocessing operations were primarily done in ArcGIS 10.0 software using ArcView and ArcInfo. All data are projected to a common projected coordinate system and datum (UTM Zone 10, NAD 1983).

Data Sources. Zoning and tax lot feature classes were collected from Metro's Regional Land Inventory System (RLIS). A land cover raster dataset was provided by the Lower Columbia River Estuary Partnership (LCREP). The U.S. Army Corps of Engineers provided LIDAR datasets for the area of interest that were used in combination with U.S. Geological Survey information to interpolate a regional shoreline at 5-meters NGVD. Regional redundancy indexes were found in a table in the Oregon Department of Transportation's Mitigation Operations Manual, an application of the Northwest Habitat Institute's IBIS relational database (<http://www.nwhi.org/index/ibis>).

Area of Interest Layer. A point feature class was created at the approximate center of the Columbia and Willamette River confluence and the buffer tool in ArcToolbox was used to create a 4-mile radius circular polygon around the point feature class.

Port of Portland and Port of Vancouver Land Ownership In Area of Interest



Figure 1. Property Owned by the Port of Vancouver and the Port of Portland in the Area of Interest

Port Ownership Layer. Vector polygon layers of the tax lot ownerships in the City of Portland, City of Vancouver, and Multnomah County were clipped using the extent of the area of interest polygon and added into an ArcMap project. The three tax lot datasets were merged into a single polygon using the “merge” tool in ArcToolbox. A short integer data type field called “value” was added to the attribute table of the merged polygon. A select by attribute option was used to select each tax lot record with an ownership by the Port of Portland or the Port of Vancouver. Then the field calculator was used to populate the “value” field of each selected record with the number 1. Next the records not in port ownership were selected and the field calculator was used to assign a “0” to each of their “value” fields. The “polygon to raster” tool in ArcToolbox was used to convert the polygon into a raster dataset with 1-meter square cells with the priority field and value field both set to the “value field” option.

Industrial Zoning. Vector polygon layers of the zoning in the City of Vancouver, the City of Portland, and Multnomah County were clipped using the extent of the area of interest polygon and added into an ArcMap project. The three zoning datasets were merged into a single polygon using the “merge” tool in ArcToolbox. A short integer data type field called “value” was added

Industrial and Marine Cargo Zoning Designations in Area of Interest



Figure 2. Industrial and Marine Cargo Zones in the Area of Interest

to the attribute table of the merged polygon. A select by attribute option was used to select each zone record with an industrial or marine cargo designation. Once selected, the option to only display the selected records was used and then the field calculator was used to populate the “value” field of each record selected with the number 1. Then the records not in industrial or marine cargo zones were selected and the field calculator was used to assign a “0” to each of their “value” fields. The “polygon to raster” tool in ArcToolbox was used to convert the polygon into a raster dataset with 1-meter square cells with the priority field and value field both set to the “value field” option.

Alternative Port Development Sites. The multiply tool in the Spatial Analyst Toolbox was used to multiply the matching geographically referenced cell values of the zoning and tax lot raster layers to create an output raster that only assigned values of 1 for areas that are both owned by a port and that are zoned for industrial or marine cargo use. This effectively isolated the port owned lands proximate to the major shipping channels that are zoned for industrial or marine cargo use. Alternative port development sites could then be selected from this layer.

Alternative Port Development Sites in the Area of Interest

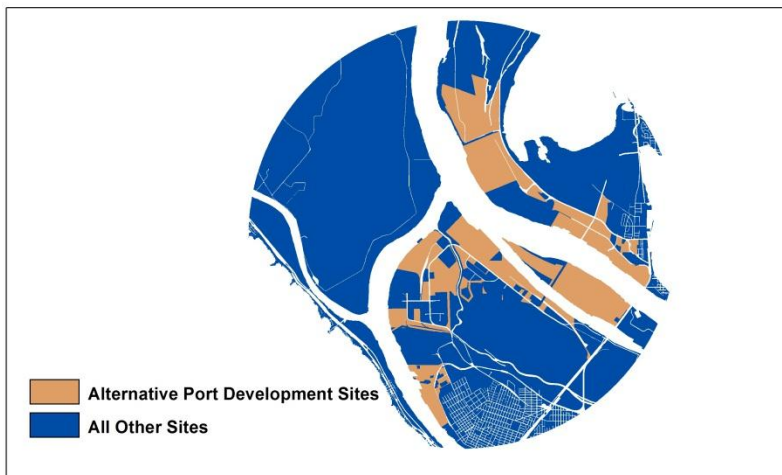


Figure 3. Alternative Port Development Sites in the Area of Interest Based on Ownership and Zoning

Land Cover at Alternative Port Development Sites. A Lower Columbia River Estuary Partnership (LCREP) land cover raster dataset was added to the ArcMap project and clipped to the area of interest. Each cell in the raster dataset has a coded unique numeric value assigned to it based on cartographically determined existing land cover types and is geo-referenced to projected coordinates. The multiply tool in the Spatial Analyst Toolbox was used to multiply the matching geographically referenced cell values of the alternative port development sites (1) and of the geographically referenced cells of the land cover layer (10,11, 23, . . .) to create an output raster (Figure 4) that only contains land cover coded values for the areas that are alternative port development sites. All other areas are assigned a “0” value.

Habitat Based Ranking of Alternative Port Development Sites. The next step was to identify and apply a peer reviewed metric for determining and mapping the relative wildlife importance of each of the alternative port development site land cover classes. The metric selected is *functional redundancy* (Table 1).

Functional redundancy roughly translates to the number of wildlife species performing a specific wildlife function (e.g., vascular plant dispersal) and is determined by tallying the species in a Key Ecological Function (KEF) matrix where species are related to specific KEF categories for specific habitat types and conditions. One hypothesis is that functional redundancy supports

Land Cover Types on the Alternative Port Development Sites in the Area of Interest

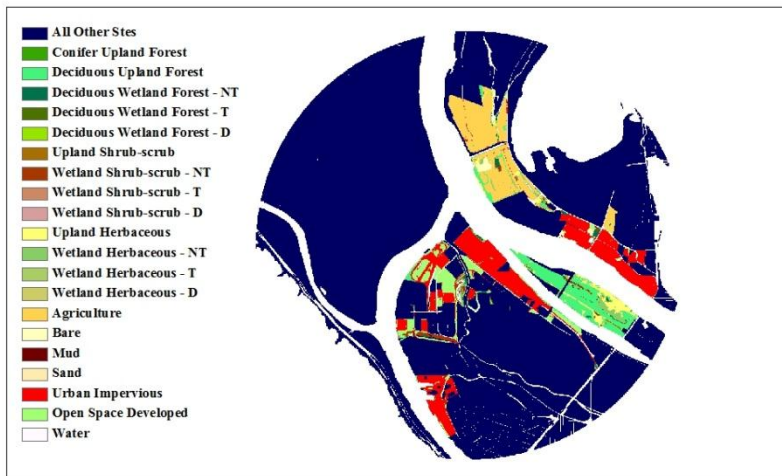


Figure 4. Land Cover Types on Alternative Port Development Sites in the Area of Interest.

resilience for particular functions with a positive correlation between functional redundancy and functional resilience. It also follows that the greater the functional redundancy, the more sustainable the resources served by the prevailing functions (Johnson and O'Neil 2001).

The KEF represents the primary ecological roles of each species in a collective group of species occupying and utilizing their shared habitat. It denotes the relationship between species and their required habitat elements as well as with other species in their collective habitat structure. These functions influence both biotic and abiotic habitat condition and alteration (Johnson and O'Neil 2001). It is important to understand that these functions occur within a context of statistically definable spatial (e.g., x, y, z coordinates) and temporal variability highly associated with a multiple scale habitat structure.

The habitat types associated with the Johnson and O'Neil redundancy index assignments are in a different and somewhat less detailed land cover classification than that used in developing the LCREP land cover raster dataset. Therefore, a crosswalk table (Table 1) had to be developed before their associated redundancy indexes could be transferred to the LCREP dataset. Crosswalk assignments were done by the author but informed through consultations with Northwest Habitat Institute when possible. Several relatively minor modifications were made to redundancy index scores:

- 1) All redundancy indexes were rounded up to the nearest whole integer. It was judged misleading to assign a decimal precision to an index at this landscape level of application;

Table 1. Area of Interest Modified Oregon Functional Redundancy Indexes by Ecoprovince and Habitat (Oregon Department of Transportation Mitigation Operations Manual Landscape Level Application of IBIS - <http://www.nwhi.org/index/ibis>).

IBIS – Habitat Type	Lower Columbia River Estuary Partnership Cover Type	Lower Columbia Ecoregion – Project Generalization *
Westside Lowlands Conifer Forests	10 - coniferous upland forest	17.9 - 18
Westside Oak and Douglas-fir Forest and woodlands	11 - deciduous upland forest 40 - upland scrub-shrub	17.54 - 18
Westside Grasslands	50 - upland herbaceous	12.5 - 13
Agriculture Pasture and Mixed Environs	70 - agriculture 71 - tree farms 91 - open space developed	4.8 - 5
Urban and Mixed Environs	90 - urban impervious	4.0 - 4
Open Water	93 – water	27.1 - 27
Herbaceous Wetlands	NA	NA
Westside Riparian/Wetlands – non-tidal **	23 - coniferous wetland forest 25 - coniferous wetland forest - diked 26 - deciduous wetland forest 28 - deciduous wetland forest – diked 42 - wetland scrub-shrub 44 - wetland scrub-shrub - diked 52 - wetland herbaceous 54 - wetland herbaceous - diked	19.1 - 19
Westside Riparian/Wetlands – tidal **	53 - wetland herbaceous 24 - coniferous wetland forest 27 - deciduous wetland forest 43 - wetland scrub-shrub 80 – bare 81 – mud 82 – sand 84 – rock 60 – Aquatic Bed	19.1 - 23 19.1 - 23 19.1 - 23 19.1 - 23 12.7 - 20 12.7 - 20 12.7 - 20 12.7 - 20 19.1 - 23
* Decimals are rounded to integers for discrete raster cell RI-value assignments ** Riparian tidal is split from riparian non-tidal and RI-values are averaged between riparian and water		

- 2) Because of the physical locations of these datasets, wetland herbaceous LCREP land cover types were not associated with the Johnson and O’Neil land herbaceous wetland land cover type but were instead split between tidal and non-tidal Westside riparian wetlands. The wetland herbaceous redundancy index was then reassigned a Westside riparian wetland redundancy index; and
- 3) All tidal Westside riparian wetland redundancy indexes are the averages of the redundancy indexes of their non-tidal riparian wetland counterparts and open water.

Landscape Level Redundancy Index Scores for Land Cover Types
on Alternative Port Development Sites in Area of Interest

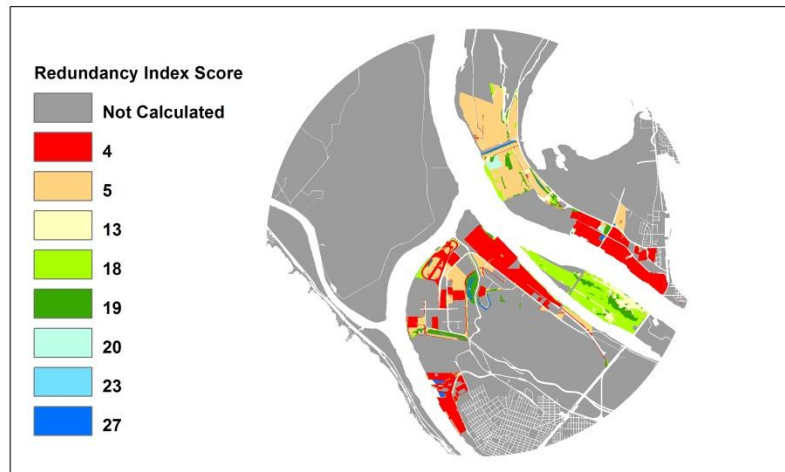


Figure 5. Landscape Level Redundancy Indexes for Port Marine Cargo Site Alternatives

Tidal connections are considered to offer higher opportunities for fish to interact with in-situ habitat elements and for consequential increased opportunities for overlapping ecological functions to occur.

Once the crosswalk table was complete, the next step was to use it to reclassify the LCREP land cover dataset using the “Reclassify” tool in ArcToolbox. Essentially this means that a new raster layer (Figure 5) was created using the LCREP land cover raster as a template. But instead of land cover coded values, the new raster’s cell values were assigned redundancy indexes following their template’s geographically referenced land cover crosswalk assignments.

Relative habitat values of alternatives. Aerial imagery of the area covered by the layer of potential marine cargo development sites was reviewed and evaluated for alternative development site selections based on the following screening criteria:

- 1) The site contains few existing vertical manmade structures;
- 2) The site has at least 300-acres of contiguous land; and
- 3) The site is contiguous along a major shipping lane.

Three sites were selected:

- 1) Port of Portland Terminal 6;
- 2) Port of Vancouver Gateway Site; and
- 3) West Hayden Island

Using the create feature class tool in ArcToolbox, three polygons were digitized on the aerial imagery using the three screening criteria described above. Each of the polygons digitized

represents the boundary of an alternative port marine cargo development site (Figures 6 - 14) in this project's area of interest.

Alternative No. 1 - Port of Portland Terminal 6. While this site is already serving as a bulk marine cargo facility, it is included in the alternatives analysis because it:

- 1) meets the three screening criteria;
- 2) provides an alternative with relatively minor fish and wildlife habitat conflicts; and
- 3) may have yet to be determined opportunities for increased bulk marine cargo storage through a combination of structural and operational improvements.

Terminal 6 is evaluated for its existing wildlife score using the redundancy index metric. Over 428-acres, 98% of the land cover, on Terminal 6 is paved surface, qualifying the paved area for the lowest redundancy index score (4) possible in the ranking system. While other habitat types are found inside the site's boundary, most are confined to the edges of the pavement and contribute little to the overall redundancy score for the site (4.2).

Alternative Number 1 - Land Cover - Port of Portland Terminal 6

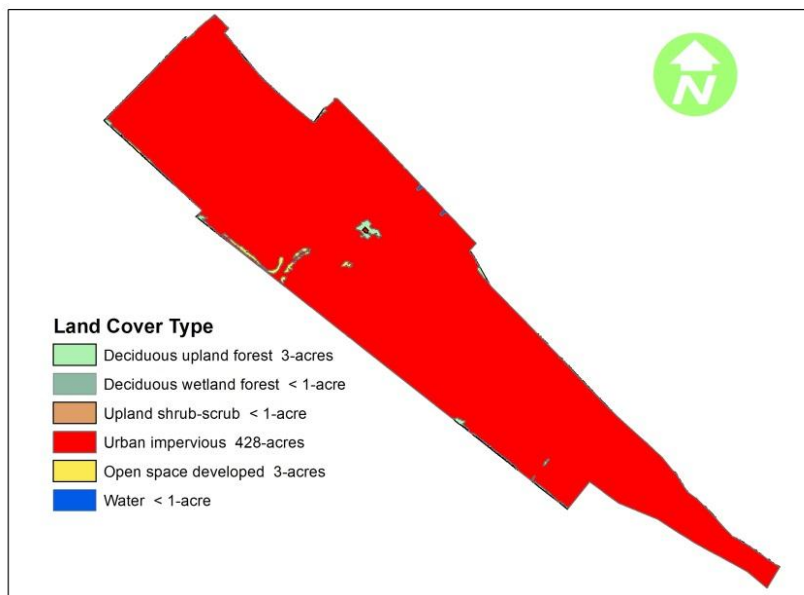


Figure 6. Alternative 1 – Terminal 6 - Land Cover Types

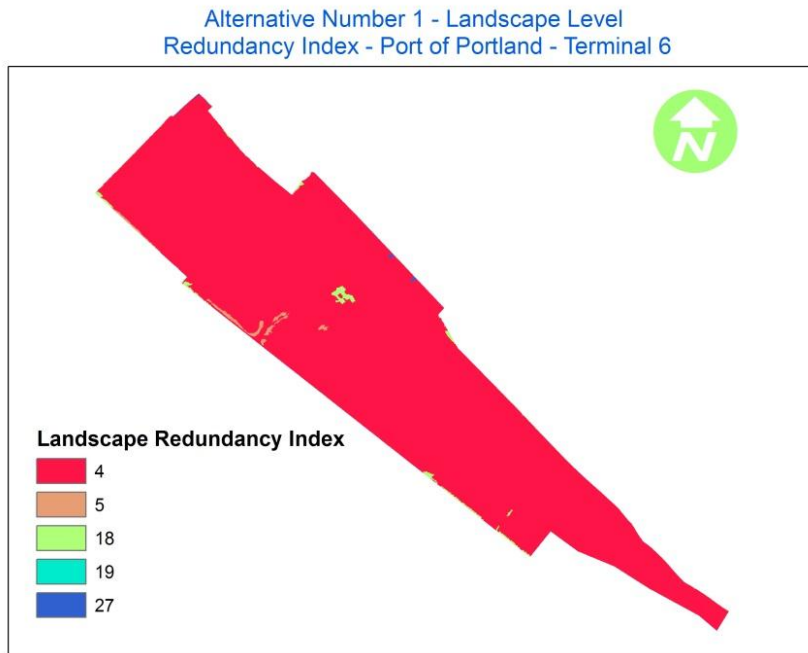


Figure 7. Alternative 1 – Terminal 6 – Redundancy Indexes



Figure 8. Alternative 1 – Port of Portland Terminal 6 - Aerial Image

Alternative No. 2 - Port of Vancouver Gateway. This site is included in the alternatives analysis because it:

- 1) meets the three screening criteria;
- 2) provides an alternative with relatively minor to moderate fish and wildlife habitat conflicts; and
- 3) has demonstrated potential for containing bulk marine cargo facility improvements (<http://www.federalregister.gov/articles/2006/08/28/E6-14216/intent-to-prepare-a-draft-environmental-impact-statement-for-the-proposed-port-of-vancouver-columbia>):

Gateway was evaluated for its existing wildlife value using the redundancy index metric. Over 800-acres, 84% of the land cover, at Gateway is characterized by agriculture conversion. Agriculture is assigned the second lowest redundancy index score possible in the ranking system. While other habitat types are found in the area, they are mostly confined to the southern portion of the area identified and contribute moderately little to the overall score of the site (6.9).

Alternative Number 2 Land Cover Types (acres) - Gateway



Figure 9. Alternative 2 – Gateway Land Cover Types

Alternative Number 2 - Landscape Redundancy Index
Scores (acres) - Gateway



Figure 10. Alternative 2 – Gateway Landscape Level Redundancy Indexes

Alternative Number 2 - Gateway Aerial Image



Figure 11. Alternative 2 – Gateway Aerial Image

Alternative No. 3 – West Hayden Island. This site is included in the alternatives analysis¹ because it:

- 1) meets the three screening criteria; and
- 2) has an opportunity for bulk marine cargo storage (mostly owned by the Port of Portland).

Over 825-acres, 99% of the land cover, on West Hayden Island is characterized by vegetated wildlife habitat, qualifying the site for moderate redundancy index scores (17.1) indicating [that out of the three alternatives reviewed](#), it is the most susceptible to wildlife habit losses.

Alternative Number 3 Land Cover Types (acres) - West Hayden Island



Figure 12. Alternative 3 - West Hayden Island Land Cover Types

¹ Significant portions of West Hayden Island are not owned by the Port of Portland (See Appendix 1). But in order to make alternative development site redundancy index comparisons relatively straightforward, the entire area inside the West Hayden Island site boundary is evaluated as one contiguous unit.

Alternative Number 3 Landscape Redundancy Index Scores - West Hayden Island

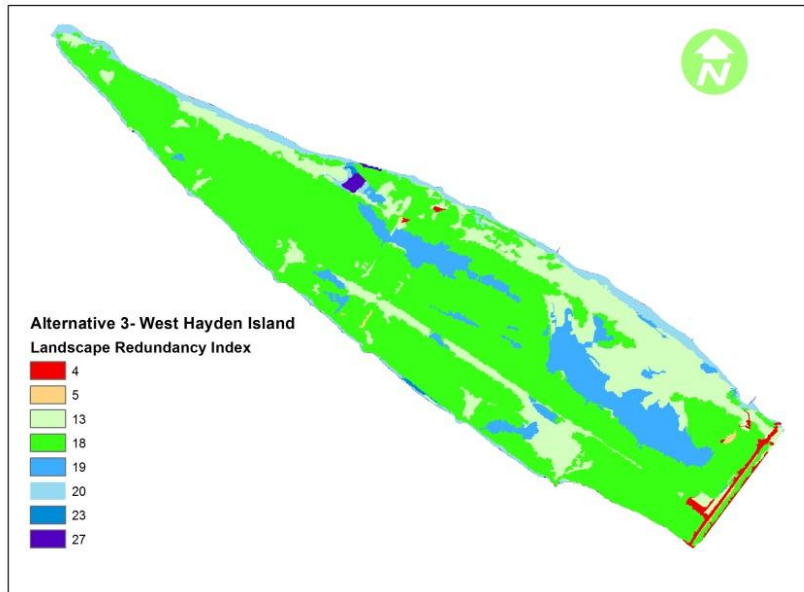


Figure 13. Alternative 3 – West Hayden Island Landscape Level Redundancy Indexes

Alternative Number 3 - West Hayden Island - Aerial Image



Figure 14. Alternative 3 – West Hayden Island Aerial Image

Least Potential for Environmental Damage Alternative (Figure 15). The acreage of each LCREP land cover types was totaled in three separate columns, one for each alternative site under evaluation. Then the acreage for land cover type in each column was multiplied by its assigned redundancy index, resulting in three more “weighted columns,” one for each alternative site. The totals of the weighted columns were then divided by the totals of their corresponding unweighted columns to derive a weighted redundancy index for each of the alternative sites reviewed.

Based on the wildlife redundancy index metric alone, the alternative with the least potential for environmental damage is the Port of Portland’s Terminal 6 with a wildlife redundancy score of 4.2. The Port of Vancouver’s Gateway site ranks second with a wildlife redundancy score of 6.9. West Hayden Island has the highest potential for habitat damage with a wildlife redundancy score of 17.1. Logic follows the alternative sites with the lowest risks to wildlife habitat damage

Lower Columbia River Estuary Partnership Cover Type		RI	UW Alt 1 (Acres)	UW Alt 2 (Acres)	UW Alt 3 (Acres)	W Alt 1	W Alt 2	U Alt 3
10 - coniferous upland forest		18	0	0	1	0	0	18
11 - deciduous upland forest		18	3	22	500	54	396	9000
40 - upland scrub-shrub		18	1	1	22	18	18	396
50 - upland herbaceous		13		18	165	0	234	2145
70 - agriculture		5		813		0	4065	0
71 - tree farms		5				0	0	0
91 - open space developed		5	3	5	2	15	25	10
90 - urban impervious		4	428	16	8	1712	64	32
93 - water		27	1	13	4	27	351	108
23 - coniferous wetland forest		19				0	0	0
25 - coniferous wetland forest - diked		19				0	0	0
26 - deciduous wetland forest		19	1	11	13	19	209	247
28 - deciduous wetland forest - diked		19		1		0	19	0
42 - wetland scrub-shrub		19		7	13	0	133	247
44 - wetland scrub-shrub - diked		19				0	0	0
52 - wetland herbaceous		19		30	62	0	570	1178
54 - wetland herbaceous - diked		19		1		0	19	0
53 - wetland herbaceous		23		1	2	0	23	46
24 - coniferous wetland forest		23				0	0	0
27 - deciduous wetland forest		23			1	0	0	23
43 - wetland scrub-shrub		23			1	0	0	23
80 - bare		20		29		0	580	0
81 - mud		20		1	1	0	20	20
82 - sand		20		1	40	0	20	800
84 - rock		20				0	0	0
Total:			437	970	835	1845	6746	14293
Final Landscape Level Redundancy Index Scores								
POP T6			POV Gateway		POP WHI			
4.221967963			6.954639175		17.11736527			

Figure 15. Wildlife Redundancy Scores for Each of the Port Marine Cargo Development Site Alternatives

are better suited for port development than higher risk sites.

Practicable Alternatives. The question of which alternative poses the highest risk to wildlife habitat is relatively easy to answer compared to the question of which alternatives are practicable from multiple perspectives (including but not limited to economic, social, political, and multi-

faceted environmental). This report does not attempt to answer that question but does offer some guidance on the matter.

Because of the size and scope of the proposed marine cargo project, the sensitivity of human and biological resources in and around the areas proposed for placement (near the confluence of the Columbia and Willamette Rivers), and the Federal authorities responsible for protecting the trust resources at risk, it is inevitable that at some future time an Environmental Assessment (EA) and/or an Environmental Impact Statement (EIS) will be required per the auspices of an umbrella authority known as the National Environmental Policy Act (42 USC 4321 et seq.) (NEPA) and all of its accompanying legislative authorities (e.g., Clean Water Act (33 USC 1251 et seq.), Endangered Species Act (16 USC 1531 et seq.), Fish and Wildlife Coordination Act (16 USC 661 et seq.), Migratory Bird Treaty Act (16 USC 703-712), etc.). At this juncture the Federal Action agency(s), other cooperating and participating Federal Agency(s), stakeholder state agencies, and local governments will all be gathered to help write and review all of the NEPA documents necessary to meet the requirements of the law and to complete the final Record of Decision.

The recommendation of this report is for the Port of Portland and the City of Portland to approach the appropriate Federal action agency(s), the U.S. Army Corps of Engineers (COE) and possibly the Federal Emergency Management Agency (FEMA), and begin a formal NEPA process as soon as possible. This will help ensure: 1) a healthy Federal, state, and local government partnership; 2) a seamless relationship between regulation and planning; and 3) significantly reduced risk of eleventh hour surprises.

In preparing for NEPA consider the following:

- 1) Purpose and need should not be so narrow as to unnecessarily preclude a less environmentally damaging alternative;
- 2) Place high emphasis on finding solutions that serve the project's purpose and need but that also result in the least amount of environmental damage necessary to meet the targeted goals;
- 3) While working to meet NEPA requirements understand that they are inextricably linked to a number of other environmental laws and requirements, including but not limited to the mandate to find the least environmentally damaging practicable alternative (LEDPA) per the Environmental Protection Agency's 404(b)(1) guidelines and the Presidential Executive orders that require all Federal agencies to protect wetlands and floodplains (Executive Order 11988 entitled "Floodplain Management and Executive Order 11990 entitled "Protection of Wetlands," both dated May 24, 1977);
- 4) When defining and selecting from the range of alternatives, consider the direct, indirect, and the cumulative impacts to the natural environment;
- 5) The following sequence should be considered as an overarching template applied during project scoping, planning, and development:

“Mitigation” includes:

- (a) Avoiding the impact altogether by not taking a certain action or parts of an action;
- (b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- (c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- (d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- (e) Compensating for the impact by replacing or providing substitute resources or environments.

Compensatory mitigation plans should be developed in enough detail for each of the project alternatives to allow a useful estimate of costs of compensatory mitigation for each of the alternatives. These relative costs should then be carefully considered when estimating the overall economic benefit of a given alternative over the other alternatives and in selecting a preferred alternative.

There are several approaches to preparing for a NEPA analysis that are highly discouraged:

- (a) Reverse engineering of the decision making is not advised if you want to avoid significant project delays and potential costly and lengthy litigation;
- (b) Weeding out, patronizing, or in any way intimidating the participants who are voicing minority reports and/or who are otherwise in opposition or not completely compliant with the status quo are also tactics that will ultimately undermine reputations and credibility, and basically should just not be practiced in a democratic society; and
- (c) Participating in, and then counting on, backdoor negotiations to gain a pass through the necessary regulatory and planning requirements are at best unethical and at worst illegal.

Regional Cumulative Effects of Development on Habitat Value. In order to better understand the cumulative effect of development actions on our focal area of interest (AOI) habitat value, it is necessary to first document the history of effects for all previous development actions in that AOI (Environmental Protection Agency 1999). Fortunately, historic reconstruction (<http://oregonstate.edu/dept/ODFW/freshwater/inventory/columbia/habproject.htm>) of land cover and present day land cover (LCREP 2011) has been prepared and provided as GIS feature classes that use nearly identical overarching classification criteria. While there are some limitations on the confidence of historic data, and it's interpretation, it is judged by project leaders (<http://oregonstate.edu/dept/ODFW/freshwater/inventory/columbia/historicmaps.htm>) to reasonably represent historic conditions for use in making small scale (large area) comparisons with present day land cover.

Method Logic

Since the classification criteria are nearly the same for both the historical and the present day land cover data, it was decided that Johnson and O'Neil Redundancy Indexes applied to present day land cover could also be used for the historical datasets. Under this premise, historic and contemporary land cover pixels sharing the same classifications are assumed to have equivalent habitat values and are subsequently assigned the same redundancy indexes.

While this offers a pseudo normalization effect to the comparison process by creating a common base redundancy index value to 'like' habitat classes identified in both time periods, there are some significant limitations to this logic. For example, a number of species that were present in the AOI in the 1850s have since been extirpated (e.g., North American Grizzly bear, Grey wolf, California condor, etc.). These species were therefore not used in determining present day land cover redundancy index scores. Moreover, while post European settlement related activity was already taking a toll on vegetated land cover in the 1850s (Christy and PuteraL1992), the overall disturbance regime of historic land cover types can generally be assumed to be less disturbed than they are now. Habitat patches were likely generally larger and both horizontally and vertically more diverse. Finally, most of the species in the AOI in the 1850s were natives, whereas today there are significantly more nonnative species present (Sytsma et al 2004), many of which are aggressively invasive in the areas they occupy. With these caveats in mind, one would suspect that if the present day Johnson and O'Neil redundancy index rating method was applied to habitats in the 1850's, the derived scores would generally be significantly higher than their present day counterparts.

Developing habitat redundancy indexes that reflect the historic condition is beyond the scope of this paper. Consequently the habitat comparisons displayed in Figures 16 and 17 should be considered highly conservative and to likely significantly underestimate the actual habitat value differences between the 1850s and today.

Two other factors were used to add to the overall habitat value scores: 1) presence of Bald eagle nests and 2) river corridor habitat used by juvenile salmonids to the 5-meter NGVD (based on estimated AOI Ordinary High Water) elevation. Bald eagles (U.S. Fish and Wildlife Service 1996) and juvenile salmonids (Thom and O'Rourke 2005) were selected as focal species/guilds largely because of their importance as indicators of ecosystem health. Where there is an overlap of an area considered important to a Bald eagle nest or a juvenile salmonid with the underlying redundancy index layer, one point is added to the redundancy index score. Multiple overlaps result in one point addition for each overlapping layer. There was no attempt to distinguish or rate differently a currently active nest.

While there is a good historical reconstruction for land cover classes in the 1850s (<http://oregonstate.edu/dept/ODFW/freshwater/inventory/columbia/habproject.htm>), there is no analogous documentation of Bald eagle nest locations for an area as specific as the AOI. Isaacs and Anthony 2011 was used to inform the creation of a highly simplified hypothetical historic Bald eagle nest feature class for use in the historic AOI. The four criteria used were: 1) point locations are stratified random assignments; 2) primary stratification is within 1-mile of a major river channel; 3) secondary stratification is

inside historic forested land cover class; and 4) the minimum distance between nests is 1300-feet. The Bald eagle nest locations displayed in the 1850s AOI are at best a model representation of their possible distribution and density at a regional scale.

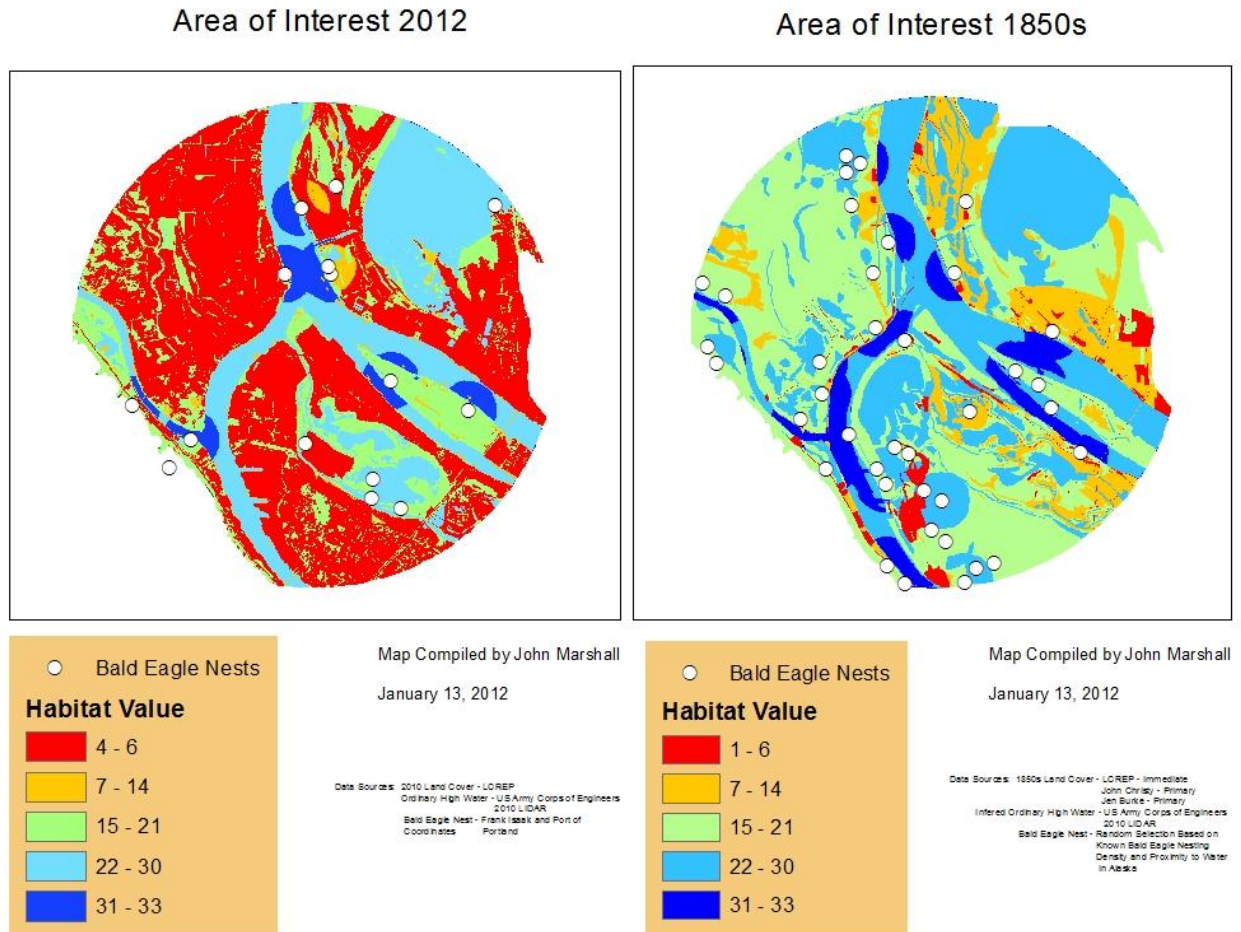


Figure 16. Geographic Comparison of Ordinal Habitat Values in the AOI between the 1850s and the Present.

A series of GIS geoprocessing procedures (Appendix 3) culminating in an overlay operation using the ArcGIS Raster Calculator tool adds points to all geographically referenced pixels for each of the habitat value layers employed and assigns total habitat pixel value scores in a continuous raster layer, one final layer is derived for each time period AOI. Enabling properties for each of the final raster layers allowed a manual classification of 5 classes (high, medium-high, medium, medium-low, and low) and to display the geographic distribution of the habitat values in the historic and present day AOI. Classification threshold selections were subjective decisions blending quantile and natural break methods.

the list (Federal Register / Vol. 72, No. 130 / Monday, July 9, 2007) and are experiencing varying rates of recovery in their overall range; others (e.g., Chinook salmon) are not. During the past hundred years, the number of Chinook salmon returning to spawn in the Estuary has decreased from a range of 450,000–550,000 fish to an average of 100,000. Since reaching a low of 25,000 returning fish in 1999, Chinook salmon returns have slightly improved. Habitat loss and degradation are cited as the leading causes of salmonid population declines (LCREP 2005).

There are a number of practical applications for cumulative effects information. The following are suggested applications in the lower Columbia River Estuary:

- Determine priority areas to protect the best remaining habitat while allowing development and compensatory mitigation in relatively lower value habitat in order to achieve the maximum regional habitat value recovery;
- Determine if added development will cross critical thresholds limiting species and/or habitat recovery potential in their home ranges;
- Determine the physical locations of potential reference sites for use as templates for habitat recovery; and
- Determine the physical location of ‘control sites’ for use as on-going monitoring of regional habitat “health” indicators as measured by scientifically tested metrics for gauging both habitat degradation and recovery.

The AOI used in this paper is an artificially defined area based primarily on suitability criteria for alternative locations for marine cargo site locations, not ecological criteria. Therefore, it has limited utility in defining larger regional cumulative effects. It is presented in this paper to illustrate the need for cumulative effects to be considered in regional planning and specifically to planning and regulatory decisions affecting the Columbia and Willamette River confluence.

The habitat evaluation method used assigns higher numeric value to aquatic habitat and terrestrial habitat proximate to aquatic areas and influenced by periodic inundation. Moreover, the method is designed for regional application and cannot offer site level comparisons that calibrate the relative value scale for specific habitat types in the AOI (e.g., deciduous upland forest). It is at best a coarse filter for making regional habitat value comparisons. Nevertheless, because of the stark contrasts resulting from the magnitude and areal extent of habitat loss and degradation in the AOI, this method is judged to provide an adequate means for determining where the best remaining habitat in the AOI is located. Its utility in a regional alternative analysis is to enable relative comparisons of habitat value between candidate development sites. In this context, the absolute numeric value of any given site is not the primary focus. The primary focus is on the relative numeric habitat values of candidate development sites in the AOI. Decision makers can use this information to help determine the least environmentally damaging practicable alternative development options. They can also ascertain from the application of this method that the last remaining contiguous block of “*relatively*” high habitat value greater than 100-acrs in the vicinity of the Columbia and Willamette River confluence, and still associated with a main river channel, is West Hayden Island.

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Appendix I. Oregon Department of State Lands Ownership on West Hayden Island

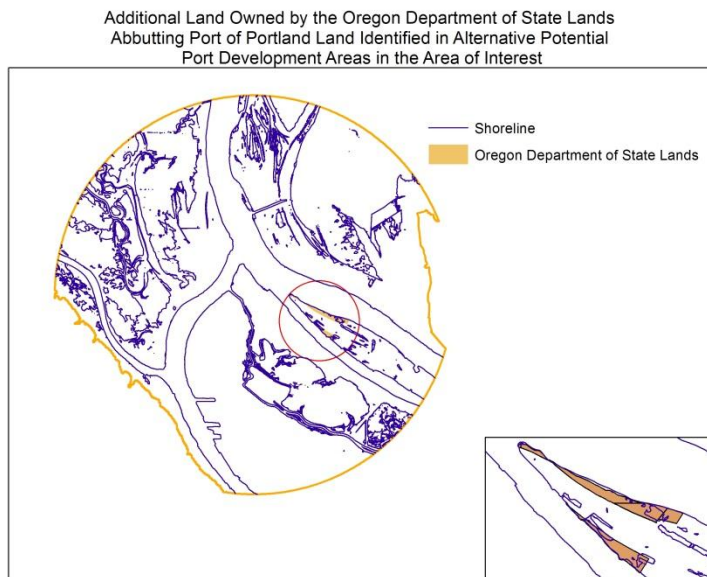


Figure 1a. Oregon Department of State Lands Ownerships in the Area of Interest.



Figure 1b. Land Cover Types on Oregon Department of State Lands Property.

Appendix I. Oregon Department of State Lands Ownership on West Hayden Island (Cont.)

Landscape Level Redundancy Index Scores for Land Cover Types
on Oregon Department of State Lands Ownerships

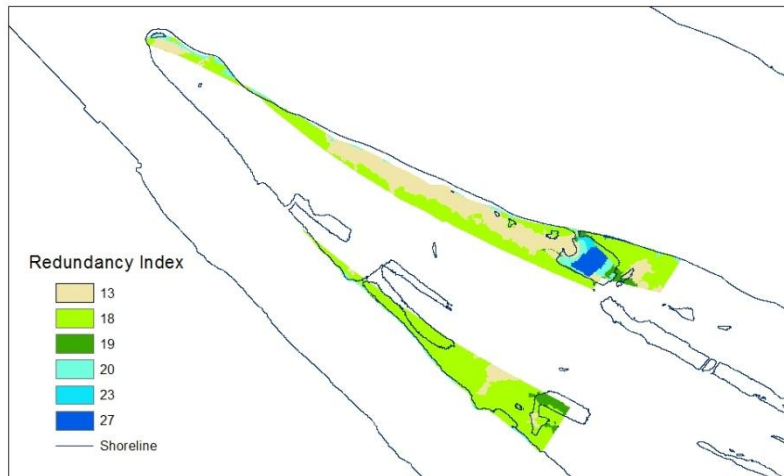


Figure 1c. Landscape Level Redundancy Indexes on Oregon Department of State Lands Property.

Appendix 2. Northwest Habitat Institute Priority Species List for the Lower Columbia River Ecoprovince

This Priority species list was derived by first determining all the potential fish and wildlife species that could breed in the lower Columbia River ecoprovince. These species were then reviewed for having a: Federal and/or State Status, Partners-In-Flight Species of Continental Importance Designation, Game Status, Strong Association with Salmonids, and/or Functional Specialist Species. If the species met one or more of these designations, then it was considered as being a priority species for the ecoprovince. These species may also be considered as being a concern within the ecoprovince, and may warrant further consideration in any mitigation, restoration or conservation effort.

Pacific Lamprey	Marbled Murrelet
Tui Chub	Band-tailed Pigeon
Mottled Sculpin	Mourning Dove
White Sturgeon	Northern Pygmy-owl
Pumpkinseed	Sunfish Spotted Owl
Steelhead	Common Nighthawk
Rainbow Trout (Non-Anadromous)	Rufous Hummingbird
Cutthroat Trout (Westslope)	Williamson's Sapsucker
Cutthroat Trout (Coastal)	Red-breasted Sapsucker
Chinook Salmon	Pileated Woodpecker
Chum Salmon	Olive-sided Flycatcher
Sockeye Salmon (kokanee and anadromous)	Willow Flycatcher
Coho Salmon	Pacific-slope Flycatcher
Cope's Giant Salamander	Horned Lark
Columbia Torrent Salamander	Purple Martin
Cascade Torrent Salamander	Chestnut-backed Chickadee
Dunn's Salamander	Brown Creeper
Larch Mountain Salamander	Winter Wren
Clouded Salamander	Western Bluebird
Oregon Slender Salamander	Wrentit
Tailed Frog	Black-throated Gray Warbler
Western Toad	Hermit Warbler
Red-legged Frog	Yellow-breasted Chat
Cascades Frog	Vesper Sparrow
Painted Turtle	Western Meadowlark
Western Pond Turtle	Montane Shrew
Ringneck Snake	Baird's Shrew
Turkey Vulture	Fog Shrew
Canada Goose	Long-legged Myotis
Wood Duck	Fringed Myotis
American Wigeon	Long-eared Myotis

Appendix 2. Northwest Habitat Institute Priority Species List for the Lower Columbia River Ecoprovince (Cont.)

Mallard
Blue-winged Teal
Cinnamon Teal
Ring-necked Duck
Harlequin Duck
Bufflehead
Barrow's Goldeneye
Hooded Merganser
Common Merganser
Osprey
Bald Eagle
Northern Goshawk
Peregrine Falcon
Ruffed Grouse
Blue Grouse
Mountain Quail
California Quail
American Coot
Snowy Plover
Wilson's Snipe
Caspian Tern

Silver-haired Bat
Townsend's Big-eared Bat
Western Gray Squirrel
American Beaver
White-footed Vole
Muskrat
Red Fox
Gray Fox
Black Bear
Raccoon
Mink
Northern River Otter
Mountain Lion
Bobcat
Roosevelt Elk
Black-tailed Deer
Columbian White-tailed Deer
Northern Fur Seal
California Sea Lion
Harbor Seal
Northern Elephant Seal

Appendix 3. General Geoprocessing Procedure for Cumulative Effects Project (not necessarily in actual workflow order)

Land Cover Layers

- All layers are projected to NAD 1983 UTM Zone 10 datum and projected coordinate system;
- Land cover polygon data are converted to raster files at 1-m² pixel resolution;
- Because of reclassification problems in ArcGIS software, all land cover raster files are converted to ASCII text files and then imported into IDRISI Taiga and converted to IDRISI raster file formats;
- In IDRISI Taiga, land cover raster files are reclassified with each land cover type being assigned a redundancy index using Table 1 crosswalk (reclassification files are compiled separately and imported for use in making pixel reclassification assignments);
- Land cover raster files are exported from IDRISI and reconverted to ESRI raster file formats; and
- The present day and historic land cover raster files are inserted into separate data frames in an ArcMap project.

Main River Channel Layer

- A Spatial Analyst surface tool is used with Corps of Engineers 2010 Columbia River LIDAR data to derive a polyline elevation contour feature class in an ArcMap project;
- The 5-meter NGVD contour is selected and exported to a separate layer;
- An editing session is started in an ArcMap project and the 5-meter NGVD contour polyline is simplified by removing all vertices except those associated with the main river channels and (adjusting snapping settings as needed) the open ends are connected to form a closed polyline;
- X-tools polyline to polygon conversion tool is used to create a polygon feature class from the edited closed polyline created in the previous step;
- A Union tool is used create an output polygon layer that comprises a combination of the river channel polygon and a AOI polygon;
- A short integer field is added to the attribute table of the Union output polygon called "Value;"

- An editing session is started in ArcMap for the Union output polygon and the record representing the portion of the polygon covered by the main river channels is selected, a '1' is typed in the "Value" field portion of that record and a '0' is typed in the same field in the next record representing the remaining "empty" portion of the polygon, save and stop editing; and
- Use polygon to raster tool to convert the modified Union output polygon (which includes multiple shallow water inlets along the main shoreline) to a raster file at 1-m² pixel resolution.

Bald eagle Nest Buffers 2011 Layer

- 2011 Bald eagle nest latitude and longitude decimal degree coordinates are entered into a Microsoft Excel spreadsheet which is then added to an ArcMap project;
- Add XY data function is used to project the coordinates to an "event" in ArcMap using the WGS 1984 geographic coordinate system;
- The point events representing Bald eagle nest locations in the previous step are exported to a geodatabase feature class and then projected to a NAD 1983 UTM Zone 10 projected coordinate system;
- Use buffer tool to create a 2500-foot buffer around each point and allow each buffer to be saved as a separate feature class;
- A Union tool is used to create an output polygon layer that comprises a combination of the buffer polygon and a AOI polygon;
- A short integer field is added to the attribute table of the Union output polygon called "Value;"
- An editing session is started in ArcMap for the Union output polygon and the record representing the portion of the polygon covered by the eagle nest buffer is selected, a '1' is typed in the "Value" field portion of that record and a '0' is typed in the same field in the next record representing the remaining "empty" portion of the polygon, save and stop editing; and
- Use polygon to raster tool to convert the modified Union output polygon to a raster file at 1-m² pixel resolution; and
- Repeat the last four steps for each Bald eagle nest buffer.
- Bald eagle Nest Buffers Historic Layer

- Create a 1-mile buffer around the main river channel polygon;
- Open the attribute table in the historic vegetation polygon and use select by attribute to select all forest cover class records;
- Export selected forest cover class records to a separate feature class and add it to your ArcMap project;
- Clip the newly created forested cover classes layer to the 1-mile river buffer layer;
- Use random point feature class tool to create a point feature class representing hypothetical Bald eagle nests, confined to the clipped forested cover class layer, and set the minimum distance parameter between points to be 1300-feet;
- Use buffer tool to create a 2500-foot buffer around each point and make provision to have each buffer saved as a separate feature class;
- Use 'Union' tool to create an output polygon layer that comprises a combination of the buffer polygon and a AOI polygon;
- A short integer field is added to the attribute table of the Union output polygon called "Value;"
- An editing session is started in ArcMap for the Union output polygon and the record representing the portion of the polygon covered by the eagle nest buffer is selected, a '1' is typed in the "Value" field portion of that record and a '0' is typed in the same field in the next record representing the remaining "empty" portion of the polygon, save and stop editing; and
- Use polygon to raster tool to convert the modified Union output polygon to a raster file at 1-m² pixel resolution; and
- Repeat the last four steps for each Bald eagle nest buffer.

Combine all Layers (Addition)

- For each time period AOI create a new blank ArcMap project:
 - Add the reclassified land cover raster file layer with completed pixel redundancy indexes assignments;
 - Add the main river channel raster layer;
 - Add each of the Bald eagle nest buffer raster layers;

- In Spatial Analyst tools use the Raster Calculator to ‘add’ each of the raster layers in your ArcMap project to generate a final Habitat Value continuous raster file data set; and
- Classify the raster pixels using symbology options under properties.