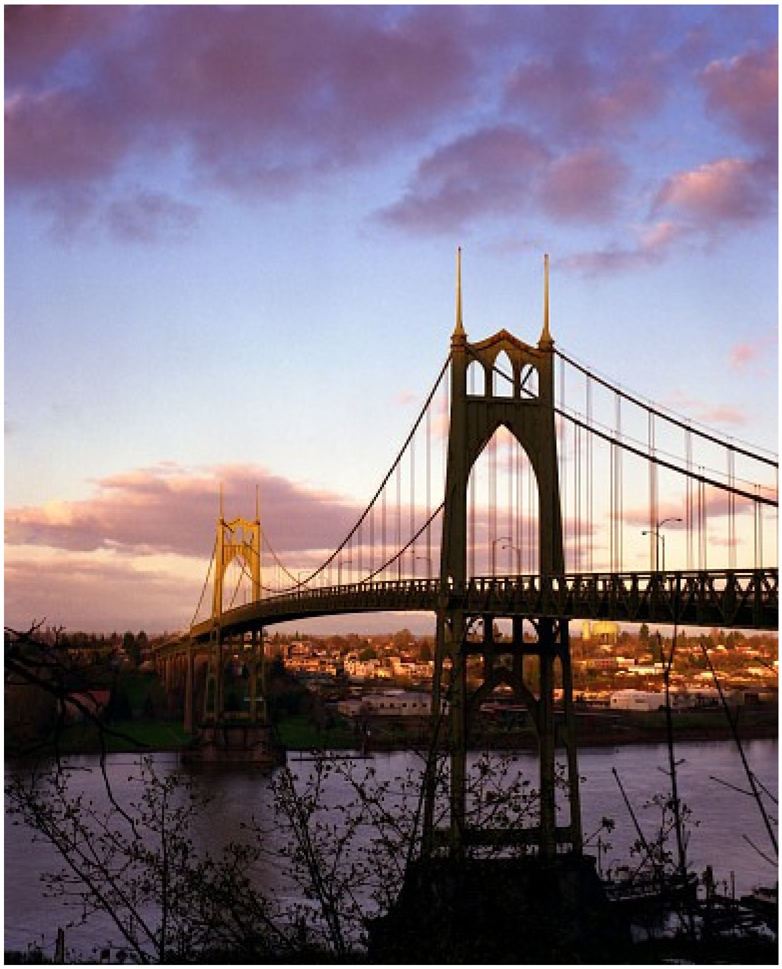
River Restoration Program Development

Habitat Valuation System



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1. Introduction

A habitat valuation methodology has been developed for the City of Portland's proposed River Plan Mitigation Bank. The goals of the habitat valuation are to 1) develop a method that is based on the best available science, user-friendly and transparent; 2) meets the mitigation criteria of regulating agencies such as the Department of State Lands and the US Army Corps of Engineers; 3) ensure no net loss of natural resource function in the North Reach of the Willamette River through development impacts that cannot be otherwise avoided or minimized, and 4) utilize a system that is compatible with the Portland Harbor Natural Resources Damages settlements.

The Habitat Equivalency Analysis (HEA) model developed by the National Oceanic and Atmospheric Administration (NOAA) was selected as the model to determine the amount of debits and credits at the impact sites and restored sites respectively. In support of HEA, the Habitat Evaluation Procedure (HEP) model developed by the US Fish and Wildlife Service (USFWS) and the Oregon Rapid Wetland Assessment Protocol (ORWAP) will be utilized for valuation of all habitat types found at each mitigation site before and after restoration and at each affected site before and after the site is developed.

2. Habitat Equivalency Analysis

Habitat Equivalency Analysis (HEA) is an analytical framework, developed by NOAA, for determining the amount of mitigation needed to compensate for the interim or permanent losses of a resource. HEA calculates the amount of mitigation needed by establishing an equivalency between what is lost and what is gained through the mitigation project over time. Compensation is also gained for temporal losses of habitat resources through mitigation projects providing additional resources of the same type.

Typically, HEA has been used to assess damages from such actions as oil spills, hazardous substance releases, vessel groundings, etc. The HEA method is specifically used in cases of habitat injury when the function of the injured area is ecologically equivalent to the function that will be provided by the replacement (mitigated) habitat. Figure 3 shows a depiction of the loss in services caused by a spill and the replacement of those services provided through construction of new habitat.

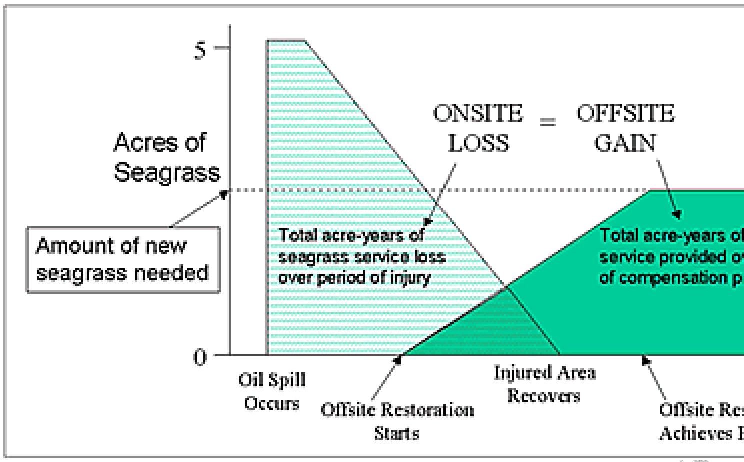

Figure 1. Diagram showing the onsite services lost and the offsite services gained over time (from NOAA 1995).

HEA can be employed to evaluate ecological function gain from restoring habitats by comparing habitat in an area before and after restoration occurs. Four factors are considered in the HEA equation: 1) a valuation of all habitats found on the site before and after restoration; 2) estimates of the time needed for each restored habitat to achieve its full ecological function value; 3) the duration that the restored habitats will continue to fully function; and 4) a discounting factor (Wolotira 2008).

The basis for pre- and post-restoration habitat values will be determined through use of a HEP model developed for the riverine, riparian, stream, and upland habitats, and the Oregon Rapid Wetland Assessment Protocol (ORWAP) for wetland habitats.

The duration of restoration sites is usually based on legal documents prohibiting future use of the site for any purpose other than fully functional habitat (usually identified in legal documents as “in perpetuity”). In this case, “in perpetuity” translates into a finite period, for example, no more than 300 years when discounting (the fourth factor) is considered.

To make past and future losses and gains comparable, a *discount* factor must be applied. The regulations and NOAA (1999) recommend using a 3 percent discount rate when scaling compensatory restoration for discounting interim service losses and restoration falling within industry standards. A discount rate accounts for an item of high current value gradually losing its worth over time.

The total value for each habitat is a function of its initial value; an annual discount factor; an annual percent increase towards full value; the final value that the habitat can attain; a product of the discount factor times the annual habitat benefits; and the minimum number of years that the restoration site will exist. The summation of habitat value is expressed as a function of discounted ecological services over an area through time or discounted Service Acre Years. Below is the HEA model and a description of the inputs.

TOTAL HABITAT VALUE (THV) is represented by the formula:

$$THV = \sum_{Y_i=1}^{Y_f} [((1+d)^{(Y_b - Y_i)})(Y_i / Y_f)(V_f - V_0)] + \sum_{Y_i=Y_f+1}^{n} [((1+d)^{(Y_b - Y_i)})(V_f - V_0)]$$

where:

- Y_i= the i[th] year
- Y_f = final year, or year when habitat reaches full ecological function;
- d = annual discount rate, or 0.03;
- Y_b = baseline year of the life of the habitat (usually “1”);
- n = number of years of habitat existence = 300;
- V_0 = initial (unrestored) value of habitat. (before or after the impact?)
- V_f = maximum (or final) value of the restored habitat

The habitat values both before and after restoration or impact are assessed through two habitat evaluation procedures: HEP for riverine, riparian, stream and upland habitats, and ORWAP for wetland habitats. Both procedures are provided below.

Habitat acres, which is an input to the HEA model is determined scientifically through data collected onsite through the HEP model, described below.

3. Habitat Evaluation Procedure (HEP) MODEL

HEP provides a means for designing a mathematical model based on the habitat suitability of the project site for one or more species that represent those habitats. The output of the model provides a quantitative value to be used for further evaluation and comparison of the actions.

HEP was developed by the U.S. Fish and Wildlife Service (1980) to facilitate the identification of impacts from various federal actions on fish and wildlife habitat. HEP can provide numeric scores for existing conditions at a project site, potential future without-project conditions, and various action alternatives for a species or assemblage of species in a particular geographic area. HEP is comprised of one or more Habitat Suitability Indices (HSIs), which are mathematical relationships designed to represent the habitat suitability of an area for a single species or assemblage of species. A set of variables that represent the habitat requirements for the species (e.g. percent cover, water depth, tree height) is combined into a mathematical model. The variables are then measured in the field and their corresponding index values are inserted into the model to produce a score that describes existing habitat suitability. The value is an index score between 0 and 1. The mathematical model proposed for this HEP is derived both from existing HSIs and HSIs developed for species of concern that do not have existing models.

These developed HSIs are based upon data in the literature of species habitat requirements and preferences and are inherently based on best professional judgment.

A HEP model was created for each of the following habitat types: riverine, riparian, stream, upland, and grassland. The selection of species to include in each HEP model was based on several criteria. First and foremost, the species' geographic range must include the project vicinity. The species must also utilize the habitat type or types that are currently present, or are proposed for restoration. Species with existing HSI models are preferred. Utilizing previously developed and verified models provides a greater level of scoring certainty, scientific credibility and replicability. Suitable HSI models must include habitat variables for which data collection is possible, given the availability of time and resources. Finally, variables must also show a change in score between the existing and proposed condition. If the project does not affect the suitability index score for a species, it will not be possible to quantify an effect. Habitat variables that do not meet the above requirements will be omitted.

The HSIs for various habitat parameters for each species are combined arithmetically or geometrically to yield an overall index score for the species. Scores for each species can be used individually or combined to yield an overall index score for multiple species or species assemblages for each habitat type. Habitat requirement for individual species or assemblages of species represent habitat conditions that are suitable for other species and represent indicators of a functioning ecosystem.

HSIs exist for the following species and were reviewed for potential inclusion in the HEP including: mink *(Mustela vison)*, beaver *(Castor canadensis)*, yellow warbler *(Dendroica petechia)*, green heron *(Butorides virescens),* great blue heron *(Ardea herodias)*, downy woodpecker *(Picoides pubescens)*, red-winged blackbird *(Agelaius phoeniceus)*, wood duck *(Aix sponsa)*, mallard *(Anas platyrhynchos)*, lesser scaup *(Aythya affinis)*, osprey *(Pandion haliaetus)*, bald eagle *(Haliaeetus leucocephalus)*, black-capped chickadee *(Poecile atricapilla)*, downy woodpecker (*Picoides pubescens*), American kestrel (*Falco sparverius*), native amphibians, and bullfrog *(Rana catesbeiana)*, Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), and chum salmon (*Oncorhynchus keta*). HSIs and variables within these models were selected for the HEP based upon the above criteria. Those that did not meet these requirements were omitted. In order to address key species that have not had models developed previously, two new HSIs were developed for the western pond turtle (*Clemmys marmorata marmorata)* and the mainstem juvenile Chinook model. Other species considered for the model but not included are species of concern: Pacific lamprey (*Lampetra tridentate)* and sturgeon (*Acipenser transmontanus)*.

The HEP models developed for this project are community-based, modified models where multiple species were selected to represent the range of species that utilize the riverine, riparian, stream, upland, and grassland habitats of the lower Willamette. In some cases, existing species models were combined to represent a guild of species that occupy a common niche in the study area in order to fully capture the suite of habitat requirements. In other cases,

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appropriate HSI models did not exist and models were developed for species that utilize key habitat features that contribute to the overall ecological function.

4. Riparian Model

4.1 *Riparian Model Species*

4.1.1 Western Pond Turtle

The western pond turtle is a species of concern in the study area. Western pond turtles forage in water and eat a wide variety of aquatic invertebrates, terrestrial insects, small fish, crayfish, and frogs. Overwintering may occur in mud on the bottom of ponds, under overhanging banks, or in forested areas under a thick layer of leaf litter. During the rest of the year, turtles generally occur in aquatic habitats, with a slow to moderate current. A significant amount of time is used for basking on rocks, logs or emergent vegetation. Nesting can occur from late April through July. Females excavate nests in compact, dry soils with high clay or silt content and sparse vegetation (grasses or other herbaceous species). The turtles prefer warmer waters and require emergent basking sites to thermoregulate their body temperature.

The habitat suitability indices identified for use in the HEP model to address habitat preferences for western pond turtle include: water depth, water temperature, cover along water's edge, and the presence of suitable nesting sites.

4.1.2 Beaver

Beaver are herbivorous aquatic mammals found throughout North America wherever suitable riparian and wetland habitats occur. The HSI model and habitat preferences for beaver are described in Allen (1982). Beaver are generalized herbivores, but have strong preferences for specific plant species and size classes. Aspen, willow, cottonwood, and alder are the preferred species. Woody stems less than 10 centimeters in diameter near water are preferred, and herbaceous vegetation and leaves are consumed during the summer. Aquatic vegetation is also utilized.

The habitat suitability indices for beaver, selected to address their habitat preferences include: tree canopy closure, shrub crown cover, trees between 1-6 inches dbh, average height of shrub canopy, and species composition of woody vegetation.

4.1.3 Wood Duck

The wood duck represents cavity nesting waterfowl species that utilize riparian areas for nesting. Wood ducks inhabit creeks, rivers, floodplain lakes, swamps, and beaver ponds (Sousa and Farmer 1983). Wood ducks have been referred to as primarily herbivorous, although invertebrates also make up a part of their annual diet. Suitable cover for wood ducks may be provided by trees or shrubs overhanging water, flooded woody vegetation, or a combination of these two types. For nesting, wood ducks utilize bottomland hardwood forests with trees of sufficient size to contain usable cavities that are near water.

The habitat suitability index selected for wood duck is the amount of brood cover available, which consists of overhanging vegetation and woody debris within 1 meter of the water surface.

4.1.4 Neotropical and Other Migrant Birds (Yellow Warbler and Green Heron)

The yellow warbler and the green heron were selected to represent neotropical and other migratory birds that may use the riparian habitat of the Willamette River. However, their foraging characteristics are sufficiently different that they are evaluated separately.

Yellow warblers are a breeding bird throughout the U.S. The existing model and habitat requirements are described in Schroeder (1982). The yellow warbler prefers riparian habitats composed of abundant, moderately tall, deciduous shrubs ranging in height from 1.5 to 4 meters (6-13 ft). Shrub densities between 60 and 80% are considered optimal and coniferous areas are avoided. Greater than 90% of prey species are insects and foraging takes place primarily on small limbs in deciduous foliage. Nests are generally located 0.9 to 2.4 meters (3-9 ft) above the ground in willows, alders, and other hydrophytic shrubs and trees, including box elders and cottonwoods. Male yellow warblers have greater mating success in shrubs less than 3 meters (10 ft) tall.

Green-backed herons are wading birds that inhabit a wide range of aquatic environments and also represent neotropical migratory birds that utilize riparian habitat for a large portion of their lifecycle. They are somewhat adaptable and general in their habitat preferences. Breeding cover is provided by woody material capable of supporting a nest in proximity of suitable feeding areas. Optimum breeding habitat is provided with suitable clumps of deciduous shrubs/trees within 0.4 km (0.25 mi). There must be some breeding cover within 1.6 km (1.0 mi). Herons forage in openings, among emergent vegetation, and along soft, muddy borders of shallow water. Good feeding cover requires a muddy or sandy bottom, water less than 25cm (10") deep, and a moderate amount of vegetative cover. Green-backed herons require water. Permanent water provides the optimum value while semi-permanent will receive some utilization.

The habitat suitability indices selected to represent neotropical migrant bird habitat preferences include: deciduous shrub cover, hydrophytic shrub cover, overall canopy cover, and deciduous shrub canopy height.

4.1.5 Native Amphibians

This habitat suitability index is a combination of the habitat requirements of both aquatic and terrestrial amphibians; roughskin newt, red-legged frog and the Pacific treefrog. Washington Department of Fish and Wildlife (WDFW 1997) describes the habitat requirements of these species in the HSI for native amphibians which are summarized below.

Roughskin newts occur in most of Oregon, and are considered to be aquatic salamanders, which utilize ponds and slow-moving streams for most of the year or year-round. They prefer forested or partially wooded habitats adjacent to ponds, lakes or sloughs, often where there is

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extensive aquatic vegetation. Juveniles and adults live in and under rotting logs and forage in the ponds or moist forest floors.

Red-legged frogs occur on the west side of the Cascade crest in Oregon, Washington and British Columbia. They prefer moist coniferous or deciduous forest and forested wetland habitats. They breed in cool slow-moving waters such as shaded ponds and sloughs in winter to early spring. Juveniles and adults will live in emergent wetlands, logs, or brush adjacent to pond edges. During the rainy season, they move into forest habitats and live under logs and debris, foraging on the forest floor.

Pacific treefrogs are the most common frog in the northwest and can live in a variety of habitats including marshes, wet meadows, forests and brushy disturbed areas. Adults live in wet meadows and riparian areas.

All native frogs have been reduced in part due to the presence of the non-native bullfrog. Bullfrogs often eat smaller frogs, and even small bullfrogs, and fish. This habitat suitability index also incorporates a negative index for some habitat characteristics that are preferred by bullfrogs, such as water temperature and permanently ponded deep water.

The habitat suitability index parameters selected for native amphibians include: area of permanent water, emergent or submergent aquatic vegetation, cover along water's edge, width of riparian zone, maximum water temperature, and land use within 200 meters of the wetland edge.

4.2 *Riparian Model Parameters*

4.2.1 Western Pond Turtle

The Habitat Suitability Index for western pond turtle is calculated according to the following equation:

$$\mathbf{HSI_{WPondTurtle} = (V_1 + V_2 + V_3 + V_4 + V_5) / 5}$$

V_1 = % Area with water depth preferred by adults (1-2 m) ***(Morreale & Gibbons, 1986)***

% Area	SI
0	0
20	0.5
50	1.0
75	1.0
100	0.2

V_2 = % Cover along water's edge including canopy, LWD, emergent wetland vegetation, etc. *(Morreale & Gibbons, 1986)*

% Cover	SI
0	0
25	0.2
50	0.5
75	1.0
100	1.0

V_3 = Water temperature during low flows *(Morreale & Gibbons, 1986; Holland, 1994)*

Temperature (C)	SI
5	0
10	0.2
15	0.6
20	1.0
25	1.0
30	0.6

V_4 = % Area with water depth less than 0.3 meters *(Bill Castillo, ODFW, pers. com.)*

% Area	SI
0	0.1
25	1.0
50	1.0
75	0.3
100	0

V_5 = Availability of suitable nesting sites (qualitative) *(Bill Castillo, ODFW, pers. com.)*

Availability	SI
None	0
Very few (1-2 in project area)	0.2
Sparse (3-4 in project area)	0.5
Moderate (5-7 in project area)	0.8
Abundant (>7 in project area)	1.0

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4.2.2 Beaver

The Habitat Suitability Index for beaver is calculated according to the following equation:

$$\mathbf{HSI_{Beaver} = (V_1 + V_2 + V_3 + V_4 + V_5) / 5}$$

V_1 = Percent tree canopy closure (the percent of the ground surface shaded by a vertical projection of the canopies of woody vegetation ≥5.0 m (16.5 ft) in height) *(Allen 1982)*

Percent canopy closure	SI
0	0
25	0.5
50	1.0
75	0.8
100	0.6

V_2 = Percent of trees in 2.5 to 15.2 cm (1 to 6 inches) dbh size class *(Allen 1982)*

Percent of trees	SI
0	0.2
25	0.4
50	0.6
75	0.8
100	1.0

V_3 = Percent shrub crown cover (the percent of the ground surface shaded by a vertical projection of the canopies of woody vegetation < 5 m (16.5 ft) in height) *(Allen 1982)*

Percent cover	SI
0	0
25	0.6
50	1.0
75	0.9
100	0.8

V_4 = Average height of shrub canopy *(Allen 1982)*

Average height (meters)	SI
0	0
1	0.3
2	1.0
3	1.0
4	1.0

V_5 = Species composition of woody vegetation (trees and/or shrubs) *(Allen 1982)*

Vegetation Class	Description	SI
A	Woody vegetation dominated (>50%) by one or more of the following species: aspen, willow, cottonwood, alder	1.0
B	Woody vegetation dominated by other deciduous species	0.6
C	Woody vegetation dominated by coniferous species	0.2

4.2.3 Wood Duck

The Habitat Suitability Index for wood duck is calculated according to the following equation:

$$HSI_{Wood\ Duck} = V_1$$

V_1 = Percent of the water surface covered by potential brood cover (shrub cover, overhanging tree crowns within 1 m (3.3 ft) of the water surface, woody downfall, and herbaceous) *(Sousa and Farmer 1983)*

Percent surface covered	SI
0	0
25	0.4
40	0.8
50-75	1.0
85	0.6
100	0

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4.2.4 Neotropical and Other Migratory Birds

The Habitat Suitability Index for neotropical birds is calculated according to the following equation:

$$\mathbf{HSI_{Neotropical\ Birds} = (V_1 + V_2 + V_3 + V_4) / 4}$$

V_1 = % deciduous shrub cover (Yellow Warbler) *(Schroeder, 1982)*

% Cover	SI
0	0
25	0.4
50	0.75
60	1.0
80	1.0
90	0.8
100	0.6

V_2 = % overall canopy cover (Green Heron, encompasses the # of perch sites requirement) *(USFWS 1980b)*

% Canopy Cover	HSI
0-20	0
20-40	0.1
40-60	0.2
60-70	0.8
70-80	1.0
80-100	0.1

V_3 = Average height of deciduous shrub canopy height (Yellow Warbler *Schroeder 1982)*

Canopy Height (m)	SI
0	0
0.5	0.25
1.0	0.5
1.5	0.75
2.0	1.0

V_4 = % canopy comprised of hydrophytic shrubs (Yellow Warbler) *(Schroeder 1982)*

% Hydrophytic Shrubs	SI
0	0.1
25	0.3
50	0.55
75	0.8
100	1.0

4.2.5 Native Amphibians

The Suitability Index for native amphibians is calculated according to the following equation:

$$HSI_{Native\ Amphibians} = (V_1 + V_2 + V_3 + V_4 + V_5 + V_6) / 6$$

V_1 = % Area with permanent water *(modified from WDFW 1997)*

% Area of Permanent Water	SI
0	0
10	0.6
25-40	1.0
>50	0.2

V_2 = % Area with emergent or submergent wetland/aquatic vegetation *(WDFW 1997).*

% Area Wetland Vegetation*	SI
0	0
25	0.5
>50	1.0

**Areas dominated by reed canary grass and/or purple loosestrife cause HSI = 0.2.*

V_3 = % Ground cover along the water's edge, including debris, overhanging vegetation, undercut banks, etc. *(WDFW 1997)*

% Cover	SI
0	0
25	0.3
50	0.6
75	0.9
100	1.0

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V_4 = Width of riparian zone *(WDFW, 1997)*

Width (m)	SI
0	0
10	0.2
30	0.6
>60	1.0

V_5 = Maximum *w*ater temperature during low flows *(modified from Graves & Anderson 1987*)

Temperature (°C)	SI
0	0.1
5	0.5
10	1.0
15	0.3
20	0

V_6 = Land use within 200 meters of the wetland edge *(WDFW 1997)*

Land Use	SI
Developed	0
Row Crops	0.1
Managed Pasture	0.5
Fallow Grass/herbs	0.7
Shrubs/trees	1.0

4.3 *Riparian Model Equation*

HEP Riparian Model	
Western Pond Turtle	V_1 = Percent area with water depth preferred by adults V_2 = Percent cover along water's edge V_3 = Water temperature during low flows V_4 = Percent area with water depth less than 0.3 meters V_5 = Availability of suitable nesting sites $HSI_{W\ Pond\ Turtle} = (V_1 + V_2 + V_3 + V_4 + V_5) / 5$

Beaver	V_1 = Percent tree canopy closure V_2 = Percent of trees in 2.5 to 15.2 cm dbh size class V_3 = Percent shrub crown cover V_4 = Average height of shrub canopy V_5 = Species composition of woody vegetation $HSI_{Beaver} = (V_1 + V_2 + V_3 + V_4 + V_5) / 5$
Wood Duck	V_1 = Percent of the water surface covered by potential brood cover $HSI_{Wood\ Duck} = V_1$
Neotropical Birds	V_1 = Percent deciduous shrub crown cover V_2 = Percent overall canopy cover V_3 = Average height of deciduous shrub canopy V_4 = Percent of shrub canopy comprised of hydrophytic shrubs $HSI_{Neotropical\ Birds} = (V_1 + V_2 + V_3 + V_4) / 4$
Native Amphibians	V_1 = Percent area with permanent water V_2 = Percent area with emergent or submergent wetland/aquatic vegetation V_3 = Percent ground cover along the water's edge V_4 = Width of riparian zone V_5 = Maximum temperature during low flows V_6 = Land use within 200 meters of the wetland edge $HSI_{Native\ Amphibians} = (V_1 + V_2 + V_3 + V_4 + V_5 + V_6) / 6$

HEP Equation Riparian

$$HSI_{Riparian} = (HSI_{WPondTurtle} + HSI_{Beaver} + HSI_{Wood\ Duck} + HSI_{Neotropical\ Birds} + HSI_{Native\ Amphibians}) / 5$$

5. Riverine Model

5.1 *Riverine Model Species*

In the Willamette River, historically, many juvenile fish resided in the river for a period of months or up to a year or more (NWPCC 2004).

Habitat preferences of juvenile Chinook in the Willamette River and Puget Sound tributaries are described below. Natural beaches appeared to be an important habitat for younger age classes of Chinook salmon. In addition, beaches were not a preferred habitat of large predator fishes and it was recommended that enhancements directed at creating beaches will likely provide a benefit to salmonids. Unaltered nearshore habitats appear to be important to smaller fish as juvenile salmonids are generally associated with the upper portion of the water column. All off-channel habitats were utilized by juvenile salmonids as they are likely important for forage and refuge. Seawalls appeared to be avoided by juvenile Chinook. Riprapped sites were

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underutilized by juvenile salmonids. However, densities of large predators were constantly highest at sampling sites dominated by rocky habitats in the summer and autumn. In the spring, only bank vegetation showed a relationship with Chinook density. In the winter, sand substrate, shallow water, and moderate amounts of bank vegetation were associated with higher catches.

Habitat suitability indices selected for juvenile Chinook habitat preferences include: percent bank vegetation cover, riparian vegetation type, depth, shallow water, open water, substrate type, and natural shoreline.

Other species of concern that could be included in the model are Pacific lamprey and coho salmon.

5.2 *Riverine Model Parameters*

The Habitat Suitability Index (HSI) for riverine habitat is based on the habitat requirements of juvenile Chinook. The juvenile Chinook HIS is calculated according to the following equation:

$$\mathbf{HSI_{Juvenile\ Chinook} = (V_1 + V_2 + V_3 + V_4 + V_5 + V_6 + V_7) / 7}$$

V_1 = % Cover Bank Vegetation *(Friesen, et al 2004)*

% Cover	SI
0-10	0
11-20	0.3
21-30	1
31-40	0.6
41-80	0.2
81-100	0.1

V_2 = Riparian Vegetation Type *(City of Seattle 2006)*

Type	SI
Mature Native Vegetation	1.0
Native Shrubs	0.7
Non-native Shrubs	0.5
Grass/Landscape	0.2
Impervious	0

V_3 = Depth (<20 m from the shore) *(Friesen, et al. 2004; Allen and Hassler 1986)*

Depth (m)	SI
0.0 – 0.5	0.5
0.6 – 3.0	1.0
3.1 – 10	0.6
>10	0

V_4 = Proportion of Shallow Water < 10 feet in Depth *(City of Seattle 2006)*

Percent	SI
0	0
25	0.25
50	0.5
75	0.75
100	1.0

V_5 = Proportion of Open Water within 35-feet of Shoreline *(City of Seattle 2006)*

Percent	SI
0	0
25	0.25
50	0.5
75	0.75
100	1.0

V_6 = Substrate *(Friesen, et al. 2004; Allen and Hassler 1986)*

Substrate Type	SI
Bedrock/armoring	0.25
Riprap	0.35
Cobble/Sand	1.0
Fines	0.45

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V_7 = Proportion of Natural Shoreline (Unarmored) (*City of Seattle 2006)*

Percent	SI
0	0
25	0.25
50	0.5
75	0.75
100	1.0

5.3 *Riverine Model Equation*

HEP Riverine Model	
Juvenile Chinook	V_1 = Percent cover bank vegetation V_2 = Riparian Vegetation Type V_3 = Depth (<20m from shore) V_4 = Proportion of Shallow Water <10 feet in Depth V_5 = Proportion of Open Water within 35-feet of Shoreline V_6 = Substrate V_7 = Proportion of Natural Shoreline $HSI_{Juvenile\ Chinook} = (V_1 + V_2 + V_3 + V_4 + V_5 + V_6 + V_7) / 7$

HEP Equation Riverine **$HSI_{Riverine} = (HSI_{Juvenile\ Chinook})$**

6. Stream Model

6.1 *Stream Model Species*

6.1.1 Coho

Naturally spawned coho occurring in the lower Willamette River were listed as threatened on June 28, 2005 as part as the Lower Columbia River Coho ESU. Coho fry and juveniles rear in freshwater for one or two years typically, although even longer freshwater residence can occur. Fry typically congregate after emerging from the gravel and within a few days begin swimming along the bank margins, especially near overhanging vegetation, large wood structures and beaver ponds. Coho often hold in pools and periodically come out to capture prey in riffle areas. Coho will also typically settle on the bottom during darkness. Areas with a high percentage of off channel habitat and with woody debris and pools are the most productive for coho. Coho move into side channels and under debris for wintering. Lack of suitable over-wintering habitat is considered to be a primary limiting factor for Lower Willamette coho (McElheny et al., 2006)

6.1.2 Steelhead

Summer and winter runs of steelhead occur in the Willamette River. Naturally spawned steelhead, occurring in the lower Willamette River, were listed as threatened on March 19, 1998 as part of the Lower Columbia River Steelhead DPS. Juveniles rear in freshwater for one to four years utilizing areas with boulders, woody debris or other cover, and frequently feed in riffles. Areas with dense riparian vegetation and other cover provide the best habitat for steelhead juveniles.

Habitat suitability indices selected for the tributary fish model incorporate habitat preferences for Chinook, coho, and steelhead and include: maximum water temperatures, instream cover, spawning substrate, and canopy cover.

6.2 *Stream Model Parameters*

6.2.1 Coho

The Suitability Index for coho is calculated according to the following equation:

$$\mathbf{HSI_{Coho} = (V_1 + V_2) / 2}$$

V_1 = Instream cover (LWD) present *(modified from McMahon, 1983)*

Instream cover (% of surface area)	SI
0	0.1
10	0.2
20	0.4
30	0.8
40	1.0

V_2 = Canopy cover over stream *(modified from McMahon 1983)*

Canopy Cover (%)	SI
0	0.2
25	0.3
50	0.8
75	1.0
100	1.0

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6.2.2 Steelhead

The Suitability Index for steelhead is calculated according to the following equation:

$$HSI_{Steelhead} = (V_1 + V_2) / 2$$

V_1 = Maximum water temperature during low flow *(Raleigh, et al. 1984)*

Temperature (°C)	SI*
0	A = 0, B = 0**
5	A = 0.5, B = 0.3
10	A = 1.0, B = 0.9
15	A = 0.9, B = 1.0
20	A = 0.5, B = 0.9
25	A = 0, B = 0

***A** = prespawning adults, **B** = juveniles
**Average the adult and juvenile values for V_2

V_2 = Predominant substrate size in riffle or run areas *(Raleigh, et al. 1984)*

Class	Description	SI
A	Rubble or small boulders predominant; limited amounts of gravel, large boulders, or bedrock	1.0
B	Rubble, gravel, boulders, and fines occur in approximately equal amounts or gravel is predominant	0.6
C	Fines, bedrock, or large boulders are predominant. Rubble and gravel are < 25%	0.3

6.3 *Stream Model Equation*

HEP Stream Model	
Coho	V_1 = Instream cover (LWD) present V_2 = Canopy cover over stream $HSI_{Coho} = (V_1 + V_2) / 2$
Steelhead	V_1 = Maximum water temperature during low flows V_2 = Predominant substrate size in riffle and run areas $HSI_{Steelhead} = (V_1 + V_2) / 2$

HEP Equation Stream $HSI_{Stream} = (HSI_{Coho} + HSI_{Steelhead}) / 2$

7. Upland Model

7.1 Upland Model Species

Multiple bird species were selected to highlight the various habitats provided in the uplands of the Willamette River including the downy woodpecker (*Picodies pubescens*), the black-capped chickadee (*Parus atricapillus*) and the American kestrel (*Falco sparverius*).

7.1.1 Downy Woodpecker

The downy woodpecker is a primary cavity nester that prefers soft snags for nest sites (Schroeder 1983a). They nest in both coniferous and deciduous forest stands in the Northwest. Optimal nest sites are live trees with a broken off dead top. It has been estimated that they require 3 or more snags per acre. They forage more in the lower height zone of trees than in tree canopies and on smaller limbs than on dead limbs.

7.1.2 Black-capped Chickadee

The black-capped chickadee inhabits wooded areas and nests in cavities in dead or hollow trees in a variety of forest types (Schroeder 1983b). Deciduous forests types are preferred in the Pacific Northwest. They are versatile in their foraging habits and forage from the ground to the tree tops but prefer low or intermediate heights in trees and shrubs. Canopy volume has been found to be the proximate cue used by the chickadees to determine potential food supply.

7.1.3 American Kestrel

The American kestrel is a small diurnal raptor of open and semi-open country. The kestrel is a common breeding species throughout the Willamette Valley-Puget Trough Ecoregion (USFWS 1978). Kestrels hunt from exposed perches such as tree, fence posts, or telephone poles and lines with hunting perches averaging 22.3 feet in height. Kestrels are secondary tree cavity nesters. Preferred nest sites in Oregon were found to be 10-35 feet above the ground. They return to the same net areas in consecutive years, hence a reduction in suitable nets sites may limit populations.

7.2 *Upland Model Parameters*

7.2.1 Downy Woodpecker

The Suitability Index for Downy woodpecker is calculated according to the following equation:

$$\mathbf{HSI_{Downy\ Woodpecker} = (V_1 + V_2\ ) / 2}$$

V_1 = Basal Area *(modified from Solomon 1983a*)

Basal Area (m2/ha)	SI
0	0
4	0.4

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Basal Area (m2/ha)	SI
8	0.8
10	1.0
20	1.0
24	0.8
28	0.6
30	0.5

V_2 = Number of Snags *(modified from Solomon 1983a*)

Basal Area (m2/ha)	SI
0	0
1	0.2
2	0.4
3	0.6
4	0.8
>5	1.0

7.2.2 Black-Capped Chickadee

The Habitat Suitability Index for black-capped chickadee is calculated according to the following equation:

$$HSI_{Black\text{-}capped\ Chickadee} = (V_1 + V_2 + V_3 + V_4) / 4$$

V_1 = Percent Tree Canopy Closure *(modified from Solomon 1983b*)

Basal Area (m2/ha)	SI
0	0
25	0.5
50	1.0
75	1.0
100	0.6

V_2 = Average Height of Overstory Trees *(modified from Solomon 1983b*)

Basal Area (m2/ha)	SI
0	0
5	0.5
10	0.75
>15	1.0

V_3 = Tree Canopy Volume/Area of Ground Surface *(modified from Solomon 1983b*)

Canopy Volume / Ground Area (m3/m2)	SI
0	0
2	0.2
4	0.4
6	0.6
8	0.8
>10	1.0

V_4 = Number of Snags 10 to 25 cm DBH/0.4 ha *(modified from Solomon 1983b*)

Number of Snags	SI
0	0
0.5	0.25
1	0.5
1.5	0.75
2	1.0

7.2.3 American Kestrel

The Habitat Suitability Index for American kestrel is calculated according to the following equation:

$$HSI_{American\ Kestrel} = (V_1 + V_2) / 2$$

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V_1 = Distance to Open Land *(modified from USFWS 1978*)

Distance (miles)	SI
0	1.0
1.5	1.0
2	0.8
3	0.4
4	0

V_2 = Average DBH of Trees *(modified from USFWS 1978*)

Average DBH (inches)	SI
0	0
6	0
8	0.2
10	0.6
>12	1.0

7.3 Upland Model Equation

HEP Stream Model	
Downy Woodpecker	V_1 = Basal Area V_2 = Number of Snags $HSI_{Downy\ Woodpecker} = (V_1 + V_2) / 2$
Black-capped Chickadee	V_1 = Percent Tree Canopy Closure V_2 = Average Height of Overstory Trees V_3 = Tree Canopy Volume/Area of Ground Surface V_4 = Number of Snags 10 to 25 cm DBH / 0.4 ha $HSI_{Black\text{-}capped\ Chickadee} = (V_1 + V_2 + V_3 + V_4) / 4$
American Kestrel	V_1 = Distance to Open Land V_2 = Average DBH of Trees $HSI_{American\ Kestrel} = (V_1 + V_2) / 2$

HEP Equation Upland

$$HSI_{Upland} = (HSI_{Downy\ Woodpecker} + HSI_{Black\text{-}capped\ Chickadee} + HSI_{American\ Kestrel}) / 3$$

8. Grassland Model

8.1 *Grassland Model Species*

The grassland model has been adapted from the Willamette Partnership's Procedure for Upland Prairie Credit Calculator (Adamus 2009). This model was developed with a focus on grassland species of concern with a focus on the Fender's blue butterfly.

Other species that were discussed for inclusion in the model include the streaked horned lark, the meadow lark, the Camas pocket gopher, and the western gray squirrel.

8.2 *Grassland Model Parameters*

The Suitability Index for grassland habitat is calculated according to the following equation:

$$\mathbf{HSI_{Grassland} = (V_1 + V_2 + V_3 + V_4 + V_5) / 5}$$

V_1 = % Areal Cover of Woody Vegetation *(Adamus 2009*)

Areal Cover (%)	SI
<1	0.7
1-5	1.0
5-15	0.5
15-30	0.3
>30	0

V_2 = % Areal Cover of Non-native Herbaceous Vegetation *(adapted from Adamus 2009*)

Areal Cover (%)	SI
<5	1.0
5-25	0.7
25-50	0.5
50-75	0.3
>75	0

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V_3 = Ratio of Native Forbs to Native Perennial Graminoids Areal Cover *(adapted from Adamus 2009*)

Areal Cover Forbs (%)	SI
>80	0.7
60-80	1.0
40-60	0.5
20-40	0.3
<20	0

V_4 = Distance to Closest Other Grassland Habitat *(adapted from Adamus 2009*)

Distance (Miles)	SI
<0.25	1.0
0.25-0.5	0.5
0.5-1	0.3
>1	0

V_5 = Size of Closest Other Grassland Habitat Within 5 Miles *(adapted from Adamus 2009*)

Size (acres)	SI
30-100	1.0
10-30	0.8
1-10	0.5
0.25-1	0.3
<0.25	0

8.3 *Grassland Model Equation*

HEP Grassland Model	
Grassland	V_1 = Percent areal cover of woody vegetation V_2 = Percent areal cover of non-native herbaceous vegetation V_3 = Ratio of Native Forbs to Native Perennial Graminoids Areal Cover V_4 = Distance to Closest Other Grassland Habitat V_5 = Size of Closest Other Grassland Habitat Within 5 Miles $HSI_{Grassland} = (V_1 + V_2 + V_3 + V_4 + V_5) / 5$

HEP Equation Grassland $\mathbf{HSI_{Grassland} = (HSI_{Grassland})}$

9. Oregon Rapid Wetland Assessment Protocol (ORWAP)

The Oregon Department of State Lands requires that a functional assessment be conducted to fulfill the needs of state permitting and compensatory wetland mitigation programs. For the wetland habitat areas of the Bank, the Oregon Rapid Wetland Assessment Protocol (ORWAP) is recommended to assess the functions and values of wetlands. ORWAP is a standardized protocol applicable to wetlands of any type anywhere in Oregon. ORWAP specifically provides information on the function, value, service, condition, stressors, and sensitivity of the wetland in question.

The ORWAP procedures involve an office and a field component, in which 140 indicators are assessed onsite, as well as from information gathered mainly from websites and aerial imagery. The office component involves an aerial image assessment, a delineation of the wetland area with topo and wetland maps, a soils assessment using soils survey maps, and queries on other web pages to obtain information such as water quality, and habitat quality. Field data collected includes an assessment of each vegetation type and soil type on site, a qualitative delineation of the wetland boundary, identification of hydrologic characteristics and an assessment of non-native species and impairments.

The data are entered into an Excel spreadsheet from which logic models are programmed to produce scores on a 0 – 10 scoring scale for several wetland indicators including function, value, service, condition, stressors, and sensitivity. The ORWAP methodology (Adamus *et al* 2009) is provided in Appendix A of this document.

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10. References

Adamus, P. J. Morlan, and K. Verble. 2009. Manual for the Oregon Rapid Wetland Assessment Protocol (ORWAP). Version 2.0. Oregon Department of State Lands, Salem, OR.

Allen, A.W. 1982. Habitat suitability index models: Beaver. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.30. 20p.

Allen, M.A., and T.J. Hassler. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) – Chinook salmon. U.S. Fish and Wildlife Service Biological Report 82(11.49). U.S. Army Corps of Engineers, TR EL-82-4.

City of Seattle. 2006. Shoreline Alternative Mitigation Plan. Preliminary Plan. Appendix B: Habitat Suitability Index Model for Lake Union/Lake Washington Ship Canal and Technical Memorandum. City of Seattle Department of Planning and Development. Seattle, Washington.

Friesen, T.A., and J.S. Vile, A.L. Pribyl. 2004. Migratory Behavior, Timing, Rearing, and Habitat Use of Juvenile Salmonids in the Lower Willamette River. Oregon Department of Fish and Wildlife Columbia River Investigations. Clackamas, Oregon.

Graves, B.M., and S.H. Anderson. 1987. Habitat Suitability Index Models: Bullfrog. Biological Report 82(10.138). National Ecology Center. U.S. Fish and Wildlife Service. Washington D.C.

Holland, D.C. 1994. The Western Pond Turtle: Habitat and History. Oregon Department of Fish & Wildlife, prepared for U.S. DOE, Bonneville Power Administration. Project #: 92-068.

McMahon, T.E. 1983. Habitat Suitability Index Models: Coho Salmon. Report FWS/OBS-82/10.49, Western Energy and Land Use Team, U.S. Fish & Wildlife Service, Washington, DC.

Morreale, S.J. & J.W. Gibbons. 1986. Habitat Suitability Index Models: Slider Turtle. Biological Report 82(10.125), National Ecology Center, U.S. Fish & Wildlife Service, Washington, DC.

Northwest Habitat Institute (NHI). 2007. HAB Primer: Introduction to the Habitat Appraisal and Barter (HAB) method for Fish and Wildlife Habitat Assessment.

NWPCC (Northwest Power and Conservation Council). 2004. Draft Willamette Subbasin Plan.

Raleigh, R.F., T. Hickman, R.C. Solomon & P.C. Nelson. 1984. Habitat Suitability Information: Rainbow Trout. Report FWs/OBS-82/10.60, Western Energy and Land Use Team, U.S. Fish & Wildlife Service, Washington, DC.

Schroeder, R.L. 1982. Habitat suitability index models: Yellow warbler. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.27. 7p.

Schroeder, R.L. 1983a. Habitat suitability index models: Downy woodpecker. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.38. 10pp.

Schroeder, R.L. 1983b. Habitat suitability index models: Black-capped chickadee. U.S. Department of the Interior, Fish and Wildlife Service. FWS/OBS-82/10.38. 12pp.

Sousa, P.J. and A.H. Farmer. 1983. Habitat suitability index models: Wood duck. U.S. Department of the Interior, Fish and wildlife Service. FWS/OBS-82/10.43. 27pp.

US Fish and Wildlife Service (USFWS). 1978. Terrestrial Habitat Evaluation Criteria Handbook: Region 2410 (Puget Sound Trough and Willamette Valley). Portland, Oregon.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat Evaluation Procedures (HEP). 102 ESM. USDI Fish and Wildlife Service. Division of Ecological Services. Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 1980b. Draft Review Copy Green Heron Habitat Suitability Index Model. U.S. Fish and Wildlife Service. Washington, D.C.

Warncke, W. 2006. ODOT's habitat value approach to compensatory mitigation debit/credit calculations. In: Proceedings of the 2005 International Conference on Ecology and Transportation. Eds. Irwin, C.L., Garrett, P. McDermott, K.P. Center for Transportation and the Environment. North Carolina State University. Raleigh, North Carolina.

Washington Department of Fish & Wildlife. 1997. Draft Habitat Suitability Index Model:
Pond Breeding Amphibian and Cover Model. Prepared for the U.S. Army Corps of Engineers, Columbia River Channel Deepening Project.

Adamus, P. 2009. Procedure for upland prairie credit calculator. Ecosystem Credit Accounting System. Willamette Partnership.

Wolotria, R.J. 2008. Habitat Evaluation of the Blue Heron site for a specific type of juvenile Chinook salmon. National Marine Fisheries Service – Northwest Region. Habitat Conservation Division.

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