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Mapping at Multiple Scales Using a Consistent Wildlife Habitat Classification to Improve Transportation & Conservation Planning

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ABSTRACT:

A basic tenet to streamline transportation and conservation planning is consistency. We offer a paper that gives an overview of the steps necessary to create a consistent methodology for habitat assessment. This process was developed in the Pacific Northwest and combines three components for determining the baseline condition for fish and wildlife habitat. Each component captures a portion of the information necessary to consistently assess wildlife habitats across large areas. The first component is a hierarchical wildlife habitat classification scheme that can be mapped at various scales. The second piece is a relational database that ties multiple species-habitat relationships to the hierarchical classification scheme. Finally, the third component necessary is a consistent mapping methodology that can tie together both relational databases and classification schemes at various hierarchical scales. The information presented describes each component and offers a broad outline of how to combine these three components to determine baseline habitat value for wildlife. Examples are used to illustrate several products from this approach that are useful for transportation and conservation planning. Creating a consistent methodology for wildlife habitat assessment can help streamline transportation and conservation projects by enabling resource managers to determine baseline habitat values, focus the discussion on high value areas, and improve mitigation efforts based on value rather than acreage.

INTRODUCTION*:*

To determine baseline wildlife habitat conditions for effective natural resource management, three essential components are needed to develop a common methodology. First there is a need for a consistent wildlife habitat classification system and a common set of ecological definitions because without it agencies and organizations develop their own. Second is a relational database that ties multiple species to specific habitat types. Third is the development of consistent habitat mapping approach. Currently, numerous methods exist for assessing baseline wildlife habitat conditions, depending on location and the parties involved in the assessment. This makes comparisons of findings difficult, and hinders the development of a unified ecological picture. Examples of wide-ranging and inconsistent classification systems currently in use were highlighted when Northwest Habitat Institute (NWHI) recently surveyed the natural resource agencies and organizations within the Columbia River Basin. More than 75 people were contacted and more than 60 currently used habitat classifications were recorded. Some of these are: Potential Natural Vegetation of the Conterminous United States (Kuchler 1964), Fisheries and Oregon Estuarine Habitat Classification System (Bottom et al. 1979), Classification of wetlands and deepwater habitats of the United States (Cowardin et al. 1979), Forest Habitat Types of Northern Idaho (Cooper et al. 1991), A Hierarchical Approach to Classifying Stream Habitat Features (Hawkins et al. 1992), Washington Gap (Cassidy et al. 1997), Montana Gap (Redmond et al. 1998), Idaho and Western Wyoming Gap (Homer 1998), Oregon Gap (Kiilsgaard 1999), USGS’s National Land Cover Database (2001), ODFW Aquatic Inventories Project (2002), NatureServe’s A Working Classification of U.S. Terrestrial Systems (Comer et al. 2003), and the U.S. Forest Service has several including: Field guide for Forested Plant Associations of the Wenatchee National Forest (Lillybridge et al. 1995), A Structural Classification for Inland Northwest Forest Vegetation (O'Hara et al. 1996), Pacific Northwest Ecoclass Codes for Seral and Potential Natural Communities (Hall 1998), and Classification and Management of Aquatic, Riparian, and Wetland Sites on the National Forests of Eastern Washington: Series Description (Kovalchik and Clausnitzer 2004).

Given the wide variety of habitat classification systems, the need exists to incorporate a consistent and transferable language that transcends both resource and data management. For example in the Pacific Northwest, Wildlife-Habitat Relationships in Oregon & Washington (Johnson and O’Neil 2001) has provided the regions principal wildlife habitat information and contains the premise that wildlife habitat information be compiled in a way that management decisions are built on a common understanding. This is done by focusing on multiple aspects of wildlife habitat, while creating a consistent language in regards to its terms and assessment for fish and wildlife.

The problem of developing a consistent methodology for determining a baseline habitat condition is further exacerbated because few classification schemes have wildlife species associations. Many are either focused solely on a specific habitat, single species, or small species assemblages. Given that habitat provides value for numerous species, it is time for an assessment method that can be used at all hierarchical scales and also evaluate habitat value for all species that could potentially use it. Additionally, this methodology should connect an ecosystem-based approach to management and include system functions. This can be accomplished by including a relational database that ties multiple species habitat relationships. For example, the Integrated Habitat and Biodiversity Information System (IBIS) developed by NWHI, is an informational resource that promotes the conservation of Northwest fish, wildlife, and their habitats through education and the distribution of timely, peer-reviewed scientific data. IBIS contains extensive information about Pacific Northwest fish, wildlife, and their habitats, but more noteworthy, IBIS attempts to reveal and analyze the relationships among these species and their habitats. The development of more relational databases nationally would allow resource managers to develop assessment strategies that are more holistic, containing management strategies for multi-species, and contain an ecosystem-based foundation.

Creating wildlife habitat maps is essential to any baseline habitat assessment project and currently mapping at various scales requires different methods. For example, basin and ecoprovince habitat maps are often at a coarse level while subbasins and individual sites are at a finer level of resolutions. To determine baseline habitat value for wildlife at almost any site requires mapping at multiple scales. Therefore, effort needs to be taken to develop a consistent mapping methodology that can integrate multiple hierarchical scales. Mapping methodologies should also be able to incorporate a habitat classification scheme and relational wildlife habitat databases.

PURPOSE:

In committing to further develop a consistent wildlife habitat classification scheme, relational data sets, and habitat mapping approach to determine baseline wildlife habitat conditions, natural resource management becomes more effective and efficient. In developing these components, a consistent habitat classification emerges that: 1) monitors, inventories and evaluates fish and wildlife; 2) consistently maps resources in classifications to evaluate landscape changes in terrestrial and aquatic habitats and land use; 3) develops a common protocol for on-the-ground or remotely sensed data collection; 4) allows predicting absence-presences of species in an area; and 5) becomes a tool in the process of measuring habitat recovery actions as well as assessing impacts and mitigation activities. Northwest Habitat Institute (NWHI) along with the help of many scientists, natural resource managers, agencies, and organizations has developed an approach to address the three critical components needed to successfully determine baseline habitat value for wildlife. We provide a broad outline of how to combine these three components to determine baseline habitat value for fish and wildlife at a location or general area. Examples are used to illustrate several products that can be generated from this approach that can help streamline for both transportation and conversation planning.

APPROACH:

Wildlife Habitat Classification

In 1995, NWHI and the Washington Department of Fish and Wildlife took the lead to develop a consistent wildlife-habitat classification across Oregon and Washington. The main premise was to "build a common understanding for management". The habitat classification and program evolved into an Interactive Habitat and Biodiversity Information System (IBIS). This program became formally adopted from the outgrowth of a series of debriefings and lessons-learned meetings that followed the listing of the spotted owl (*Strix occidentalis*) and related "old-growth" forest issues. The development of IBIS's data sets received overall guidance by a Senior Science Team. The Senior Science Team directed that three other multi-agency teams be created to address Species-Habitat Relationships, Digital Products, and Management Applications. All teams had members that represented federal, state, private industries, and tribes. The development of IBIS was supported by 45 organizations with input from over 700 people. IBIS is recognized as a regional data and information system primarily for the terrestrial resources, with equal capabilities to address resident and anadromous fish habitat resources.

The term wildlife habitat type or habitat types refer to a group of vegetation cover types (or land use/land cover types) that were determined based on the similarity of wildlife use in a cluster analysis process (O'Neil et al. 1995). Our habitat types are based on actual conditions (e.g., current vegetation), and therefore can be mapped, and they are assumed to contain all the essential needs for a species maintenance and viability. Wildlife habitat types are not species-specific because they are based on the similarity of many wildlife species using a suite of vegetation types. However, a wildlife species habitat refers to an individual, species-specific use of a wildlife habitat type. Thus, habitat is fundamentally linked to the distribution and abundance of species and underlies explanations of the factors, patterns, and processes that support the fitness of wildlife at the individual, population, and community levels, as well as their continuing evolution (Johnson and O'Neil 2001).

Through the above efforts, a framework now exists in the Pacific Northwest that identifies 32 wildlife habitats, 46 structural conditions (i.e. tree size), and over 200 fine feature elements or key environmental correlates (KECs, e.g. down wood or snags) that can be mapped at multiple scales (i.e. basin, ecoprovince, subbasin, and site). Additionally, because key ecological functions (KEFs) are defined as the principal way species influence their environment; functions can also be mapped. For a list and definition of the 32 wildlife habitats types, 46 structural conditions, KECs and KEFs please see Johnson and O'Neil (2001) chapters 1, 2, 3 & 6. The framework of IBIS is easily understood and many of the habitat types, structural conditions, KEC's , and KEF's are applicable to regions outside the Pacific Northwest. We believe IBIS can serve as a template for other regions in the country to develop a unified wildlife habitat classification system.

Relational Data Sets

The next principal component to integrate mapping with conservation planning is linking the wildlife habitat relational data sets. IBIS contains extensive information about Pacific Northwest fish, wildlife, and their habitats. More importantly, IBIS permits users to discover and analyze the relationships among these species and their habitats. IBIS is a unique resource because it contains peer-reviewed spatial biodiversity information that traverses political and administrative boundaries while maintaining consistent terminologies and classification systems. The Wildlife-Habitat Relationships in Oregon and Washington book (Johnson and O'Neil 2001) that the IBIS data sets came from is considered "Best Available Science" by the Washington State Office of

Community Development. As a result of IBIS development, peer-reviewed biological data sets currently exist consisting of 9 data matrices that focus on the interactions of fish, wildlife, and their habitats along with linkages to GIS (Fig. 1). The data collected in this effort contains extensive information on 142 fish and 662 wildlife species and a limited amount of information on another 397 species that are found throughout the Columbia River Basin. This information includes (but not limited to): their ecological functions, life histories, habitats they inhabit, and the impact of various management activities on their existence. Currently, there are over 150,000 records of information that have been incorporated into IBIS over the past 10 years. Many species included within IBIS are found outside the Pacific Northwest and IBIS can easily incorporate new species into the database. This allows for individuals working with natural resources around the country to incorporate wildlife habitat relational data sets into planning and policy decisions.

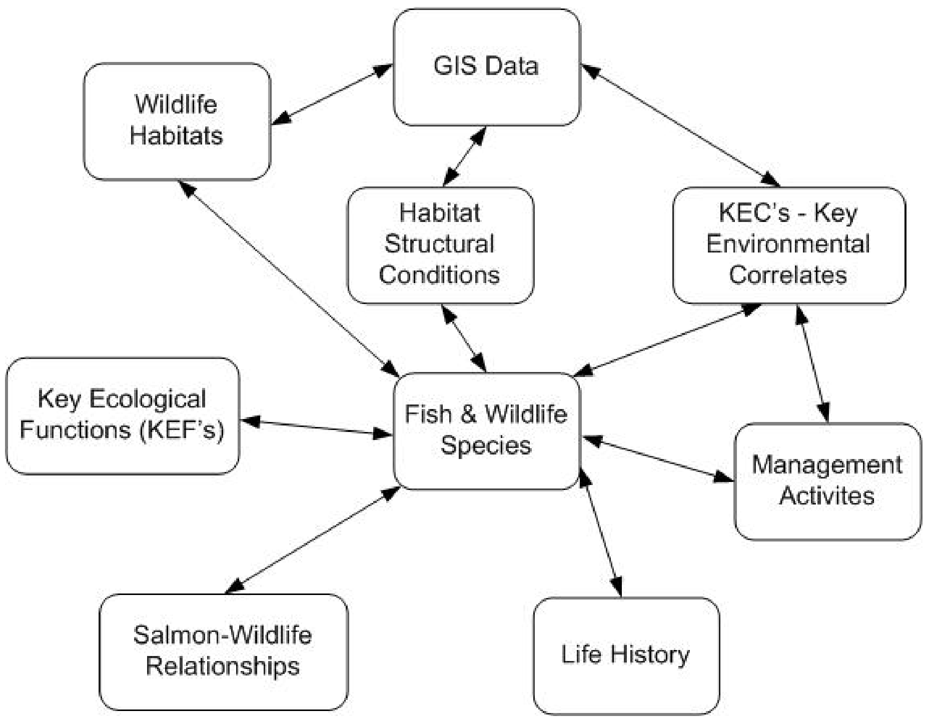

Figure 1. The primary components of the Interactive Habitat and Biodiversity Information System (IBIS).

Mapping Wildlife Habitats

Creating hierarchical wildlife habitat maps is the ultimate goal of a baseline habitat assessment project (Fig.2); and each hierarchical step currently requires a different method. Though many approaches are possible, the ones chosen in the Pacific Northwest included a coarse-scale map of current conditions of wildlife habitat types for the entire Columbia River Basin using LANDSAT (TM) imagery; a refined intermediate (coarse) level map of structural conditions for forested areas (and shrub-steppe where available) within the Columbia River Basin using LANDSAT (TM) imagery along with other predictive techniques; and fine scale mapping using high resolution photography and field mapping of some of the high priority areas within the Columbia Basin.

The lack of detailed mapping, however, is still limiting the ability to roll-up results from one hierarchical level to another. That is, basin and ecoprovince depictions are at a coarse level while some subbasins and individual sites are at a finer level of resolutions. Specific wildlife habitat types that are linear or small in nature (e.g. riparian, open water streams and canyon grasslands) are not accurately represented moving up the hierarchical scale, from site to basin, while other types that do not have this constraint like shrub-steppe are better portrayed. The implications are, one needs to be careful of the questions and answers that are being derived from the various hierarchical scales. Hence, determining a mid-scale (like ecoprovince) wildlife habitat priority may require an assessment of multiple scales. Therefore, reporting losses of habitats is better given in ranges than in an absolute value. A short overview of mapping protocols for each hierarchical scale follows.

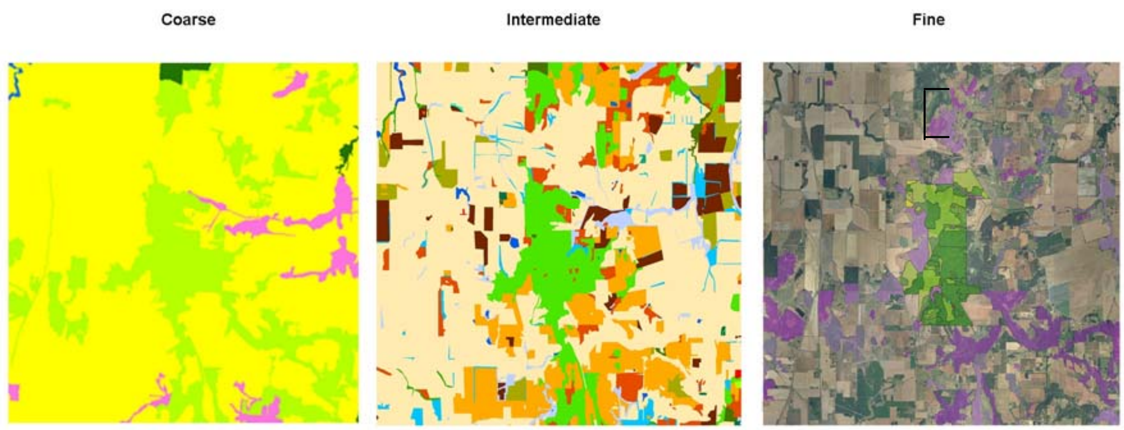

Figure 2. Multiple hierarchical maps of coarse, intermediate and fine resolution, colors represent different habitat types.

Developing and Verifying the First Tier Coarse Scale Map

A step-by-step approach is followed to process, classify, and label each map. Each scene of Thematic Mapper (TM) imagery used undergoes a series of imagery previews for radiometric quality and subsequent processing tasks using ERDAS Imagine software. Once the above steps are completed, the image can be classified according to the 32 Johnson and O'Neil (2001) wildlife habitat types and then field verified.

Land use and land-cover classification maps generated from satellite imagery are widely employed in assessment of resource condition throughout the western United States (Gopal and Woodcock 1993, Congalton 1998, Edwards et al. 1998, Kiilsgaard 1999). Validating the accuracy of these assessments is critical to the utility and acceptance of the map as a tool for resource managers. Errors found with in a given map are classified using an *a priori* target level of thematic map accuracy, for example, a per class accuracy of 75% and overall map accuracy of 80%. Target levels of thematic map accuracy assessments are based on statistical parameters (Stehman and Czaplewski 1998). The rules for statistical rigor in accuracy assessments are not easy to impose on remote sensing products because of difficulties can arise in gaining access to specific sites and surveying an adequate number of sample sites within a large site can be timely.

Therefore, many mapping efforts apply general “rules of thumb” that try to temper statistical validity with practical applicability. Our approach combining random and guided accuracy assessment incorporates a sensible approach and is commonly used by other researchers when mapping large land areas.

Developing and Verifying the Second Tier Intermediate Scale Map

The next tier in the hierarchical habitat mapping scheme creates a refined map of wildlife habitat types and structural conditions. This level of mapping is particularly useful for identifying and classifying high priority areas within a given region. In creating an intermediate scale map, NWHI mostly utilizes the GNN (Gradient Nearest Neighbor) datasets being created by the Pacific Northwest Research Station (Ohmann and Gregory 2002). The GNN method utilizes plot information along with LANDSAT TM imagery and other ancillary data to create a model that calculates the probability of unique structural and vegetative conditions across the landscape. These data will then be cross-walked to the same 32 Johnson and O’Neil wildlife (2001) habitat types as used to classify the coarse-level map and further to the 46 structural conditions defined in the IBIS database

Developing and Verifying the Third Tier Fine Scale Map

The final tier in the hierarchical mapping scheme is fine scale mapping at site specific locations. These efforts support the assessment of impacts and mitigation efforts and the debiting and crediting of habitat value at small properties (a few acres to several thousand acres). This process was developed in conjunction with the Oregon Department of Transportation (ODOT) Statewide Transportation Improvement Program- Statewide Comprehensive Mitigation and Conservation Strategy. The methodology entails the use of aerial and satellite imagery to pre-map a site. This preliminary map is then taken to the site by field crews for refinement of the delineations and classification of the map units. Field crews collect detailed information about habitat types, structural conditions, presence or absence of fine feature habitat elements or Key Ecological Correlates (KEC’s), and invasive species. Specific protocols for inventorying and recording habitat at a site have been developed by NWHI (2007).

RESULTS AND OUTPUTS:

The approach developed by NWHI has the capability to map and link the relational data sets to determine the baseline conditions of a site. Once maps exist at different hierarchical scale and relational data sets can be linked to them [see http://www.nwhi.org/index/ibis for example at ecoprovince and subbasin level information], the amount and kinds of questions that can be asked can help streamline as well as guide natural resource planning and policy, construction projects, and transportation planning. Examples are given of some of the useful tools and products that can be generated from this process.

Wildlife Species Ranges- **Western Pond Turtle (***Clemmys marmorata***)**

Specific species occurrences are of interest in evaluating projects that may impact local natural resources and wildlife. Because the relational data sets are linked geospatially, individual breeding ranges can be depicted at various scales (Figs. 4 and 5). The amount of information changes with the level of resolution of each mapping effort. But often, assessments want to know what a species level of suitability is at a given site, and we would suggest that this type of question can only be assessed at the site specific level because of the many factors involved. However, species range maps are an important and informative preliminary step for evaluating many projects impacting natural resources, including transportation.

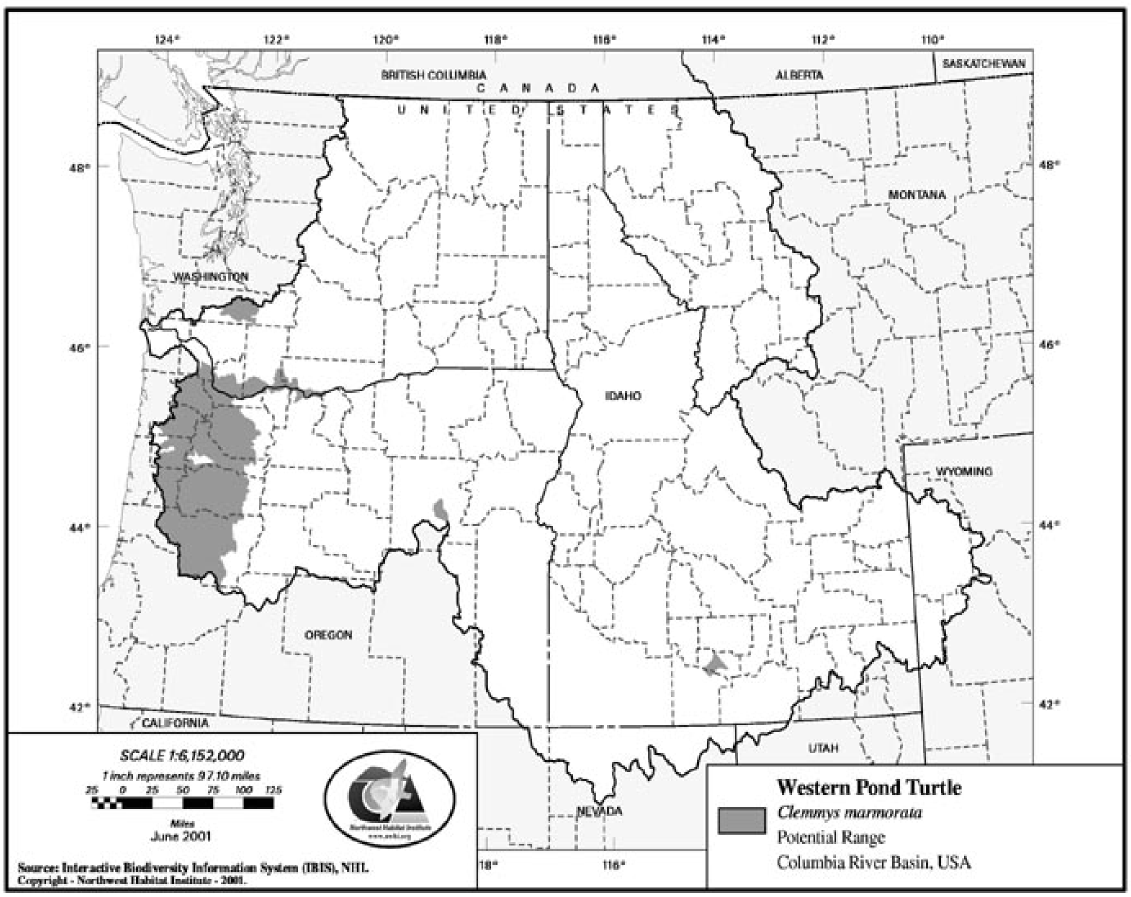

Figure 4. Course scaled range map of the Western Pond Turtle species throughout the Columbia River Basin, Oregon.

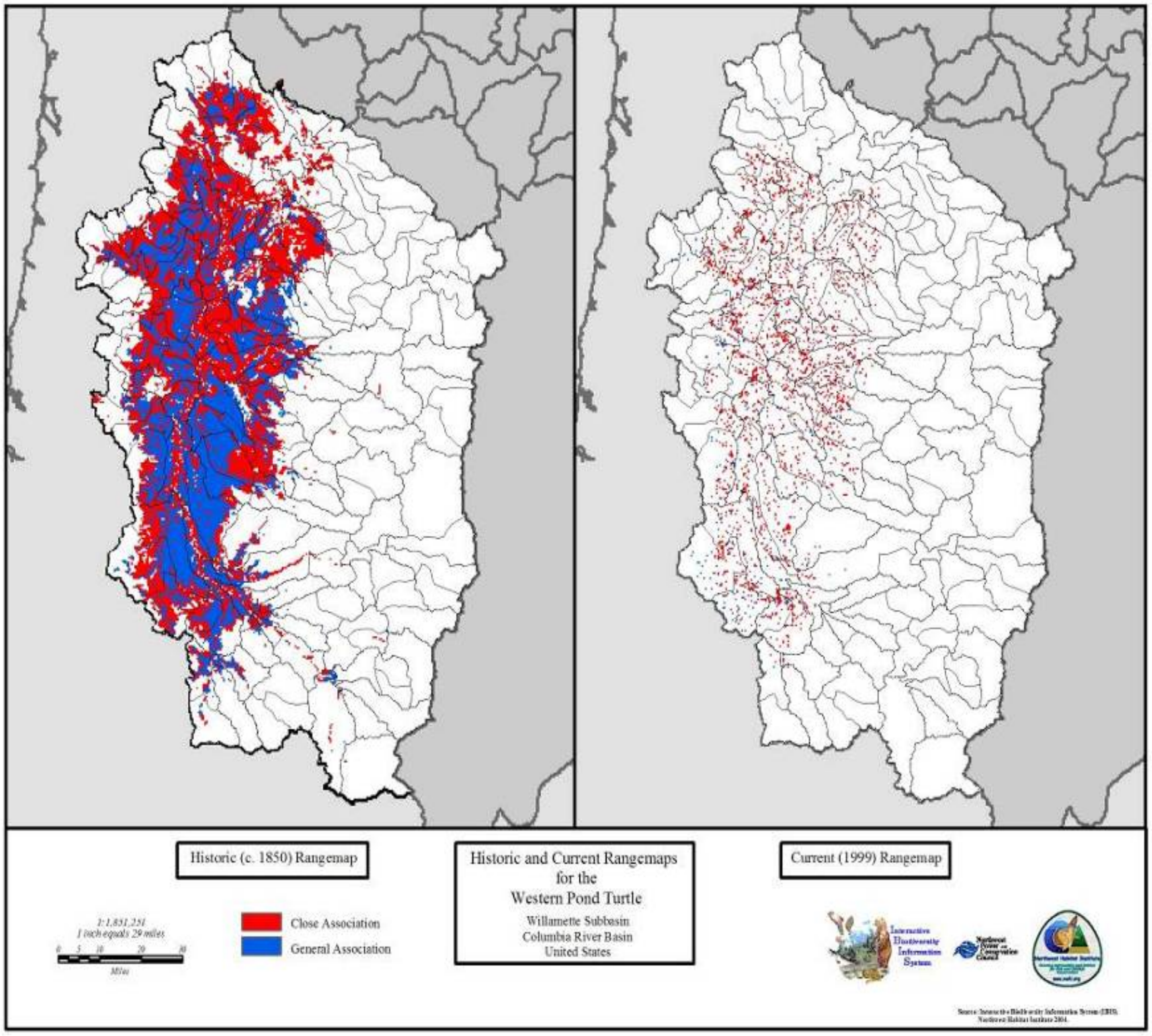

Figure 5. Intermediate scale depictions of the Western Pond Turtle's species range based on closely and general associations to its historic and current habitat at the subbasin level.

Avoid, Minimize and Mitigate- Oregon Department of Transportation I-5 Pilot bridge Project

Transportation projects comply with federal and state laws especially when it comes to sitting projects. Because mitigation is costly, transportation agencies try to avoid and minimize impacts to compensatory resources. An example of using the approach developed by NWHI was illustrated when the Oregon Department of Transportation (ODOT) asked a hypothetical question in replacing a bridge on Interstate 5. The question involved deciding on whether the replacement bridge should be built to the left or the right of the existing bridge and which direction would minimize impact to wildlife species. In order to help determine the answer to the question, NWHI created a third tier fine scale map to assess the KEC's of all potential species in the area surrounding the possible bridge replacement sites (Fig. 6). In determining a baseline habitat value, our process can also be species specific (Fig. 7). This can be helpful in making a final decision, especially if listed, species of concern or exotic species were of interest.

The Interstate 5 pilot bridge project used IBIS to develop an innovative approach to produce a habitat's value when determining project impacts to fish and wildlife. This method offers a way of addressing ecosystems while making a significant step towards streamlining environmental regulations. On April 22, 2005, The Oregon Department of Transportation (ODOT) received the Federal Highway Administration's prestigious Environmental Excellence Award for Environmental Streamlining. The award recognizes their unique approach, which includes IBIS, to the management of highway bridges throughout the state while addressing environmental issues and also saving time and money. See http://www.nwhi.org/ibis/home/ibis.asp .

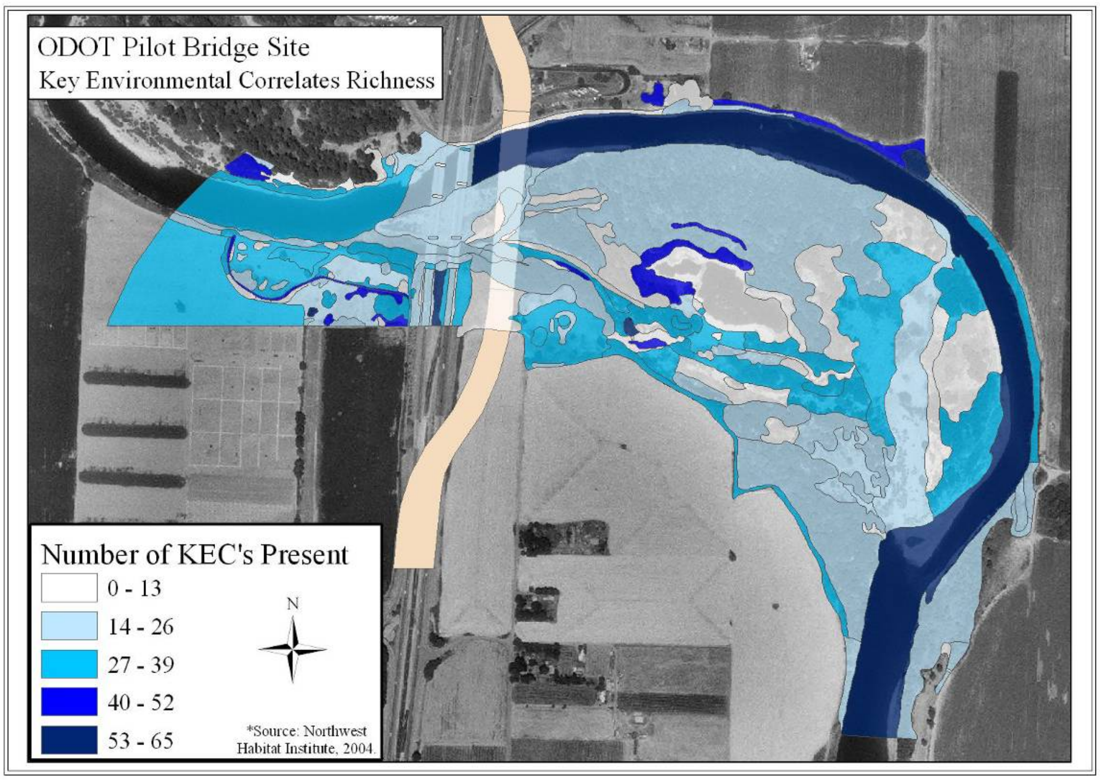

Figure 6. Fine scale map of an Oregon Department of Transportation bridge replacement site illustrating the number of Key Environmental Correlates (KEC's) based on multiple species use.

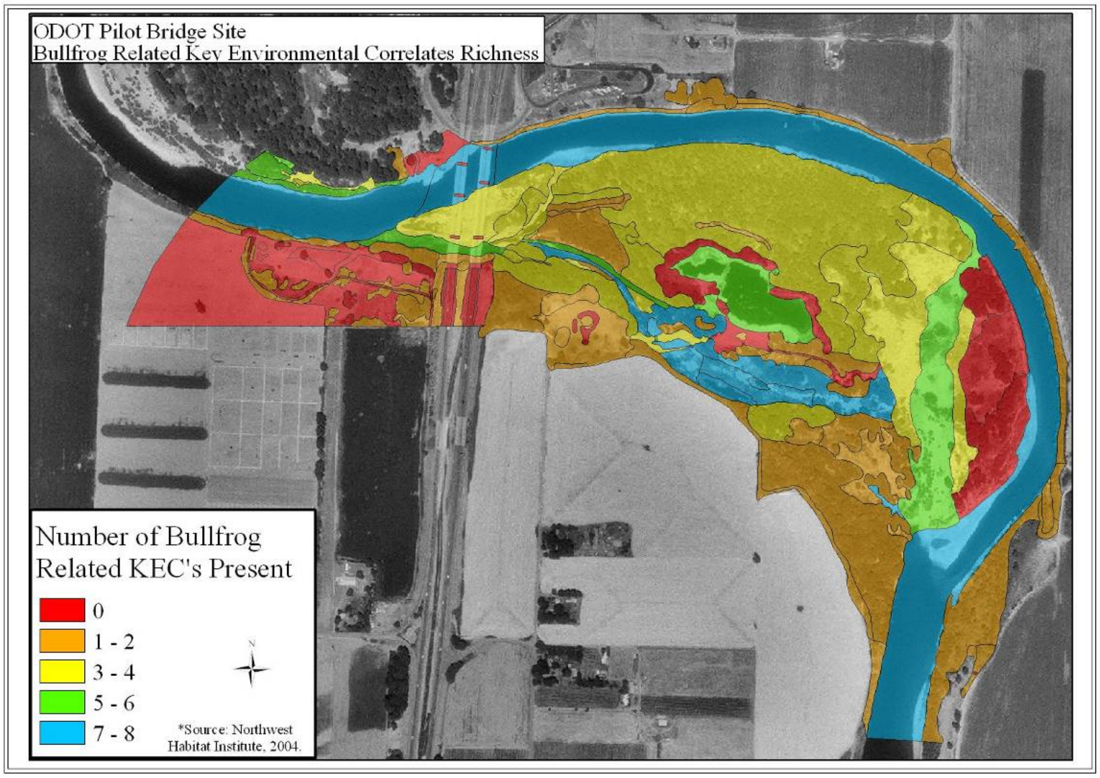

Figure 7. Fine scale map of an Oregon Department of Transportation bridge replacement site illustrating the number of Key Environmental Correlates (KEC's) for the bullfrog (*Rana catesbeina).*

Key Ecological Functions- Species functional redundancy

Key ecological functions are linked to wildlife species, and species are now relationally tied to specific habitat types, structural conditions and KECs. Site specific species information can be developed into a figure, a table, or map. For example, resource managers can determine functional redundancy by species or groups of species for a given area (Fig. 8). Additionally, KEF's can be mapped and potential change in functions based on habitat changes can be illustrated to compare historic to current conditions (Fig. 9). Lastly, because KEFs are linked to species functional specialists which are species that perform only one or two functions within an area can also be identified. This is important because a lost of these species results in an immediate lost of a function within the area.

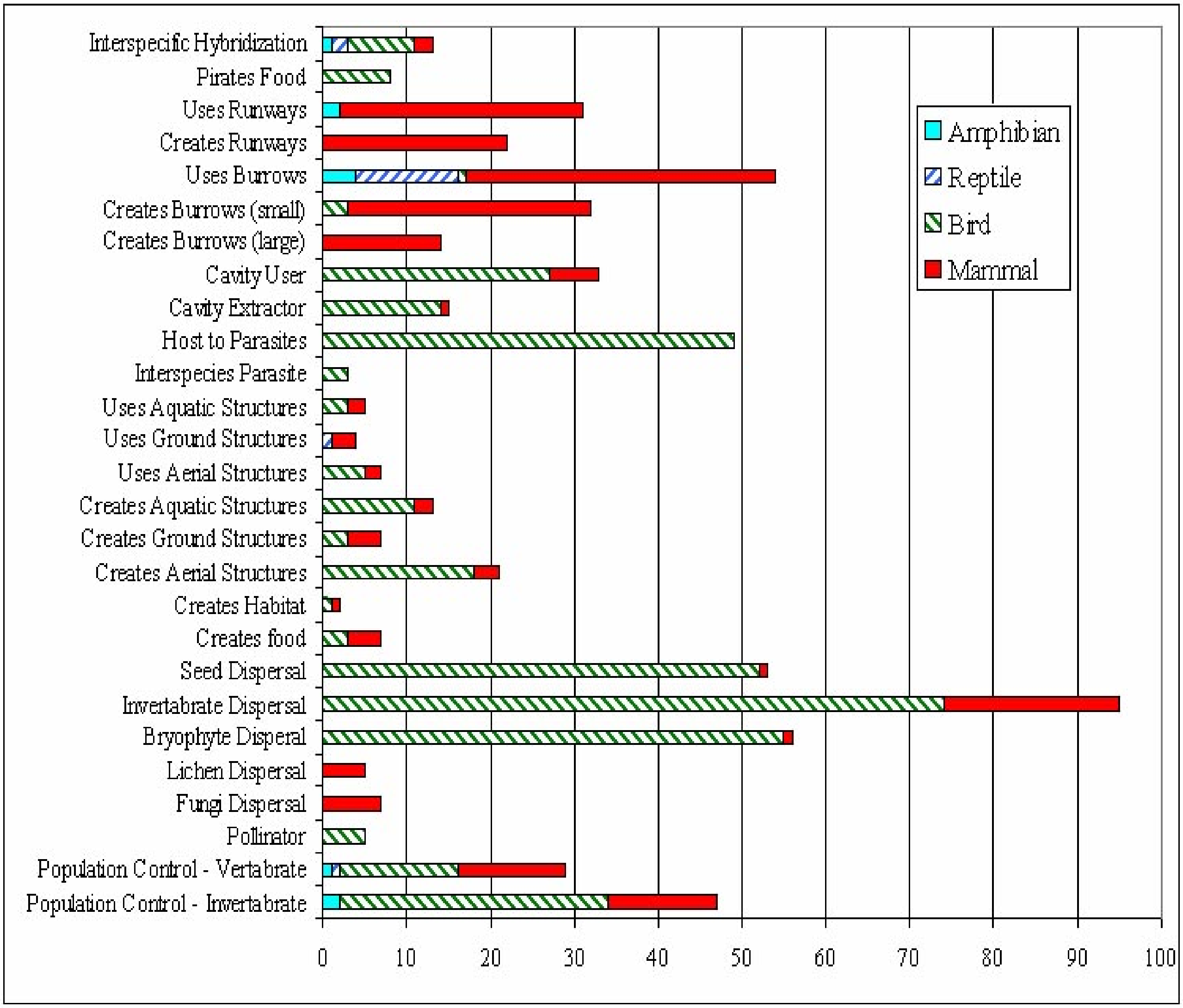

Figure 8. Bar graph depicts the number of species in each category (amphibian, reptile, bird, and mammal) that can perform the listed key ecological functions with in Blue Mountain Ecoprovince. With this graph, natural resource managers can easily determine functional redundancy in a given area.

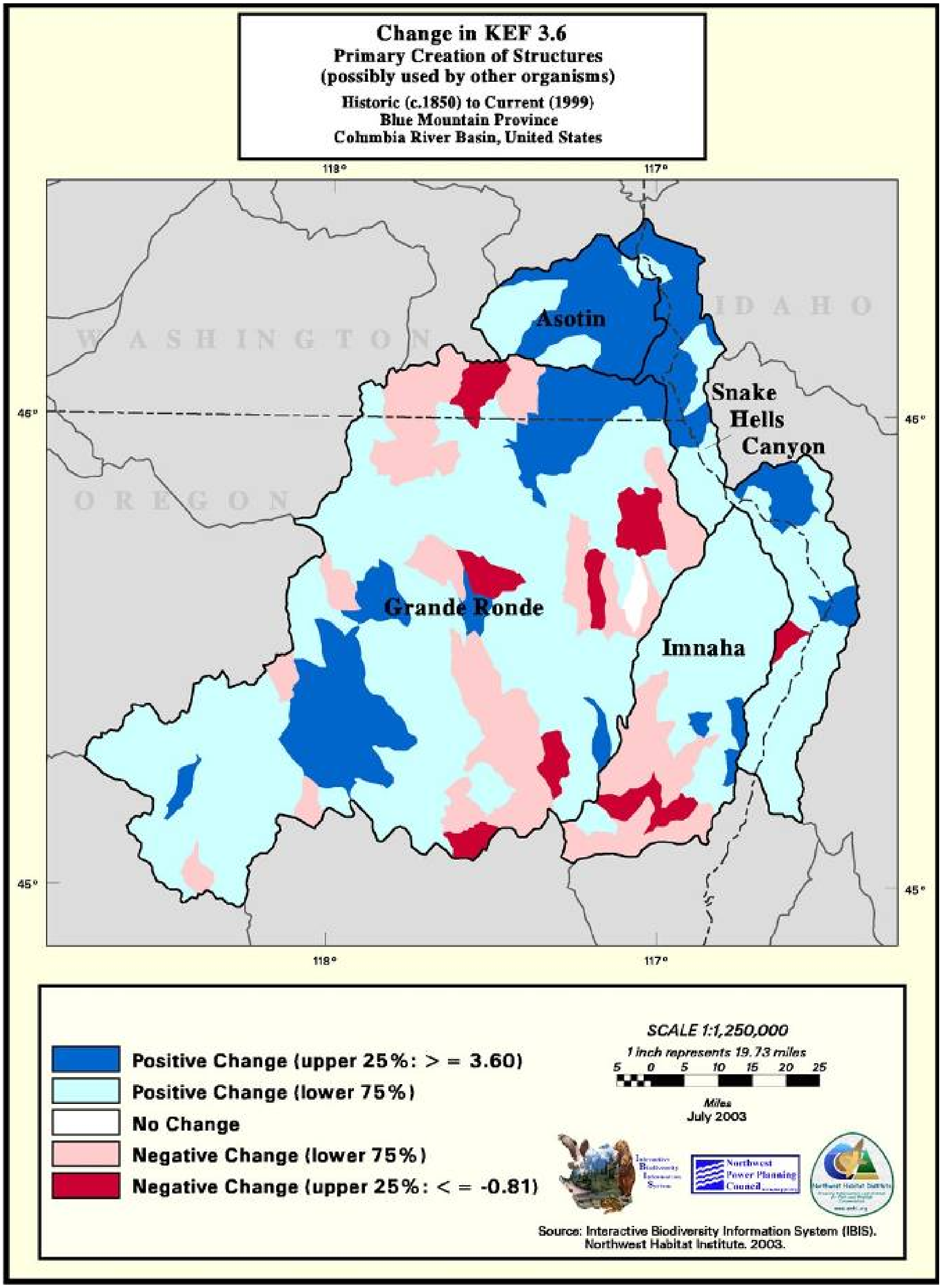

Figure 9. Map of the percent change of the KEF "primary creation of structure used by others" with in the Blue Mountain ecoprovince.

Habitat Assessment for Conservation and Mitigation

The above figures give examples of species-habitat-functions and how they can be used at various scales. With the capability to map and link the relational data sets, resource managers can determine baseline conditions of a site and more effectively develop management objective and/or determine mitigation projects with more accuracy. Habitat Appraisal and Barter (HAB) protocols (NWHI 2007a) allows the inventory of a site in a consistent format whereby applying a biological accounting system to rate habitats and track changes. In the May 2003 Memorandum on the Guidance for the Establishment, Use, and Operation of Conservation Banks, the US Fish & Wildlife Service highlights the need to establish such an accounting system to "track credits, funding and other reporting requirements" when outlining a banking agreement.

Given that habitat provides value for both fish and wildlife, it seems a habitat assessment method should assess the habitat value for *all* of the fish and wildlife species that could potentially be using it (O'Neil, 2005). This is accomplished with the HAB approach, as a complete list of species that could use the habitat is generated based on an inventory of habitat components and their relationship to ecological functions performed by species.

Habitat assessment is commonly implemented to guide recovery projects (such as conservation or mitigation "banks"), for species monitoring, to gauge impacts, or to set management priorities. As the science of habitat assessment evolves, it is becoming evident that measuring habitat *function* is critical to the success of many mitigation projects (Breaux et al., 2005), monitoring, and habitat management. An assessment methodology that measures functionality should incorporate multiple components such as vegetation, structure, surrounding landscape, and habitat size and shape (Store and Jokimäki, 2003). The HAB approach integrates multiple scales and addresses the idea underscored by Store and Jokimäki (2003) and George and Zack (2001) that habitat suitability is related to different factors on different spatial scales.

Consistency across sites is essential when comparing projects, such as differences over time for recovery efforts, or comparing successes of conservation banks. For a transportation project the same evaluation of habitat(s) is conducted at an impact site as well as mitigation site regardless of current species use or habitat quality, the HAB-value approach is inherently consistent and well-suited for mitigation and conservation banking projects. Assessing the quantity and quality of habitat can be accomplished by calculating a HAB-Currency "value" for each habitat unit that can be traded between impact projects and mitigation/conservation banks. The HAB-Currency consists of credits and debits, much like a bank account, with the calculations acting as an Accounting and Tracking Method (ATM) for those credits and debits. Utilizing the HAB-Currency calculations, if a site cannot avoid impacts to habitat, managers can compare possible scenarios for the least amount of impacts, and thus, the least amount of debits accrued by the project. There are many HAB-Currency products that can be useful for resource management (Table 1).

Table 1. Example HAB assessment product outcomes for fish and wildlife at a single inventoried site.

Maps	Charts	Reports	Values
Acreage	Amount of functional redundancy (species performing functions)	List of species	Baseline intrinsic value for a site
Habitat types	Amount of KECs characterized by functions	List of habitat types	Baseline intrinsic value; Future value at a site based on management scenarios
Key Environmental Correlates (KECs)	Amount of species diversity	List of KECs	Baseline intrinsic value; Future value at a site based on management scenarios
Key Ecological Functions (KEFs)	Species redundancy by function	List of Functions	Baseline intrinsic value; Future value at a site based on management scenarios
Structural Conditions	Acreage of Structural conditions	List of Structural Conditions	Baseline intrinsic value; Future value at a site based on management scenarios
Ecosystem Services (by acre)	Acreage of Ecosystem Services	List of Ecosystem Services	Baseline intrinsic value for a site[1]

[1]Currently being developed

Calculating HAB Value

At a given site, HAB value can be consistently calculated using the relational database and fine scale mapped products. The first step of course is mapping the site at a fine scale as is described above. Each map unit is assessed by field crews and information about its habitat type, structural condition, KEC's present and the level of invasive species in each of the three structural layers (grass, shrub, and tree) is collected. This information is then entered into the relational database for each map unit.

Next a species list that has the potential to occur at a given site is created. This is determined by listing all of those species whose geographic range intersects the site. Then, using the relational database, the species list is cross-tabulated with the functions that those species perform by the habitat type that they are know to occur in. The resulting matrix depicts species in the rows and the functions they perform in the columns and the body of the matrix shows either presence or absence of a species performing a particular function. The sum of all of those values dividing by the number of non-zero functions gives the species value for that habitat type. This value is applied to all map units in that habitat type.

The next step is to calculate the individual map unit's KEC value. This is similar to the calculation of the species value by habitat type above. Using the same species list, a matrix is constructed depicting the functions in the columns and the KEC's observed in that map unit in the rows, with the body of the matrix showing presence or absence of a KEC being associated with a particular function. The sum of all those values divided by the number of non-zero functions gives the individual map unit KEC value.

The sum of the Species and KEC value for a map unit gives its "uncorrected" per acre baseline value (Fig. 10). The level of observed invasive plant species present in the grass, shrub and tree layers are combined to give a map unit "invasive value". These are used to discount the map unit value for the presence of invasive and yields the "corrected" per acre baseline value (Fig.11). Then by multiplying each map unit's corrected baseline per acre value by the acreage of the map unit and summing across all map units at the site, a site corrected baseline value can be calculated. For a more detailed example see NWHI HAB Primer (2007b).

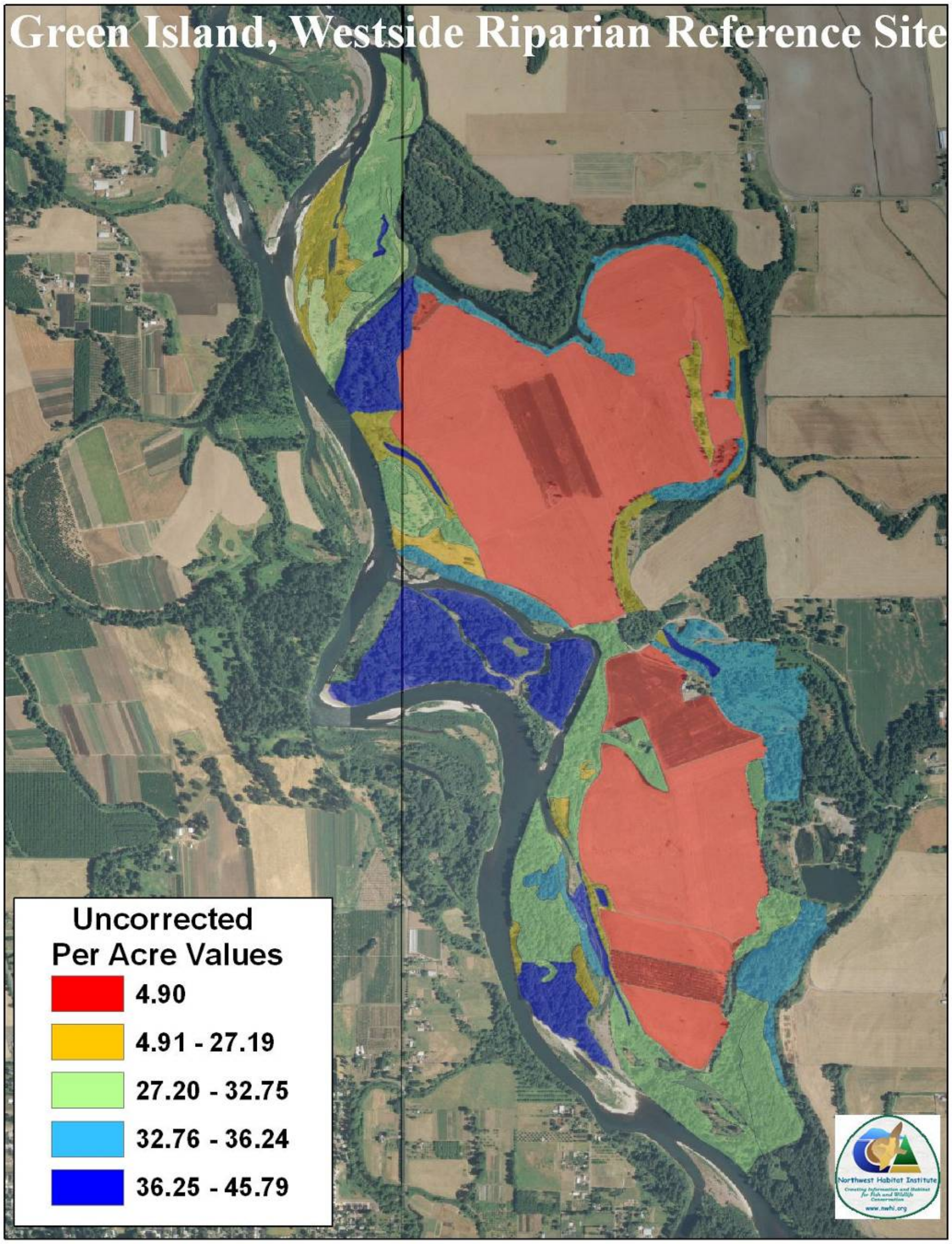

Figure 10. Polygons are delineated at an individual site and there uncorrected per acre value color coded.

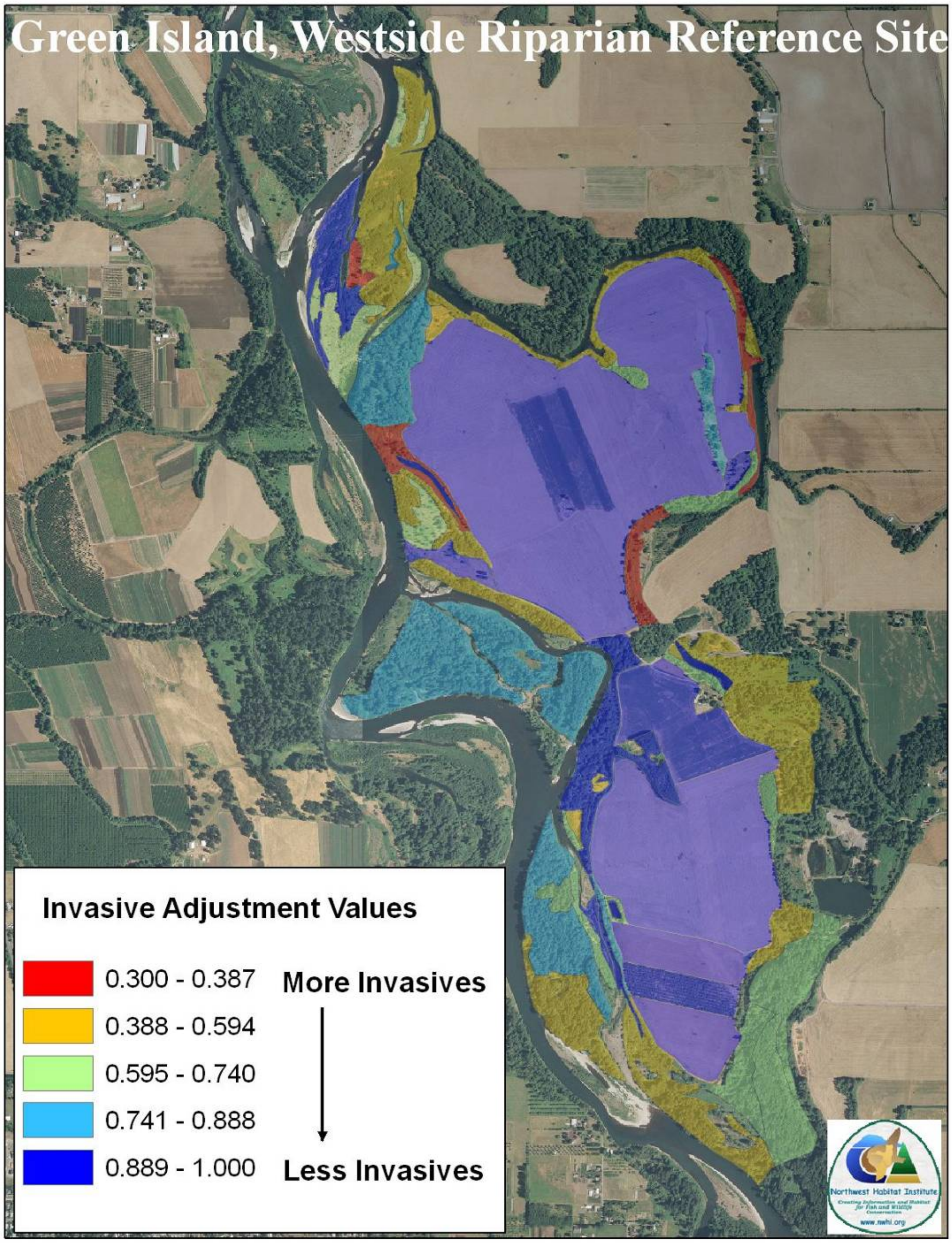

Figure 11. Polygons are color-coded with a corrected values based on the present and amounts of invasive species that occur within each polygon. Note the color changes from Figure 10 to 11.

CONCLUSION

The approach offered here provides an overview of the steps necessary to create a wildlife habitat assessment protocol at multiple scales and promotes a consistent methodology of habitat assessments across organizations. Our approach defines the necessary steps needed in order to lay the foundation for calculating baseline values for wildlife habitats. Each step enables managers to ask questions about the state of habitats, not only at the site level, but also within context of the larger regional ecosystems in which these sites reside. A consistent assessment protocol also allows managers to compare finding and facilitates monitoring the success of conservation efforts. Along with the HAB method of calculating value, this approach redefines the way wildlife habitat impacts and mitigation efforts are assessed and monitored into the future. It provides a consistent, repeatable and peer reviewed methodology to measure the functionality of wildlife habitats for all potential species at a site at multiple scales.

Transferability of this approach is occurring especially in the west with agencies in Idaho, Oregon, Washington, and Southern California using this methodology to evaluate projects; Virginia is looking to host a short course on this approach in the winter-spring 2008. Using this methodology, a national system of assessing wildlife habitat can be created. Each region could take a leading role in developing peer-reviewed habitat classification systems while coordinating on a national level to ensure consistency. These efforts would represent a paradigm shift from the current system of single or selected species indicators as defining baseline habitat value, to a more robust approach involving all potential species that could be at a site or in a region. Developing regional assessment protocols will enable managers to not only define baseline habitat conditions, but can also improve knowledge on cumulative effects and facilitate transportation agencies to refine mitigation efforts appropriate for individual transportation projects.

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