

# Measuring Up: Synchronizing Biodiversity Measurement Systems for Markets and Other Incentive Programs



## APPENDICES



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## **Measuring Up: Synchronizing Biodiversity Measurement Systems for Markets and Other Incentive Programs**

The Willamette Partnership is a non-profit coalition of diverse leaders dedicated to increasing the pace, scope and effectiveness of restoration. Measuring Up was produced by Bobby Cochran and Nicole Robinson Maness with Emily Alcott. Layout and design by Joni Shaffer.

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## Table of Contents

Appendix A. Glossary of Terms .....	1a
Appendix B. Technical Group Organizations.....	9a
Appendix C. Measurement System Assessment Criteria .....	10a
Appendix D. Measurement Systems Inventory .....	12a
Appendix E. Conservation Banking Report.....	18a
Appendix F. Typology of Metrics .....	22a
Appendix G. Case studies .....	30a

## Appendix A. Glossary of Terms

*Adapted from Business and Biodiversity Offsets Program Glossary, 2009.*

### **Abiotic factor (also see biotic factors)**

A non-living factor in the environment including light, water, and temperature.

### **Adaptive management**

A continuous process of revising management plans to take results achieved from previous behavioral or land use changes into consideration. When a management plan goes into effect, objectives are initially set. After actions to manage natural resources are taken, monitoring and evaluation results are compared against expectations. Future actions are adjusted to account for early results, such that each iteration of activity is based on past experience. Management adapts to put lessons learned into practice in the next project cycle.

### **Additionality**

In an environmental market, the environmental benefit secured through the payment is deemed “additional” if it would not have been generated absent the payment provided by the market system.

### **Attributes**

See Benchmark attributes.

### **Averted risk**

The removal of a threat to biodiversity for which there is reasonable and credible evidence.

### **Averted-risk offset**

Credited interventions which prevent future environmental harm from occurring.

### **Avoidance**

Measures taken to prevent impacts from occurring, for instance by changing or adjusting the development project’s location, scope, nature or timing.

### **Baseline**

A description of existing conditions that provides a starting point against which change resulting from a project can be measured.

### **Benchmark**

A benchmark is a reference point against which losses of biodiversity due to a project and gains through an offset can be quantified and compared consistently and transparently. It usually comprises a number of representative and characteristic ‘attributes’ used to represent the type, amount and quality of biodiversity which will be lost or gained. Comparing the observed level of each benchmark attribute at the impact site after the impact against the level at the benchmark can help to quantify the loss of biodiversity caused by the project. Similarly, comparing the observed level of each benchmark attribute at the offset site against the level at the benchmark can help to quantify the gain in biodiversity caused by the offset. A benchmark can be based on an area of land that provides a representative example, in a good condition, of the type of biodiversity that will be affected by the proposed development project. A synthetic benchmark can also be used if no relatively undisturbed areas still remain.

## **Benchmark attributes**

Benchmark attributes are the features of a biotope or habitat used to create a benchmark to represent the type, amount and quality of biodiversity present at a site. This may involve function of individual species, features of communities, or characteristics that operate at the landscape scale.

## **Best practice (or best management practice)**

An established technique or methodology that, through experience and research, have proven to lead to a desired result.

## **Biodiversity**

The variability among living organisms in terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. Biodiversity includes variety within species (genetic diversity), between species, and of ecosystems.

## **Biodiversity conservation**

The deliberate management of biological resources to sustain key biodiversity components or maintain the integrity of sites so that they support characteristic types and levels of biodiversity. Conservation includes preservation, maintenance, restoration, and sustainable utilization of the natural environment.

## **Biodiversity offsets**

Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity in species composition, habitat structure, and ecosystem function.

## **Biotic factors**

Environmental features resulting from the activities of living organisms.

## **Certification**

A process whereby an independent third party confirms that an activity, product, project, or organization satisfies the requirements set by a performance standard.

## **Community**

In the context of biodiversity offsets, the term ‘community’ is a naturally occurring, recognizable, and repeatable assemblage of plants and animals in which populations of different species share the same area or resources at the same time and are mutually sustaining and interdependent.

## **Condition**

The terms ‘condition’ and ‘state’ are often used interchangeably to describe the functionality of ecosystems. For example, condition might be measured as a fraction representing how much of the biodiversity expected to be present in natural, undisturbed circumstances is actually observed to be present. Condition can be quantified by (a) species occupancy and (b) structural and functional attributes.

## **Connectivity**

The spatial interrelationship between different areas of an original landscape, an ecosystem, or a habitat.

## **Conservation bank**

A conservation bank is a parcel of land managed to restore and/or maintain certain ecological conditions (e.g. functional wildlife habitat, presence of endangered species) for a set time period. The bank investor(s), who may or may not be the landowner(s), is allowed to sell the credits generated from the ecological conditions to parties who need them to compensate for their environmental impacts. The term “conservation bank” can refer to mitigation activity for both species and habitats and is analogous to “habitat bank” and “biodiversity bank.”

## **Conservation outcome**

A conservation outcome is the result of a conservation intervention aimed at addressing direct threats to biodiversity that leads to conservation gains. Conservation outcomes are typically in the form of: (a) extinctions avoided (i.e. outcomes that lead to improvements in a species' national or global threat status); (b) sites protected (i.e. outcomes that lead to designation of a site as a formal or informal protection area or to improvement in the management effectiveness of an existing protected area); and (c) corridors created (i.e. creation of interconnected networks of sites at the landscape scale, capable of maintaining intact biotic assemblages and natural processes).

## **Critical habitat**

Common elements found in critical habitat include threatened species; endemic or geographically restricted species; congregations of migratory and other species; assemblages that support key processes or services; and biodiversity of social, economic or cultural value.

## **Credit**

A single unit of trade that quantifies the provision (or right of use) of an ecosystem service.

## **Credit Site**

The area of land that is subject to specific management in order to generate the credits sold within an environmental market.

## **Credit provider**

The person or organization responsible for a credit site.

## **Cumulative effects**

An umbrella term for effects that accumulate over space or time. Cumulative effects may derive from the impacts of a project, plan, program, or policy combined with other past, present, or reasonably foreseeable future plans and actions.

## **Developer**

Any individual or entity undertaking a project, including building a road, mining, constructing a house, expanding agricultural operations, and implementing a project for environmental market crediting.

## **Debit**

The expression of the quantity of loss suffered as a result of environmental damage.

## **Direct area of influence**

The area in which direct impacts on biodiversity occur which can be attributed to project activities alone. A project's area of direct influence may or may not coincide with the project footprint as it reflects 'effect distances' (the distance over which particular effects, such as noise, are felt) for project activities and emissions.

## **Easement**

A right to use a part of land which is owned by another person or organization for specified purposes under specified conditions (e.g. for access to another property). A conservation easement is a contract not to develop part of a property for some designated period of time. Conservation easements typically require landowners to make absolutely no changes to the land use of the property or to maintain some ecologically desirable aspect of the land. The property still belongs to the landowner, but current and future landowners' use of the property is restricted.

## **Ecoregion**

A relatively homogeneous, ecologically distinctive area which has resulted from a combination of geological, landform, soil, vegetative, climatic, wildlife, water, and human factors.

## **Ecosystem**

A dynamic complex of plant, animal, and microorganism communities and their non-living environment which interacts as a functional unit.

## **Ecosystem approach**

A strategy for the integrated management of land, water, and living resources that promotes conservation and sustainable use based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions, and interactions among organisms and their environment.

## **Ecosystem function/process**

Functions or processes carried out or enabled by an ecosystem that are necessary for the self-maintenance of that ecosystem, such as seed dispersal, primary production, nutrient cycling, and pollination.

## **Ecosystem services**

The benefits people obtain from nature. These include provisioning services such as food, water, timber, and fiber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling.

## **Endowment**

An endowment is a type of fund that spends only the interest earned from its investments and not its capital to finance agreed-upon activities. The capital is managed to exist in perpetuity.

## **Enhancement**

The improvement of the ability of a degraded ecosystem to provide services through conservation measures such as alteration to the soils, vegetation, and hydrology. The term is sometimes used for restoration activities which enhance the environmental benefits provided by an ecosystem without restoring the ecosystem to some prior state.

## **Equivalence**

A state whereby the expected benefit (credit) generated approximately equals the damage (debit).

## **Habitat**

The particular abiotic and biotic conditions with which individuals or populations of the same species are typically associated. The term ‘habitat’ is also often extended to refer to the circumstances in which populations of many species tend to co-occur.

## **Habitat irreplaceability**

This may occur if the habitat is spatially restricted or provides a resource to local communities that cannot be restored from elsewhere.

## **Habitat structure**

The arrangement of biodiversity components in space with three major variables: complexity (the amount of variation attributable to absolute abundance of individual structural components), heterogeneity (the kinds of variation attributable to the relative abundance of different structural components), and scale (the first two components must be commensurate with the dimensions of the organisms being studied).

## **Impact site**

The area affected by the direct, indirect, and cumulative impacts attributable to the project.

## **Indicator**

A measurement that represents the status of one or many variables over time, often used as a proxy to assess progress relative to one or more objectives.

## **Indicator class**

A category that defines the broad grouping of attributes (indicators) used to measure biodiversity metrics.

## **Landscape**

Visible features of an area of land, including physical elements such as landforms, living elements of flora and fauna; abstract elements such as lighting and weather conditions; and human elements, for instance the built environment. A landscape can be a watershed, a region defined by soil or vegetation type, or an ecologically cohesive space. For the ecologist, landscape may be the habitat and connecting corridors necessary for a species to survive. At the national level, landscape may mean an entire bioregion that crosses political boundaries and encompasses multiple watersheds, core protected areas, buffers, and corridors.

## **Landscape context**

The context beyond the development project site that is likely to influence offset design and implementation, including (a) strategies identified in regional conservation and development plans, including information on threats and targets; (b) issues of scale, including connectedness to other natural and human features; (c) the effect of other conservation activities already taking place across the landscape.

## **Landscape scale conservation**

Designing, planning, financing, and managing projects with significant natural conservation value while incorporating the cultural and economic activities of people situated in the landscapes involved.

## **Like-for-like**

Conservation of the same type of biodiversity as affected by the project. More frequently referred to as ‘in-kind’.

## **Measurement system**

A suite of activities including selection of a set of quantifiable indicators, using those indicators to produce a metric that communicates the overall quality and function of land for biodiversity, validating the scores produced by the metric, and for incentive programs, placing the metric into a program that reinforces validity of the metric.

## **Metrics**

A set of measurements that quantifies results. Metrics can vary from very basic measures such as area, to sophisticated quantitative indices of multiple ecosystem components which may be variously weighted.

## **Mitigation**

Measures which aim to reduce impacts to the point where they have no adverse effects. Examples of mitigation measures include avoidance of sensitive sites, not performing disruptive work at sensitive times (e.g. breeding seasons), translocation of species to temporary or permanent alternative sites, post-project site restoration, and the creation of similar habitats to offset residual impacts.

## **Mitigation hierarchy**

The ranking of methods that ensure a level of environmental performance relative to the status quo (e.g. no net loss) is maintained in the face of anthropogenic activities. The mitigation hierarchy is defined as:

- **Avoidance:** measures taken to prevent completely damages to ecosystem services from the outset of a project (e.g. careful spatial or temporal placement of elements of infrastructure to prevent the degradation of wildlife habitat).
- **Minimization:** measures taken to reduce the duration, intensity and/or extent of impacts that cannot be completely avoided.
- **Rehabilitation / restoration:** measures taken to rehabilitate degraded ecosystems or restore cleared ecosystems following exposure to impacts that cannot be completely avoided and/or minimized.
- **Offset:** measures taken to compensate for any remaining significantly adverse impacts that cannot be avoided or minimized in order to achieve no net loss or a net gain of ecosystem services. Mitigation can include the restoration of degraded ecosystems, the creation of new ecosystems, or the protection of threatened ecosystems.

## **No Net Loss**

A target for a development project in which the impacts on biodiversity caused by the project are balanced or outweighed by measures taken to avoid and minimize the project's impacts, to undertake on-site restoration, and to offset the residual impacts, so that no loss remains. Where the gain exceeds the loss, the term 'net gain' may be used instead of no net loss.

## **Offset (verb)**

The act of fully compensating for environmental impacts.

## **Offset (noun)**

A credit generated by a party to compensate for environmental harm happening elsewhere. The party typically sells its offsets to polluters or resource users causing the environmental harm.

## **Offset activity**

Offset activities are the set of activities identified to counteract the environmental damage of the development project concerned. A very broad range of activities may be suitable. These generally tend to involve one or all of the following:

- *Undertaking positive management interventions* to restore an area or stop degradation: improving the conservation status of an area of land by restoring habitats or ecosystems and reintroducing native species. Where proven methods exist for successful reconstruction or creation of ecosystems these may be undertaken. In other instances, a project might reduce or remove current threats or pressures by, for instance, introducing alternative sustainable livelihoods or substitute materials.
- *Averting risk*: protecting areas where there is imminent or projected environmental loss; entering into agreements such as contracts or covenants with individuals in which they forego the right to convert land or harvest resources in the future in return for payment or other benefits received now.
- *Providing compensation packages* for local stakeholders affected by the development project and offset, so they benefit from the presence of the project and offset and support these initiatives.

## Offset ratio

The offset 'ratio' is the area occupied by an offset divided by the area affected by a project's impact. The offset area is often larger than the area impacted (i.e. offset ratio  $>1$ ), since the offset gains per unit area are often lower than the impact site losses per unit area.

## Out of kind

When the biodiversity conserved through the offset differs from the biodiversity impacted by the project. The option of 'trading up' to an out-of-kind offset may be advisable where an offset arising from project impacts on a common or widespread component of biodiversity may instead be switched to benefit a more threatened or rare component.

## Payments for ecosystem services (PES)

An umbrella term often applied to a wide variety of schemes in which the beneficiaries, or users, of ecosystem services provide payment to the stewards, or providers, of ecosystem services. PES give land managers incentives to protect or enhance the provision of ecosystem services, such as water, biodiversity, and carbon storage. In some cases the beneficiaries of these services, for example industrial water users, pay land managers or provide the funds to reimburse land owners for undertaking land management that produces a desired outcome. In others, payments are made by governments or donors on behalf of users or society as a whole. In a third type of PES, the government creates a market through regulation allowing trading in emission reductions or in compensatory mitigation requirements. Regardless of the particular mechanism, payments made are conditional on landowners carrying out the contractually agreed conservation or land management activities.

## Persistence

A measure of ongoing existence; the opposite of extinction. In the context of biodiversity, persistence implies absence of threats and an expectation of continued existence over the timeframe under consideration. Threat status categories (e.g. the IUCN Red List) are one important way of describing expectations of persistence. Indices of 'susceptibility to loss' offer a continuous description of persistence expectation. In conservation biology 'persistence' is often expressed as a probability.

## Persistence probability

A measure of the likelihood that a specified component of biodiversity (usually a species or species' population) will exist after a defined time interval. Increased persistence probability is the primary goal of threatened species, community and ecosystem conservation efforts. Net conservation gain implies increased persistence probability for affected biodiversity components.

## **Resilience**

The ability of an ecosystem to recover and maintain diversity, integrity and ecological processes following disturbance.

## **Restoration**

Reestablishing an ecosystem's composition, structure and function, usually bringing it back to its original (pre-disturbance) state or to a healthy state close to the original.

## **Service Area**

The area within which habitat or species loss can be offset by a credit from a specific location. It is determined by the type of resource that is being protected, any physical limitations for creating offsets, and administrative/ political boundaries.

## **State metrics**

A fraction or percentage reflecting the intactness or condition of the biodiversity component. For a species, this might be the % sites holding a species (from presence observation data); % of natural abundance (from basic counts); % former habitat area now remaining (area occupied). At the community or ecosystem level state is reflected by measures of 'condition'. These may be species-occupancy based (number actually present expressed as a percentage of the number that could be present), pressure based (number and intensity of threats) or based on measures of structure and function (intactness of key attributes).

## **Threat status**

A simple but highly integrated indicator of vulnerability. It contains information about past loss (of numbers and / or habitat), the number and intensity of threats, and current prospects as indicated by recent population growth or decline. One much used example of a threat status classification system is the IUCN Red List of Threatened Species.

## **Thresholds**

Boundary conditions between two or more different states. In the context of biodiversity offsets, one of the key 'thresholds' considered is the level beyond which impacts on biodiversity may no longer be capable of being offset.

## **Verification**

The act of reviewing, inspecting, testing, checking, auditing, or otherwise establishing and documenting whether items, processes, services, or documents conform to specified requirements. In the case of a biodiversity offset, verification could involve establishing that the planned and predicted biodiversity outcomes of the offset have been achieved. Verification is often undertaken by a third party (an independent institution or individual).

## **Weighting**

The fractional values used to reflect the relative importance of each of several attributes. In the context of biodiversity offsets, weights are used to ensure the various attributes (proxies) measured, when combined, better reflect the health of the overall ecosystem. Attributes reflecting many important ecological processes (e.g. light, water use, temperature, food, shelter) for many species will be strongly weighted. Attributes that only influence one or a few processes (e.g. food) affecting one or a few species should be weighted less. The individual weights for all attributes should add up to 1 (or 100%).

## Appendix B. Technical Group Organizations

Representatives from the following organizations served as members of the Technical Group:

**American Forest Foundation**, Washington, DC

**Business and Biodiversity Offsets Program**, Cape Town, South Africa

**Colorado State University**, Fort Collins, CO

**Defenders of Wildlife**, Portland, OR

**Ecosystem Marketplace**, Washington, DC

**Environmental Bank and Exchange**, Owings Mills, MD

**Environmental Defense Fund**, Boulder, CO

**NatureServe**, Washington, DC

**Oregon State University**, Corvallis, OR

**Pinchot Institute**, Washington, DC

**Sustainable Solutions**, Washington, DC

**The Climate Trust**, Portland, OR

**The Nature Conservancy**, Portland, OR

**U.S. Fish and Wildlife Service**, Sacramento, CA and Portland, OR

**U.S. Geological Survey**, Washington, DC

**USDA Forest Service**, Washington, DC

**USDA Natural Resources Conservation Service**, Washington, DC

**USDA Office of Environmental Markets**, Washington, DC

**Willamette Partnership**, Hillsboro, OR

**World Resources Institute**, Washington, DC

## Appendix C. - Measurement System Assessment Criteria

The following criteria were used to analyze the structure, scope, objectives, methodologies, and metrics of Tier 1 measurement systems.

### Program Details

1. Program name
2. Contact name, address, phone, e-mail
3. Private company, non-profit, academic, or government
4. Project description
5. Partners/advisors

### Habitat/Biodiversity Metric

1. What is the stated purpose of the metric? What is it measuring? (e.g. species, vegetation condition, habitat functions, terrestrial habitat, aquatic habitat, other?)
1. What is the basic scientific rationale/premise behind the metric?
2. If measuring a biodiversity/habitat proxy, what assumptions are used to correlate the proxy to habitat/biodiversity?
3. Does the metric address the concepts of Irreplaceability? Additionality? Permanence?
4. Does the use of the metric relate to any local, state or federal regulations?

### Scale

1. Unit of measurement
2. Scale of application – local/site, landscape/watershed
3. Unit of analysis
4. Applicable geography – what is it calibrated for (i.e. for a state or region)
5. Is the metric portable or transferable to other geographic areas?

### Methodology

1. How is biodiversity/habitat measured (e.g. indicators, weighting factors, etc...)
2. Is metric looking at outcomes or practices?
3. Are any stated goals/targets/benchmarks/performance standards identified (e.g. desired future condition)? If so, how were they developed?
4. Is there a (sampling) methodology or data collection system used?
5. How are sites selected?
6. How are credits calculated?
7. Is there a monitoring/verification program?
8. Is there an adaptive management program?

### System Dynamics

1. How does the measurement system address ecosystem dynamics?
  - a. Spatially (e.g. connectivity, surrounding land use)
  - b. Temporally (e.g. successional pathways, disturbance regimes, climate change)

**Scientific Credibility**

1. Overall credibility (High, medium, low)
2. Has it been peer reviewed or validated?
3. Is the metric replicable, accurate, and sensitive?
4. Has it been field tested? If so, where?
5. Concerns and limits

**Existing Use**

1. Target users
2. Time invested
3. Date of completion
4. Supporters

**Usability**

1. Overall complexity (High, medium, low)
2. Expertise/training required?
3. Used with any user tools or software?
4. Field work needed?
5. Time required per site?
6. Data sheets
7. Strengths/Weaknesses
8. Overall Practicality (High, medium, low)

**Administration of Measurement System**

1. Who provided funding to develop program?
2. Any proprietary issues with methodology or results?
3. Who is responsible for ownership and long-term maintenance of data/results?
4. Is there a strategy for ensuring the long-term viability of the program?

## Appendix D. Measurement Systems Inventory

For additional detail see evaluation matrix: <http://willamettepartnership.org/measuring-up/>  
Detailed review of 25 measurement systems.

Measurement System Name	Lead Developer	Description
<b><i>BioBanking</i></b>	Government of New South Wales, Australia	Transparent, consistent and scientifically based set of rules to assess biodiversity values. Provides rules for 1) the number and type of credits that a development site will require in order to offset its impacts and thus improve or maintain biodiversity values; and 2) the number and type of credits that can be created from undertaking conservation management at a Biobank site.
<a href="http://www.environment.nsw.gov.au/biobanking/">http://www.environment.nsw.gov.au/biobanking/</a>		
<b><i>Habitat Hectares</i></b>	State of Victoria, Australia	Developed as a rapid visual assessment of habitat conditions on a site relative to a benchmark or reference site based on vegetation. Generates a weighted score for habitat quality per hectare. Connects specific actions to anticipated and measured gains in vegetation quality.
<a href="http://www.environment.gov.au/archive/biodiversity/toolbox/templates/pubs/habitat-hectares.pdf">http://www.environment.gov.au/archive/biodiversity/toolbox/templates/pubs/habitat-hectares.pdf</a>		
<b><i>Ecosystem Mitigation Approach</i></b>	Ecosystem Management Research Institute	Uses NRCS Ecological Sites to classify the inherent ecological diversity of a proposed development site. It quantifies the existing conditions at a specific location and then compares them to a reference plant community to determine how much restoration would be required to mitigate impacts. In order to ensure comparable benefits, especially in the case of wildlife habitat, the evaluation includes a landscape level analysis that considers the spatial context of the off-site mitigation effort.
<a href="http://www.emri.org/PDF%20Docs/Adobe%20files/co%20cig%20report_reduced.pdf">http://www.emri.org/PDF%20Docs/Adobe%20files/co%20cig%20report_reduced.pdf</a>		

<b>Measurement System Name</b>	<b>Lead Developer</b>	<b>Description</b>
<i><b>Native Vegetation and Scattered Tree Offsets Program</b></i>	Government of South Australia	Offset program that permits resource companies to generate and hold credits for “significant environmental benefits” in excess of their regulatory requirements for clearance of native vegetation. The approach calculates a credit ratio (from 2:1 to 10:1) depending on quality of vegetation being cleared.
<a href="http://www.pir.sa.gov.au/__data/assets/pdf_file/0003/30990/native_veg_policy.pdf">http://www.pir.sa.gov.au/__data/assets/pdf_file/0003/30990/native_veg_policy.pdf</a>		
<i><b>Habitat Quality Index</b></i>	Bio-West Consulting	Rapid method of assessing habitat quality using structural and floristic requirements specific to avian communities. This measurement system is being developed for four broadly classified habitat types: emergent marsh, grassland/shrubland, playa, and wet meadow.
<a href="http://www.bio-west.com/services/wild_veg/wildveg_projects/HQI">http://www.bio-west.com/services/wild_veg/wildveg_projects/HQI</a>		
<i><b>Bay Bank Bog Turtle Protocol</b></i>	Pinchot Institute	Calculates credits from projects participating in the Bay Bank voluntary market. Credit density of a project is determined by adding points earned by the project based on four criteria (site size/fragmentation, invasive plants and successional species, proximal threats, and general habitat conditions) that are multiplied by the project duration (expressed as a percentage relative to the base contract length). Credit density is calculated on a per acre basis.
<a href="http://www.thebaybank.org/downloads/bog_turtle_management_guidance_070610.pdf">http://www.thebaybank.org/downloads/bog_turtle_management_guidance_070610.pdf</a>		
<i><b>Utah Prairie Dog Recovery Program</b></i>	Environmental Defense Fund	The Utah Prairie Dog Habitat Credits Exchange evaluates the value of prairie dog habitat as high, medium or low based on three general factors - 1) habitat quality, 2) landscape context, and 3) population - according to a suite of specific criteria (e.g. species richness, shrub and canopy cover, landscape location, species persistence and population numbers). Modifiers are applied to the habitat value depending on its current condition, the average of which is multiplied by the numbers of acres enrolled in the program to generate total number of credits available from a project.
<a href="http://www.edf.org/documents/7328_Utah%20Prairie%20Dog%20Habitat%20Evaluation%20Guide.pdf">http://www.edf.org/documents/7328_Utah%20Prairie%20Dog%20Habitat%20Evaluation%20Guide.pdf</a>		

<b>Measurement System Name</b>	<b>Lead Developer</b>	<b>Description</b>
<i>Gopher Tortoise Habitat Crediting Program</i>	American Forest Foundation	A system that calculates gopher tortoise habitat credits available for sale in a pre-compliance market. Includes several criteria for determining the eligibility to sell an acre of habitat and for ranking projects for selection in an auction setting; these same criteria can be used to develop an index score for habitat functions. The method looks at vegetative cover, presence of endangered species, suitable soil types, landscape context, appropriate practices, and other factors.
<a href="http://www.affoundation.org/ccs_conservation.html">http://www.affoundation.org/ccs_conservation.html</a>		
<i>Habitat Suitability Index</i>	U.S. Fish and Wildlife Service	Calculated from a species habitat model that defines the structural components of habitat characteristics most strongly correlated with wildlife distribution and abundance. Allows for standardized collection of habitat data and also predictive capability when existing and future habitat conditions are compared to the optimum conditions. Output values range from 0.0-1.0 (with 1.0 representing maximum habitat quality in a defined area).
<i>Recovery Credit System for Golden-cheeked Warbler</i>	Environmental Defense Fund	Identifies conservation units appropriate to sustaining species based on criteria such as habitat area and habitat patch size. Recovery credits are calculated by applying multipliers to the area of conservation unit. Credits are sold through reverse auction.
<a href="http://www.edf.org/pressrelease.cfm?contentID=10907">http://www.edf.org/pressrelease.cfm?contentID=10907</a>		
<i>Delaware Comprehensive Assessment Protocol</i>	Delaware Department of Natural Resources and Environmental Control	Measurement system for determining the condition of a wetland site relative to a reference condition. Method scores attributes of vegetation, hydrology, soils, topography, structure, and surrounding land uses to calculate a functional score of a wetland. The outcome is an index of how much that function is departing from a reference standard or minimally altered site.
<a href="http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/DE_%20Comprehensive%20Assessment%20_v5.1.pdf">http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/DE_%20Comprehensive%20Assessment%20_v5.1.pdf</a>		

Measurement System Name	Lead Developer	Description
<i>Ecometrix Salmon Habitat Crediting Protocol</i>	Parametrix	Protocol and metric for quantifying score for ecological function of a stream for salmon habitat. A suite of mathematical models uses data collected by visual assessments and calculates an output between 0 and 1 that represents a percentage of optimal function provided by a habitat. This score is multiplied by the length of the stream to calculate the number of functional linear feet of functioning habitat.
<a href="http://willamettepartnership.org/ecosystem-credit-accounting/salmon/copy_of_salmon-habitat">http://willamettepartnership.org/ecosystem-credit-accounting/salmon/copy_of_salmon-habitat</a>		
<i>Oregon Wetlands Rapid Assessment Protocol</i>	Oregon Department of Transportation	Rapid functional assessment for wetlands that combines visual assessments of a suite of on-site and near off-site indicators. The Protocol computes a score for 16 different wetland functions which are summed to calculate a total functional score for a wetland between 0 and 1 (1 being an optimally functioning wetland). This can be multiplied by the delineated area of a wetland to calculate the functional acres of wetland.
<a href="http://www.oregonstatelands.us/DSL/WETLAND/or_wet_prot.shtml">http://www.oregonstatelands.us/DSL/WETLAND/or_wet_prot.shtml</a>		
<i>Counting on the Environment Upland Prairie Calculator</i>	Willamette Partnership	Calculates the amount of credits that might be generated for restoration, enhancement, or preservation of upland prairie habitat in the Willamette Valley. Credits are awarded based on the amount of anticipated future habitat function as measured by a quantitative assessment of both the current and “post-conservation” conditions of a site.
<a href="http://willamettepartnership.org/ecosystem-credit-accounting/prairie">http://willamettepartnership.org/ecosystem-credit-accounting/prairie</a>		
<i>Universal Mitigation Assessment Methodology</i>	Florida Department of Environmental Protection	A functional assessment for wetlands and surface waters, also applicable to several terrestrial habitat types. Quantifies gains and losses by developing a multiplier applied to area. Considers landscape support, water environment, and community structure. Also applies factors for time lag for recovery and risk of project failure.
<a href="http://www.dep.state.fl.us/labs/library/index.htm">http://www.dep.state.fl.us/labs/library/index.htm</a> and <a href="http://www.dep.state.fl.us/water/wetlands/docs/mitigation/UMAM_Training_Manual_ppt.pdf">http://www.dep.state.fl.us/water/wetlands/docs/mitigation/UMAM_Training_Manual_ppt.pdf</a>		

<b>Measurement System Name</b>	<b>Lead Developer</b>	<b>Description</b>
<b><i>Conservation Banking</i></b>	U.S. Fish and Wildlife Service	Awards credits based on acres of habitat occupied by an endangered species and put under conservation easement.
<a href="http://www.fws.gov/endangered/landowners/conservation-banking.html">http://www.fws.gov/endangered/landowners/conservation-banking.html</a>		
<b><i>Healthy Forests Reserve Program</i></b>	USDA Natural Resources Conservation Service	Forest landowners receive conservation easement payments and cost-share for practices designed for habitat recovery of listed species on their land.
<a href="http://www.nrcs.usda.gov/programs/hfrp/proginfo/index.html">http://www.nrcs.usda.gov/programs/hfrp/proginfo/index.html</a>		
<b><i>Wildlife Habitat Incentives Program</i></b>	U.S. Department of Agriculture	Voluntary program for landowners who want to develop and improve wildlife habitat on private land. Provides technical assistance and up to 75 percent cost-share assistance for practices that establish and improve fish and/or wildlife habitat.
<a href="ftp://ftp-fc.sc.egov.usda.gov/MD/web_documents/programs/whip/2006/MD_WHIP_Plan_2006.pdf">ftp://ftp-fc.sc.egov.usda.gov/MD/web_documents/programs/whip/2006/MD_WHIP_Plan_2006.pdf</a>		
<b><i>Qualitative Habitat Evaluation Index</i></b>	Ohio Environmental Protection Agency	Provides information on a stream's ability to support fish and macroinvertebrate communities by evaluating in-stream habitat and the land that surrounds it; uses six separate metrics to evaluate a stream site – the sum of which produce a total QHEI score (from 0-100). A higher score is indicative of better stream habitat for aquatic biological communities.
<a href="http://www.epa.ohio.gov/portals/35/documents/QHEIManualJune2006.pdf">http://www.epa.ohio.gov/portals/35/documents/QHEIManualJune2006.pdf</a>		
<b><i>Rangeland Health Assessment Procedure</i></b>	Bureau of Land Management	Provides information on the functioning of ecological processes relative to the reference state for the ecological site or other functionally similar unit for that land area using quantitative indicators evaluated against a reference condition.
<a href="ftp://ftp-fc.sc.egov.usda.gov/GLTI/technical/publications/IIRH_v4_8-15-05.pdf">ftp://ftp-fc.sc.egov.usda.gov/GLTI/technical/publications/IIRH_v4_8-15-05.pdf</a>		

<b>Measurement System Name</b>	<b>Lead Developer</b>	<b>Description</b>
<i>Habitat Evaluation Procedure</i>	U.S. Fish and Wildlife Service	Assesses impacts of proposed water development projects on fish and wildlife resources. HEP is based on the assumption that habitat for wildlife species can be described by a habitat suitability index.
<a href="http://www.fws.gov/policy/ESMindex.html">http://www.fws.gov/policy/ESMindex.html</a>		
<i>Habitat Equivalency Analysis</i>	National Oceanic and Atmospheric Administration	Designed to determine the compensation the public is due to reconcile injuries to the ecosystem and the lost services the ecosystem provides to the biotic component. Assigns a habitat functional score to each habitat unit in a site and multiplies that by the area. Time for habitat to recover from injuries and become fully functional is also accounted for using a standard discount rate of 3 percent.
<a href="http://www.csc.noaa.gov/coastal/economics/habitatequ.htm">http://www.csc.noaa.gov/coastal/economics/habitatequ.htm</a>		
<i>InVEST</i>	Natural Capital Project	Decision support tool that models and maps the delivery, distribution, and economic value of ecosystem services. Biodiversity metrics that are included in the biophysical models are: 1) habitat quality in major habitat types (forest, wetland, etc); 2) “countryside biodiversity score”; and 3) species viability.
<a href="http://www.naturalcapitalproject.org/InVEST.html">http://www.naturalcapitalproject.org/InVEST.html</a>		
<i>New Zealand Risk Index Method</i>	Department of Conservation New Zealand	Uses a risk index to calculate biodiversity losses and gains based on effects of past habitat loss and legal protection. Index is derived from survival-area and survival-abundance relationships for a given area to create a ‘persistence probability’. An Excel spreadsheet provides a template for the calculation, enabling the user to identify what spatial extent and intensity of conservation management is required to offset biodiversity loss caused by the development project.
Not available		
<i>Ohio Rapid Assessment Method for Wetlands</i>	Ohio State Environmental Agency	Relatively fast and easy method for determining the appropriate category of a particular wetland (low, medium or high quality).
<a href="http://www.epa.state.oh.us/portals/35/guidance/wetland1.pdf">http://www.epa.state.oh.us/portals/35/guidance/wetland1.pdf</a>		

## Appendix E. Conservation Banking Report

A significant volume of projects and dollars flow through the endangered species conservation banking program managed by the U.S. Fish and Wildlife Service. For this report, the Willamette Partnership reviewed how measurement and science touches conservation banking programs, with a particular emphasis on California where most of the existing banks are located (Speciesbanking.com, 2010).

### **Conservation Banking in the United States**

Conservation banking emerged in the United States in the late 1980s and early 1990s. Pioneered in the State of California, conservation banking was first known as endangered species credit banking. Conservation banks in the U.S. followed the example set by wetland and stream mitigation banking with programs across the country embracing market-based trading schemes. Conservation banking is regulated by federal agencies and as of 2010, there are 93 types of species credits and 51 types of habitat credits (Madsen et al., 2010). U.S. Fish and Wildlife Service is incorporating all federal conservation banks into the RIBITS database system (personal communication V. Layne, 2011), but there is presently no central repository for conservation banking measurement systems and instruments (personal communication N. Carroll, 2010). The dominant metric used in conservation banking is 1 credit of habitat = 1 acre. Other credit metrics that exist include: 1 credit = the amount of land required to support one breeding pair, or 1 credit = a wetland unit with adjacent upland habitat. This review focused on the region with the most sophisticated processes: California.

### **Conservation Banking: California**

Extensive environmental laws and a high number of federally listed endangered species have combined to drive California's active conservation banking industry. There are 101 active known conservation banks in California (Speciesbanking.com, 2010). The California conservation banking process follows the following steps: (1) Analyze impacts for a project or group of projects (2) Develop a conservation bank instrument, (3) Calculate credits, (4) Achieve performance standards, (5) Follow a management plan, (6) Monitor.

*1. Analyze impacts.* When a species is listed as federally threatened or endangered, pursuant to section 7 of the Endangered Species Act, a consultation is requested. A consultation is a written document that defines the habitat requirements of a particular species. Habitat requirements are defined by federal agency staff and are based on best professional judgment, literature review, and site visits and assessments. These documents typically outline (1) description of proposed action (project size/impact), (2) preservation or creation ratios and project guidelines, (3) species description, (4) definition of an environmental baseline, (5) effects of proposed action (direct, indirect, and cumulative), (6) an incidental take statement, (7) an outline of reasonable and prudent measures to avoid impact, and (8) conservation recommendations.

*2. Develop a Conservation Bank Enabling Instrument or Conservation Bank Agreement.* The Conservation Bank Enabling Instrument (CBEI) or Conservation Bank Agreement (CBA) is a legally binding agreement that establishes the bank and outlines the bank's operation framework (e.g. credit release schedule, required assessments, establishment of baseline conditions, financial assurances, service area definition, management and monitoring requirements, and duties of the bank operator and property owner). CBEIs and CBAs are reviewed by agencies that will be authorizing species credits; the agencies are collectively referred to as the Conservation Bank Review Team (CBRT). These can be any combination of federal and/or state agencies such as the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the California Department of Fish and Game.

*3. Calculate Credits.* Current biological information for a site is provided by the bank sponsor and verified by the CBRT. This information includes habitat maps and maps of species occurrences on the bank site, and is used to calculate the acreage that would be available for credits in a preservation bank.

If habitat is being created, then a Habitat Development Plan is prepared for the potential bank, and credit calculations are based on created habitat acreages determined feasible by the CBRT. Typically 1 credit = 1 acre (Sacramento Fish & Wildlife Office, 2009). The Service Area is the geographic area in which the bank is authorized to sell credits. Service Areas are based on available information about the species’ biology, range, Recovery Plans (if available), and on economic considerations.

4. *Achieve performance standards.* Once a bank has been finalized, credits will be released as a bank meets defined performance standards for properly functioning habitat according to a Credit Release Schedule. These credit release schedules allow developers to understand the timing and the quantity of mitigation credits available. Credits are released at varying percentages over time (see Table E.1). Credit release is based upon the bank meeting designated performance standards (Sacramento Fish & Wildlife Office, 2010). For a bank with just preservation, the performance standards would be based on funding the endowment and recording land protection instruments (personal communication with US FWS Senior Biologist Valerie Layne, April 2011).

**Table E.1** Credit release schedule and performance standards for the Elderberry plant (Sacramento Fish & Wildlife Office). A “Qualified Biologist” and “Normal” to “Exceptionally Vigorous” are defined in the Performance Standard definition process paper (from Sacramento Fish & Wildlife Office 2010).

Credit Release #	Year	Performance Standards	Credits Released
1	Year 1	Bank establishment	15%
2	Year 1	USFWS Acceptance of As-builts	25%
3	Year 2	60% survival of original planted elderberries without replanting, and all survivors categorized as “normal” to “exceptionally vigorous”  60% survival of associates without re-planting  Irrigation Permitted  Endowment funded at 15%	15%
4	Year 3	Year 2 standards +  Endowment funded at 40%	15%
5	Year 5	Year 3 standards +  No more than 10% decline in overall health of <i>Sambucus</i> from baseline conditions  No irrigation permitted or fertilizer application  Endowment funded at 70%	15%
6	Year 7	Year 5 standards +  Endowment funded at 100%	15%

*5. Follow a management plan and 6. Monitor.* A requirement of conservation bank development in the United States is that banks must be conserved in perpetuity. Bank long-term management plans are developed by the bank sponsor. These management plans include baseline conditions (e.g. vegetation, hydrology, soils, land use) and outline a schedule of short- and long-term monitoring tasks that are required of the bank sponsor and/or property owner (e.g. Wildlands Inc., 2010). Annual monitoring tasks assess the overall bank condition, including erosion, the presence of exotic or deleterious species, water quality, fire hazard, as well as other conditions that may require management action. Management plans stipulate an adaptive management framework, requiring the bank owners and operators to respond accordingly to variable conditions such as climate change, flooding and fire.

Long-term management plans require oversight of (1) biological resources, (2) security, safety, and public access, (3) infrastructure and facilities, (4) recreation, education and habitat restoration, and (5) reporting and administration. For biological resources, management plans require annual monitoring, and subsequent adaptive management, by a “qualified biologist” to review hydrology, soils, invasive or non-native species, and nuisance wildlife species (e.g. muskrat, beaver). In order to ensure that banks maintain their ecological integrity, long-term management and monitoring must be carefully outlined and implemented. Tools like the *Center for Natural Lands Management’s* Property Analysis Record software program can help calculate management responsibilities and financial requirements for managing conservation lands in perpetuity (<http://cnlm.org>).

### **Endangered species mitigation success stories beyond California**

Though California is leading the way in conservation banking, a number of other states across the United States have also implemented innovative approaches to compensatory mitigation of losses to endangered species habitat. In Bainbridge, GA, International Paper has pioneered the preservation of the Red-Cockaded Wood Pecker. International Paper worked with the Environmental Defense Fund, the U.S. Fish and Wildlife Service, and the Georgia Department of Natural Resources to create a Habitat Conservation Plan for the company’s Southlands Experimental Forest. Using banking under the Habitat Conservation Plan, International Paper expanded its forest from 1,500 to 5,000 acres. Five years after the bank’s inception, the forest’s woodpecker population jumped from two woodpecker groups, with three birds (all male) to 50 birds, and 13 breeding pairs.

In Mobile, AL, the Mobile Area Water and Sewer System (MAWSS) is managing land to protect the gopher tortoise. MAWSS has conserved 222 acres of forest habitat. Landowners can purchase credits and have tortoises moved to the forest, where they are tracked and monitored for health (Environmental Defense Fund, 2010). Florida’s Wildlife Commission has developed a Mitigation Park Program, similar to an in-lieu fee program. Pointing to the financial difficulty of on-site mitigation, and the sometimes spatially fragmented nature of service areas, Florida consolidates mitigation through the development of parks. Florida allows public access to these sites and highlights the economic and ecological advantages of streamlining and consolidating the mitigation parks (Florida Wildlife Commission, 2010). Developers make a contribution to the Florida Wildlife Commission’s Land Acquisition Trust Fund. The State has received over \$33 million in mitigation funds and has purchased approximately 10,000 acres at nine different mitigation sites (Florida Wildlife Commission, 2010).

### **Conclusions**

Conservation banking in the United States is well developed and extremely active. As of 2010, Speciesbanking.com estimates that there are 134 active banks in the United States, 93 different species credits, 51 habitat credit types, 11 states with active banks, and 246,113.90 acres preserved in perpetuity

(Speciesbanking.com, 2010). California continues to pioneer this process, and a number of lessons can be learned from their success and challenges. Challenges include: transparency, a lack of stringent metric development processes, and fragmentation of habitat challenges. Drawing on lessons learned from California, carefully crafted federal policy can generate a number of opportunities to improve the conservation banking process. These opportunities include: guidelines for the habitat definition process, requirements of public review for bank performance standards, creation of a nationwide mitigation tracking database (similar to the Army Corps RIBITS), standardized training for verifiers and bank operators, and standards of practice for bank enhancement and management.

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## Appendix F. Typology of Metrics

The section below describes the general approach, guiding ecological principles, and strengths and weaknesses of each of the four sets of assumptions that shape the transformation of indicators into an overall metric of biodiversity benefit described in Section 2.2.2 in the Final Report.

### **Vegetation-based metrics**

A large class of metrics uses the condition of vegetation as a proxy for habitat quality, comparing a study area with reference sites, states, or benchmark conditions. The difference between the actual condition and the reference condition is used to calculate an index of similarity. That index can then be used as a score or as a multiplier to a site's area to generate a weighted score. For example, a "Habitat Hectare" is an Australian metric that produces a score from 0 to 100 capturing the quality of a site's native vegetation. That score is multiplied by the hectares of area conserved or impacted to generate a *habitat hectare*. The general approach relies on a regional classification system of vegetation classes or ecological condition (e.g. Ecological Sites in the Ecosystem Mitigation Approach, or Ecological Vegetation Classes in the Biobanking scheme), providing a framework within which to determine the attributes or characteristics of a reference state.

### **Guiding ecological principles**

The assumption in using reference or benchmark sites as targets for management or restoration objectives is that the natural, historical composition and structure of vegetative communities are optimal for supporting the range of naturally occurring wildlife habitat on the site. Establishing classification systems and reference conditions can be time-intensive, and there is ongoing debate about what constitutes "reference" or if historical conditions really are the best predictor of optimal habitat given climate change and other dynamic forces.

### **How they work**

The quality and equivalency of two sites (e.g. an impact site and a mitigation site) are assessed at both the site and landscape levels. At the site level, common attributes of vegetation condition (e.g. native species richness, percent cover of native plant species, recruitment potential, and structural elements) and some abiotic attributes (e.g. soil texture, substrate, slope) are evaluated using broad classes of quantification. These scoring categories recognize the considerable natural variation that can occur within each component. For example, less than 5 percent, 5-25 percent, 25-50 percent, and greater than 50 percent are classes for assessing the percent cover of weeds in the Habitat Hectares method. Such general scores enable the field assessor to make clear choices reducing the variability of scoring among observers (Parkes et al, 2003).

The influence of the surrounding landscape on site level characteristics can be measured in different ways. For example, the Ecosystem Mitigation Approach determines how well the geographic location of the site will support populations of indicator wildlife species by running species viability models at the landscape level. The Habitat Hectares metric looks at how the surrounding land cover will contribute to restoration goals and measures proximity of the mitigation site to patches of remnant native vegetation.

### **Monitoring and adaptive management**

The vegetation-based metrics reviewed are not accompanied by monitoring programs that clearly describe the methodology, frequency or expected outcomes or targets that would be part of a scientifically rigorous and effective adaptive management framework. Both the BioBanking and Habitat Hectares assessments have been criticized for not explicitly addressing monitoring requirements as part of their approach (Burgin, 2008; McCarthy et al, 2004). For the most part, monitoring plans are assumed

to be addressed in the management plans for these metrics (e.g. the BioBanking agreement explicitly states requirements for monitoring and for adjusting the management plan based on outcomes from “adaptive management”). This gap in well-defined processes for monitoring and adaptive management of metrics is common across all of the approaches reviewed.

### **Strengths and weaknesses**

There are several advantages to using vegetation-based metrics to characterize biological diversity and/or habitat. Rapid, on-the-ground assessments of vegetation condition yield detailed, accurate characterizations of current conditions. The use of aggregations of floristic communities provides a classification framework within which to make comparisons and develop meaningful targets for restoration or mitigation. They incorporate both biotic and abiotic attributes of sites and landscapes and facilitate the integration of individual site assessments into regional assessments and landscape planning tools. They are often straightforward, which helps improve repeatability.

Though the use of reference conditions is appealing because they provide a simple focus for management, they are limiting because of the resources required to develop them (a number of reference areas are needed in any one region) and the data/information required may not be available everywhere. This pre-requisite may prohibit or discourage the ready adoption of these types of metrics. These approaches are missing documentation relating current and projected vegetation conditions to species viability. A strong adaptive management program should include research to establish correlations between site attributes and use by wildlife habitat.

In general, these metrics strike a balance between precision and practicality for evaluating habitat quality. The simplicity of rapid, on-the-ground assessments of vegetation condition is a primary reason for their use (Gibbons and Freudenberger, 2006). Improvements in remote sensing and fine-resolution spatial data will continue to allow vegetation-based approaches to improve both their validity and the speed of application.

### **Species-based metrics**

Species-based metrics often focus on the ecosystem characteristics that define ideal or optimum habitat for one or more target species. These types of metrics rank existing habitat relative to optimum conditions or relative to projected outcomes from restoration or mitigation activities. Recovery crediting systems that are driven by regulation such as the Endangered Species Act, use criteria from national or state recovery plans for suitable habitat. The Habitat Suitability Index (HSI) approach uses existing habitat models or develops them based on best professional judgment of species’ habitat needs.

### **Guiding ecological principles**

The framework of habitat suitability for species is well established – both in the literature and in practice (Schamberger and O’Neil, 1986; Thuiller et al, 2010). The HSI, in conjunction with USFWS Habitat Evaluation Procedure, has been used in the U.S. for over 30 years (USFWS, 1980). Our review showed that the selection of attributes by the species-based metrics are rationalized and supported by both the large body of scientific research on habitat needs of specific species as well as the information/data outlined in federal and state recovery plans. For example, the State Wildlife Action Plan for the gopher tortoise described attributes (e.g. vegetation structure and type, soil substrate type, connectivity and disturbance regime) of optimal habitat quality needed for long-term species viability. These characteristics of optimum habitat provide performance standards against which to evaluate current conditions of proposed species recovery or conservation sites.

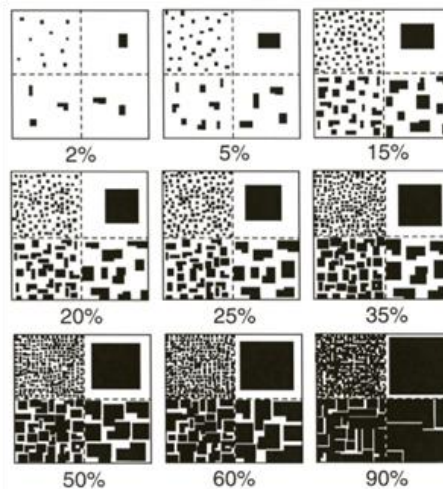
### How they work

Every aspect of a species-based approach stems from the known needs of a target species or suite of species. This starts with site selection; choosing a conservation site identified in a recovery plan or other conservation strategy. Quantitative assessment is focused on the site level, but addresses the spatial context of the site by evaluating attributes (e.g. connectivity to similar habitat, land use/cover, or adjacent lands) that support the potential range/distribution of the species. The spatial extent of surrounding conditions considered to be of influence on species viability is much larger for terrestrial species (how many acres/hectares) than for wetland species (e.g. suitable habitat within 300 feet for bog turtle).

Credits (or debits) are the unit output of many metrics, which are derived by applying an index of habitat quality to the project area. The index is a score of how well current indicators of habitat compare to the ideal. Measurement is actually the ranking of individual habitat attributes within quantitative classes of indicators. For example, to characterize percent canopy cover, the Utah Prairie Dog system uses 4 classes (0 – 3 %, 4 – 9 %, 10 – 15 %, and >16 %) and assigns a score to each of those classes.

Though the variables are quantitative, the measurements of habitat quality are not data points but data ranges. Data ranges may coarsen the characterization and analysis of habitat quality, but importantly, they:

- Limit the potential for inconsistencies and inaccuracies among users both spatially and over time; this is especially important in monitoring programs where different people will be required to assess the same attributes over a long period of time, in some cases 100 years; and
- Increase the usability of the metric as a measurement tool; field manuals can effectively assist assessors with widely varying levels of expertise to categorize attributes such as percent cover of vegetation using descriptions and diagrams of possible outcomes. See the example in Figure 1.



**Figure F.1.** Reference diagram for estimating percent cover from the Utah Prairie Dog Habitat Evaluation Guide (CITATION).

### **Monitoring and adaptive management**

For the most part, specifics on monitoring requirements are unspecified as many of these programs are still in the development or pilot project phases.

### **Strengths and weaknesses**

The species-based metrics are robust in their assumptions, conceptual framework, and approach to measurement. Indicators directly reflect a target species' ecological requirements, and management goals can be clearly defined. The approach is especially and obviously effective for conserving populations of threatened and endangered species.

The focus on the species level, however, is resource intensive. Recovery credit programs often cost more than \$100,000 to establish and require extremely rigorous monitoring and adaptive management programs to ensure their long-term success. The species-based approaches driven by Endangered Species Act compliance are generally not testing the potential effectiveness of using umbrella or keystone species as indicators of maintaining broader vegetation types.

### **Functions-based metrics**

A functional assessment focuses on the ecological processes necessary for the functioning of the ecosystem or ecosystem services (e.g. water regulation services from wetlands or salmon habitat from streams). The assessments reviewed here are extremely similar in approach. They use mostly rapid, visual assessments of ecological attributes to characterize both the on-site and surrounding-site processes considered essential to ecological function. The assumption is that the attributes they measure accurately and completely describe the ecosystem function being performed.

### **Guiding ecological principles**

To estimate the ecological function provided by a natural area, the measurable variables correlated with individual functions must be identified (Adamus et. al, 2009). Defining both the functions and their associated indicators for the ecosystems addressed in these metrics (wetlands, streams, upland prairie) are the result of peer reviewed literature and professional expertise. In some cases (e.g. Counting on the Environment's Upland Prairie Calculator), only habitat functions are captured, and there is a straightforward relationship between the service provided and how it is measured.

Many wetland functional assessments capture a range of functions, making them more complex. The metrics use mathematical relationships expressed as numerical models that translate ecosystem characteristics into an estimation of ecosystem function. The conversion of indicator estimates to estimates of functions - "aggregation procedures" - may take the form of scoring models or best professional judgment (Adamus et. al, 2009). For example, EcoMetrix calculates the functional score for "spatial separation" (SS) of a stream by combining estimates of aquatic structure (Daq), maximum water depth (MDpth), pool area (Pa), and a modifier (Hmod) depending on whether the assessment unit is an aquatic or terrestrial habitat type. Figure 2 shows the mathematical relationship used in the metric.

$$SS = [ (Daq + MDpth + Pa + Mutype) / 3 ] * Hmod$$

**Figure F.2. Functional equation used to calculate score for Spatial Separation function in Ecometrix.**

Because these assessments will be done rapidly, the challenge is to select a small number of meaningful indicators that will provide enough information about the functioning of the ecosystem at hand. At present, there is some effort to validate the conceptual models that these metrics are built upon. The challenge is that changes in function express themselves over long timelines, demanding robust adaptive management of functional assessments.

### **How they work**

The metrics considered here are applicable at a range of scales and dimensions, with sites delineated at anywhere from 1 acre (e.g. Oregon Rapid Wetlands Assessment Protocol (ORWAP) and the Universal Mitigation Assessment Methodology (UMAM) for small wetlands) to tens of acres (e.g. Prairie) to the full length of a salmon bearing stream (e.g. EcoMetrix). Many functions-based metrics have grown out of recognized deficiencies in existing mitigation programs. Moving from 1 credit = 1 acre to 1 credit = 1 functionally weighted acre captures more of the ecosystem benefits and impacts of a project.

Most functional assessments are focused on the site level, but often incorporate measures of landscape context. For example, UMAM requires the assessment of indicators such as “wildlife access to and from outside,” “impacts of land uses outside assessment area to fish and wildlife,” and “benefits to downstream or other connected areas” to evaluate the availability, connectivity, and quality of offsite habitats and of offsite land uses which might adversely impact fish and wildlife species utilizing these habitats. Spatial databases, maps, and aerial photography help characterize the ecological value of functions provided by an assessment area as influenced by its landscape position.

On-the-ground data collection is required for site level assessments. “Points” or scores are awarded based on the observed current condition of the indicator. Assessments produce ratings of the functional performance of a site relative to optimal function. For example, application of the UMAM metric gives a site score between 0 and 10 as a rating of the projected functionality of the site based on the impact or mitigation actions. A score of 10 signifies that the site provides optimal functions and is optimally located in the landscape to provide those functions. ORWAP gives a relative rating of the ability of a wetland to perform its functions with a score of 0 to 10 (10 being a theoretically “perfect”/ least altered wetland).

These levels of “optimal function” serve as performance standards for the metrics and are derived from the literature, from multiple data sampling of individual ecosystems, and from the professional judgment of natural resource scientists and managers who transpose their conceptual understanding of how these ecosystems work into representative, mathematical models. For example, the Scoring Worksheets that are part of the UMAM metric list “optimal”, “moderate”, “minimal”, and “not present” levels for each indicator that are both qualitative and quantitative descriptions of potential conditions of that indicator.

System dynamics are addressed in a variety of ways. Both ORWAP and UMAM include an evaluation of “risk” in the methodology. UMAM evaluates mitigation risk to account for the degree of uncertainty that the proposed conditions will be achieved by scoring an assessment area on a scale from 1 to 3. ORWAP evaluates “stressors,” natural and anthropogenic factors or features that diminish the levels of specific wetland functions. These are mostly subjective or qualitative evaluations.

### **Monitoring and adaptive management**

Most functional assessments were designed for use in mitigation site selection or in designing restoration projects and do not explicitly envision use as monitoring frameworks. Some functional assessments may not be sensitive enough to year-over-year changes to be used for monitoring. When they are used for mitigation purposes, performance standards may be tied to a subset of indicators tied to key functions. There is no documentation that they are tied to explicit adaptive management strategies.

### **Strengths and weaknesses**

There is broad consensus that measuring ecosystem function is important, but there is complexity inherent in these measurements that makes it challenging to interpret assessment results by an average user or field technician applying the assessment. For example, when EcoMetrix produces a result counter to expectations or best professional judgment, a user needs to dig into a web of inter-related functional equations to figure out what is driving that result. ORWAP addresses this to some degree by including all the functions that are related to a particular indicator on the score sheet. Yet, for the most part, the “cause and effect” between indicators and functions is obscure. This makes it difficult for landowners or conservation officers to design or adapt specific management practices to achieve specific results/gains on the land. The tradeoff for functional assessments lies in that space between the more textured description of ecosystem functions and values that captures more of the dynamics of a given site and the simplicity of a smaller set of attributes or measures that is easy to use and understand without much training.

### **Practice-based metrics**

Practice-based approaches are common across incentive and market programs. For example, USDA Farm Bill conservation programs provide incentives to landowners for activities that are projected to restore or enhance rangeland, cropland, forested lands, pasture lands, wetlands, streams, and other resources. Water quality trading programs sometimes use Best Management Practice (BMP) efficiency rates to pre-determine pollution removal rates.

### **How they work**

A practice-based assessment is founded on the assumption that a set of prescribed activities, implemented on the ground, will result in improvements in the quality of the ecosystem being managed. The USDA Farm Bill programs, designed to encourage landowners to manage their land in ways that produce environmental benefits, provide direct payments to landowners to “implement conservation practices that reduce erosion, protect our waters, improve fish and wildlife habitat, improve air quality, and conserve energy” (NRCS 2009). The NRCS works directly with landowners to develop a conservation plan that includes an approved suite of practices that will achieve specific environmental goals.

### **Guiding ecological principles**

The underlying assumption is that limited scientific research can be applied to predict sufficiently the environmental benefits that can occur from the implementation of conservation practices in the field. However, the relationships between resource condition and conservation activities are not very well documented (Hauffer 2007).

Farm Bill programs include Conservation Practice Standard documents and Conservation Effects documents that set out criteria for how the practice should be installed and provide information on how the application of a specific practice will likely affect the resources being managed (e.g. soil, water, air,

plants, wildlife). The guidelines are mostly prescriptive and reflect best practices for natural resources management according to NRCS. There is interest in trying to capture more measurable, site-specific biodiversity benefits from these conservation practices. For example, the current interagency Conservation Effects Assessment Project (CEAP) is focused on quantifying the effects of conservation practices on fish and wildlife species and communities.

### **Monitoring and adaptive management**

Conservation banking and other programs use tools like annual monitoring to ensure practices are complying with program criteria and generating their promised benefits. Farm Bill programs monitor the results of practice installation based on the unit associated with that practice (e.g. numbers of acres or feet treated, numbers of dollars spent). However, a systematic program to monitor the biodiversity benefits of conservation practices is not currently in place.

Monitoring plans are an explicit requirement of conservation banking agreements. Annual monitoring tasks assess the overall bank condition, including erosion, the presence of exotic or deleterious species, water quality, fire hazard, as well as other conditions that may require management action. Management plans stipulate an adaptive management framework, requiring the bank owner and operators to respond accordingly to variable conditions such as climate change, flooding and fire.

Long-term management plans require oversight of (1) biological resources, (2) security, safety, and public access, (3) infrastructure and facilities, (4) recreation, education and habitat restoration, and (5) reporting and administration. For biological resources, management plans require annual monitoring, and subsequent adaptive management, by a “qualified biologist” to review hydrology, soils, invasive or non-native species, and nuisance wildlife species (e.g. muskrat, beaver).

### **Strengths and weaknesses**

The main advantage of practice-based assessments lies in the relative simplicity of their application. The widespread adoption of conservation practices through Farm Bill programs and the rise of conservation banks as a key tool for species and habitat protection in the United States are reflections of the straightforward nature of this approach. The Benefit Cost Analyses of each of the Farm Bill programs conclude the implementation of these practices is improving conservation performance across the country.

Conservation banking similarly has ecological and biological advantages as a practice, especially due to the effects of large preserve sizes that consolidate compensation actions into one area, creating greater species connectivity and higher overall ecological function (Carroll et. al., 2008). The lack of direct measurement of ecological benefits, however, makes it difficult to assess the effectiveness, both from an ecological and cost perspective, of these practices.

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## Appendix G. Case Studies

### **Vegetation case study: Ecosystem Mitigation Approach** (Ecosystem Management Research Institute, 2009)

Sagebrush habitat faces a wide range of threats, from conversion to agricultural land, energy development pressures, overgrazing and drought. Conservation actions, including mitigation, that will result in long-term, verifiable recovery of sagebrush ecosystems is needed. The Ecosystem Mitigation Approach was developed as a mitigation metric system that quantifies off-site ecosystem services or biodiversity benefits produced to offset impacts from development in sagebrush ecosystems in a scientific and reproducible way.

#### The roots: Classes of indicators

The method uses NRCS Ecological Sites as a framework for classifying the ecological diversity of a proposed development site and corresponding mitigation site. For a target area within an ecological site, existing conditions are quantified and then compared to a reference plant community to determine how much restoration would be required in order to mitigate impacts. The reference conditions, or historical disturbance states, are derived from ecosystem site descriptions, NRCS species responses to disturbances (<http://plants.usda.gov/>), literature sources, and best professional judgment of range ecologists.

The use of reference sites is an important conceptual underpinning of the Ecosystem Mitigation Approach. A reference site for a particular ecosystem type represents a complete ecosystem – one that includes the presence of all appropriate components (e.g. species), structures (e.g. heights of vegetation) and processes (e.g. nutrient cycling or disturbance response). According to metric developers, complete ecosystems possess ecological integrity because they support a biota that is the product of evolutionary and biogeographic processes with minimal changes from human impacts. These reference sites serve as performance standards for the metric.

Proposed mitigation sites are evaluated at both the site and landscape level. Existing plant communities in the project area are mapped using existing spatial data (e.g. Gap Analysis Program data) and systematically sampled for vegetation attributes such as percent cover and height classes of native and exotic plant species, and abiotic attributes such as soil texture, elevation, slope gradient and slope complexity attributes.

One of the main objectives of the measurement system is to ensure that equivalent off-site habitat benefits can be produced to offset impacts from development. An ecological site impacted by development in one area may not produce the same wildlife benefits through ecosystem restoration in an off-site mitigation area due to landscape effects. For example, a site in one geographic location may be highly valuable to a species because of the proximity of specific habitat components, whereas in a different location without those habitat components, a very similar site would be of much lower value to the species. Mitigation sites, therefore, are evaluated at the landscape scale using habitat suitability models for selected wildlife species to determine projected changes to wildlife habitat as a result of impact or mitigation practices. Surrounding plant communities, terrain, human developments, or other land characteristics can all influence the value of each site to a particular wildlife species.

Individual practices are not specified, however, one of the findings of the Ecosystem Mitigation Approach work is that the preferred reference condition for sagebrush ecosystems is one that is characterized by a long fire-return interval with light grazing by ruminants. Management goals and

practices that lead ecosystems toward this historical disturbance state would be encouraged. Risk and viability are not explicitly addressed except to recognize the potential role that invasive exotics, especially cheatgrass, have on reducing the ecological integrity of a site.

The soil horizons: *Turning indicators into metrics*

The Ecosystem Mitigation Approach takes a vegetation-based view of conservation. It assumes that good quality sagebrush condition will sustain the range of ecosystem services provided by that ecosystem type including habitat for sagebrush-obligate species. It quantifies existing conditions at a specific location by scoring individual indicators (described above) and rates the quality of this location relative to a reference plant community for each ecological site.

Based on value of the indicators assessed on the ground, a similarity score for ecological integrity between 0 and 1 is calculated that measures a sites' departure from the historical disturbance state. Raw scores are adjusted based on the percent cover of exotic species in a site to produce an Adjusted Ecological Integrity Score.

The trunk: *Metric*

Biodiversity benefits are calculated as credits. The amount of mitigation produced through potential restoration is calculated by multiplying the Adjusted Ecological Integrity Score by the acreage of each ecological site to product "credit units". Planned development activities that reduce the ecological integrity of a site and thus its level of ecosystem services are calculated as "debit units".

The branches: *Validation and ongoing revisions*

The metric system is currently being tested at 7 different sites across the west where mitigation treatments are being applied and monitored, however, results are currently unavailable.

The leaves: *Program design*

The Ecosystem Mitigation Approach is a project of the Cooperative Sagebrush Initiative – a coalition of western land users promoting conservation of the sagebrush biome. The goal is to develop a sagebrush credit trading system that will reward verifiable conservation practices and provide a reliable bank of mitigation opportunities for landowners, industry, states, and others. It is anticipated that the Ecosystem Mitigation Approach will be the measurement system used to calculate credits and debits within the credit trading system. Program developers acknowledge that the use of a metric compared to a standard provides for consistency and reproducibility in quantifying impacts and mitigation values – both essential if a credit trading system is to be developed for sagebrush ecosystems. Details about site selection, quantifying conditions, verification and adaptive management programs have not yet been articulated.

Though it has not yet been used in actual mitigation assessments, nor is it tied to any existing crediting platform, the Ecosystem Mitigation Approach is promising. It is rigorous, connects local and landscape level metrics, is soundly based in the science of sagebrush, and relies on standardized habitat classifications from NRCS. The biggest challenge is the approach's start-up costs. NRCS ecological sites are not defined for all habitat types across the country, and habitat suitability indices are not built for all target species. Another challenge is the intensity of field data collection required to implement the Ecosystem Mitigation Approach.

## **Universal Mitigation Assessment Methodology**

(Florida Department of Environmental Protection, 2004)

The Universal Mitigation Assessment Methodology (UMAM) is a standardized, functions-based, rapid assessment developed primarily for mitigation of impacts to wetlands and surface waters (also applicable to several terrestrial habitat types) in the state of Florida. Mitigation actions include the preservation, enhancement, restoration, and creation of habitat. The methodology scores an assessment area between 0 and 10 (10 being ideally located and providing full opportunity of a site to perform functions) and gives a rating of the projected functionality of the site based on the impact or mitigation actions planned.

### The roots: Classes of indicators

UMAM is carried out in two parts. In Part 1, a Qualitative Description establishes a reference baseline for comparison of the assessment area to the optimal condition and location of that native community type and considers landscape level characteristics such as connectivity, regional significance of project area, and anticipated wildlife use.

Part 2 includes a Quantification of the Assessment Area (AA) that numerically scores sites based on a suite of ecologically significant attributes. “Location and Landscape Support” quantifies the value of ecological function supplied by an assessment area by scoring attributes such as invasive exotic plant species in proximity to the AA, impacts of land uses outside the AA, wildlife habitat area adjacent to the AA, and protection of wetland functions by natural areas or mitigation sites upland of the AA.

At the site level, the methodology assesses both vegetation and abiotic characteristics. “Vegetation and Structural Habitat” measures characteristics such as species composition of different canopy layers, age and size distributions, invasive exotics, and regeneration and recruitment. Evaluation of abiotic characteristics includes topographic features such as refugia, ponds, creek channels, flats or hummocks, nutrient loading, soil moisture, erosion and deposition. The assessment of the “Water Environment” includes water flows in and out of the AA as well as aquatic characteristics such as hydroperiods.

The metric evaluates functional performance of the AA for fish and wildlife species in terms of providing cover and refuge (e.g. breeding, nesting, denning, and nursery areas), corridors for wildlife movement, food chain support, natural water storage, natural flow attenuation, and water quality improvement which enhances fish, wildlife, and listed species utilization.

Evaluation of land management practices (e.g. mowing, grazing, fire suppression and water control features (furrows or ditches), as well as logging operations) in and around the assessment area is made based on their potential to positively or negatively affect the condition of the plant community over the long term.

The methodology is notable for the application of “risk” modifiers for time lag for recovery and potential risk of project failure. Once an evaluation of the AA has been completed, its functional score is further weighted according to 1) the amount of time that will elapse between development and offset activities, and 2) the level of risk associated with degree of uncertainty that the proposed conditions will be achieved, possibly resulting in a reduction in the ecological value of the mitigation area.

The soil horizons: *Turning indicators into metrics*

The UMAM is a functions-based method that derives indices of wetland functions and values from quickly and easily observed characteristics of a wetland. These surrogate indicators of ecological function are individually scored on a scale of 0 to 10 that describes how close to optimal a wetland functions such as wildlife habitat, water supply, flood water mitigation, etc... Scores are averaged with that number used as a multiplier against the size of the assessment area to calculate the number of functional wetland acres.

The trunk: *Metric*

Biodiversity benefits are expressed as functional acres. By calculating the mathematical difference between the current condition and with-impact or with mitigation conditions, the degree of ecological change or functional ecosystem gains and losses in an assessment area can be determined. Within the wetland mitigation banking system in Florida, the currency sold by the banker to the impact permittee is a “credit”, which represents the wetland ecological value equivalent to the complete restoration of one acre.

The branches: *Validation and ongoing revisions*

The methodology has been calibrated by the US Army Corps of Engineers in 19 counties in Florida using 81 test sites. It is currently (2010) undergoing field-testing with the Florida Audubon Society who is in the process of making recommendations for improvements.

The leaves: *Program design*

UMAM was developed by the Florida Department of Environmental Protection and the four state water management districts as a tool for addressing requirements for compensatory mitigation to impacts to wetlands within the state mitigation service area.

Site selection - Mitigation banking sites are located in Florida’s mitigation service area. The rules require the Florida Department of Environmental Protection (FL DEP) or the water management districts to establish a mitigation service area for each mitigation bank permit.

Quantifying Conditions - UMAM captures significantly more information about a site than most other wetland mitigation approaches around the country, but does so in a way that is consistent across users and less complicated to apply than other metrics. Monitoring takes place both for permit compliance and for adherence to the mitigation plan.

Verifying conservation effects - When an applicant proposes mitigation for impacts to wetlands and surface waters as part of an environmental resource permit or wetland resource permit application, the applicant submits all necessary supporting information. Water management district staff reviews hydrologic, land use, wildlife, soils and other technical information, conducts site visit and makes the final determination on UMAM scores.

Adapting Programs - Limited information is available about the adaptive management process that may be in use to improve and refine the effectiveness of UMAM.