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

Willamette Partnership

A report funded by the U.S. Department of Agriculture Office of Environmental Markets

April 2011

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.

Contact:

Bobby Cochran, Willamette Partnership
2550 SW Hillsboro Hwy
Hillsboro, OR 97123
503-681-5112
info@willamettepartnership.org

Acknowledgements: Measuring Up was funded by the USDA Office of Environmental Markets and guided by a stakeholder Technical Group made up of very knowledgeable and dedicated people and organizations listed in Appendix B.

The Willamette Partnership thanks everyone for all the hard and thoughtful work that has brought years of experience and discussion into Measuring Up.

Table of Contents

Executive Summary

The actions taken on private lands by farmers, ranchers, and foresters and on public lands by government agencies have an enormous influence on America's biodiversity. Biodiversity is a key component to a healthy natural environment, which can supply the ecosystem services that sustain our economy and human health. Billions of public and private dollars are invested in the United States each year to incentivize management practices that preserve and enhance biodiversity. Despite these financial flows the United States is not meeting its conservation goals, and multiple groups, from conservation practitioners to biodiversity market participants, are calling for better approaches to improve the effectiveness of conservation investments.

This report, prepared for the U.S. Department of Agriculture (USDA) Office of Environmental Markets, focuses on two areas of action that could help improve effective investments for biodiversity: 1) Standardizing systems for measuring the outcomes of current incentive programs, and 2) Providing options for how federal agencies and others might support biodiversity incentives, particularly markets for biodiversity. The report also addresses Section 2709 of the 2008 Farm Bill, which directs USDA to provide guidance and support for market-based approaches to engage more landowners in conservation.

Standardizing Measurement Systems for Biodiversity

Emerging environmental markets, in tandem with existing incentive programs, have the potential to make effective contributions to conservation, but little is known about how these programs quantify biodiversity. Measuring biodiversity involves selecting a set of indicators, turning those indicators into 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 the validity of the metric. This report refers to all of these activities as a *measurement system,* and describes it in detail in Section II.

For this report, the Willamette Partnership surveyed a sample of 35 measurement systems used to measure biodiversity for a broad range of purposes. From this sample, common themes and best practices for measurement were analyzed to: A) identify the elements of a good biodiversity metric, and B) build a process that develops and validates biodiversity metrics. As part of this analysis, a large volume of information was compiled for each measurement system reviewed. These data are available in spreadsheet format on the Willamette Partnership's website (www.willamettepartnership.org/measuring-up/).

A good biodiversity metric, in part, is defined as one that:

A. Incorporates the landscape context of the site (e.g. location in a priority conservation area, potential threats, connectivity, patch size);
B. Is valid (e.g. repeatable, sensitive, accurate, and transparent);
C. Is practical, economical, and easy to use by multiple incentive programs; and
D. Can be applied at different scales (e.g. can be used on 10,000 acres just as well as 1 acre).

Building a measurement system that improves how conservation investments are made is an iterative process. Section III defines the need for a national framework and standardized process to guide how biodiversity measurement systems are constructed. Within that national framework though, regions and localities need the ability to customize measurement systems to their unique natural, political, and economic environments. These measurement systems must also be responsive to new information, providing a systematic process for adaptive management.

Supporting More Effective Biodiversity Incentives

To be successful, the best measurement systems need to operate in a supportive environment, with a good program design, and well-planned program operations. The bulk of this report (Sections II and III) focus on the elements and processes needed to build sound measurement systems. Sections IV and V address the second objective of this report, which is to provide options for how federal agencies and their partners can better support effective biodiversity incentive programs. These sections focus particularly on market-based approaches for conserving biodiversity, but the options are intended to apply across different incentive programs.

These options, developed by a Technical Group of experts involved directly in building biodiversity markets around the United States, include the need to:

- Provide tools to local areas to assess incentive program readiness and feasibility;
- Clarify regulatory guidance on biodiversity markets;
- Enable high quality biodiversity measurement systems;
- Provide technical assistance to groups developing measurement systems;
- Facilitate sound program design;
- Kick-start more real world examples of biodiversity markets and incentives; and
- Engage public and private sectors to help biodiversity incentive programs succeed.

Successful implementation of the ideas presented in this report would lead to more nationally consistent measurement of biodiversity outcomes across incentive programs. There would be tools that could help answer questions like, “What is the result of the nation’s collective investment in conservation?” or “How can existing programs be targeted to improve their effectiveness?” This report has been produced for the USDA Office of Environmental Markets, but turning these options into reality would take concerted effort from the Department of the Interior, the Environmental Protection Agency, and other federal agencies working in close partnership with private organizations vested in the conservation of our nation’s natural resources.

I. Purpose, Problem Definition, and Methods

Over 60 percent of land in the United States is privately owned (Lubowski, 2006), and the majority of habitat for federally listed species is found on private land (GAO, 1994). Landowners therefore have an essential role to play in biodiversity conservation, the maintenance of ecosystem processes, and the preservation of threatened and endangered species. The U.S. Department of Agriculture (USDA), as one of the primary interfaces between private landowners and the Federal Government, helps to sustain and improve stewardship of working private lands for the benefit of fish, wildlife, clean water, clean air, and other ecosystem services. U.S Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration Fisheries, and other federal agencies also play an important role in biodiversity conservation.

''(a) TECHNICAL GUIDELINES REQUIRED.— The Secretary shall establish technical guidelines that outline science-based methods to measure the environmental services benefits from conservation and land management activities in order to facilitate the participation of farmers, ranchers, and forest landowners in emerging environmental services **markets."—**Section 2709 of The Food, Conservation, and Energy Act of 2008 H.R. 2419

Each year, USDA spends millions of dollars in direct payments for the biodiversity sources these lands supply (Casey et. al., 2006). Farm Bill programs like the Environmental Quality Incentives Program, Wildlife Habitat Incentives Program, Wetlands Reserve Program, and Conservation Reserve Enhancement Program provide cost-share and rental payments to landowners to improve and provide habitat. The U.S. Forest Service's Forest Legacy Program, also under USDA, spent almost $80 million in fiscal year 2010 to protect private forestlands (USFS, 2010).

Across the United States and in other parts of the world, conservationists have gained valuable practical experience on how to effectively target incentives to make conservation a valuable proposition across landscapes. The key objective of this report is to address Section 2709 of the 2008 Farm Bill, which states the need for USDA to provide guidance and support in helping market-based approaches engage more landowners in conservation. This report provides principles for designing more effective measurement systems for biodiversity and provides a variety of options for federal agencies, local governments, and private organizations engaged in conserving biodiversity across the United States.

The report is divided into five sections. Section II provides a framework for how biodiversity benefits can be measured over time and across scales for incentive programs from endangered species conservation banking to the Wildlife Habitat Incentives Program (WHIP). This framework is based on A) a review of 35 different measurement systems in use across the world that quantify biodiversity benefits for markets and other incentives, and B) comments from a 20-member Technical Group representing leading practitioners in biodiversity markets. The framework describes the tensions inherent in measuring biodiversity, the indicators needed to understand good quality habitat, and the points during an incentive program's implementation where science can help improve decisions.

Section III introduces a standard process for building a high quality measurement system to operationalize the principles described in Section II. The process moves from when and how to involve stakeholders and experts, to the ongoing sustainability of a measurement system. Science and good measurement is only half the battle though. To really get more and better conservation, an incentive program's design needs to consider elements like regional conservation goals, policy priorities, how to deal with risk, and other factors. Section IV provides options for optimizing program design. The report closes with Section V and a description of how the options in the report might be quickly applied in two place-based applications: Sagebrush-dominated ecosystems in the interior west and longleaf pine-dominated ecosystems in the southeastern United States. These are two areas where multiple agencies and producers are actively applying science to target Farm Bill investments and design regional market-based approaches to biodiversity conservation. This document is intended to be living and will be updated as new lessons and information become available. It lays the groundwork for more detailed technical guidance that USDA agencies and others might provide to practitioners across the country striving to enhance conservation through incentive and market-based approaches.

1.1 Methods

The tools and options included in this report are drawn from a review of 35 biodiversity measurement systems used in incentive programs across the world and from expert feedback provided by a Technical Group of practitioners developing and implementing these measurement systems. The Technical Group members are drawn from the fields of conservation, natural resources sciences and regulation, and ecosystem services markets (see Appendix B for Technical Group list).

The Measurement Systems Review builds upon recent work that analyzed existing habitat measurement systems for use in biodiversity markets (Vickerman et. al, 2009). The list of candidate measurement systems for our analysis was expanded through 1) a review of current reports on biodiversity conservation initiatives worldwide, 2) suggestions from Technical Group members, and 3) the results of a systematic Internet search. The criteria for including a measurement system as a candidate for review were its potential for contributing to science-based methodologies and performance standards that could be used to assess terrestrial or aquatic habitat and biodiversity. The 35 candidate measurement systems meeting these criteria were reviewed by the Technical Group, who identified the most promising subset of systems (Tier 1). The 25 Tier 1 measurement systems were those that:

- Had some level of credibility, constituency, or proven use increasing their likelihood of adoption;
- Struck a balance between the complexity of ecosystems and the practicality needed for implementation and eventual use in a market; *and*
- Included some element that provided lessons for other measurement systems.

Tier 1 measurement systems were analyzed against criteria, including rigor of ecological principles employed, scale of application, sampling procedures used, usability, and program administration (see Appendix C for the full list of criteria). The analysis by measurement system is presented in Appendix D. Detailed analysis was captured in an Excel database and is a resource for anyone wanting to compare measurements systems or find a model for their own measurement systems. This database is available on the Willamette Partnership's website alongside downloadable versions of this report and its appendices.

The Measurement Systems Review also paid special attention to metrics in use in the U.S. species conservation banking program[1] (see Appendix E for a detailed assessment of conservation banking). In the course of exploring these systems, it became clear that there exists a mix of terminology generated by the different origins and intended use of each of the metrics. In order to use consistent and unifying language to describe biodiversity metrics and incentive programs, a glossary is included that integrates definitions of some key terms used in the report (Appendix A).

This analysis of 25 Tier 1 measurement systems informed best practice issues and options from the Technical Group for developing robust measurement systems for biodiversity markets and incentive programs in the U.S.

[1] Conservation banks are lands conserved for species that are endangered, threatened, candidates for listing, or are species-at-risk. In exchange for permanently protecting the land, the U.S. Fish and Wildlife Service approves a specified number of habitat or species credits that bank owners may sell. Developers or others who need to compensate for the adverse impacts their projects have on species may purchase the credits from conservation bank owners to mitigate their impacts (USFWS, 2009).

II. Applying Good Science to Improve Biodiversity Investments

For the purposes of this report, ***biodiversity*** refers to the full spectrum of native plants, animals, and ecological processes, including but not limited to species and communities that are at risk. Ecologists measure a wide range of variables to describe species population status and trend, habitat conditions, and ecological processes, as well as biodiversity values of a given area. Collectively, this report calls these ***biodiversity benefits***. Due to the complexity of biodiversity and the difficulty of directly measuring it, practitioners have chosen to work with observable proxies for these benefits. The differences in existing measurement systems emerge as they select different proxies (e.g. vegetative cover or presence/absence of a species).

2.1 Balancing Measurement Complexity and Usability; Standardization and Customization

Ecosystems are complex, and our ability to measure ecosystems has come a long way in being able to describe and measure that complexity. To inform program design for biodiversity markets and other incentives, however, our scientific knowledge needs to be organized in a way that is usable. At a minimum, measurement systems need an ability to derive project-level measurements both rapidly and yet consistently and accurately from indicators that distinguish high quality from low quality biodiversity habitat. Program participants, meanwhile, need to be able to understand how a measurement system works and be able to use it for land management decisions. Selecting a measurement system that only a computer or person with a PhD in conservation biology can readily apply or interpret will not meet the needs of decision-makers or the people working most closely with landowners to implement conservation projects. In short, a measurement system for an incentive-based program should be sensitive to biodiversity change on both public and private lands, as well as being cost-effective, simple, and easy to use.

Scale considerations in measuring biodiversity benefits are both important and complex. Most landowner decisions are made on an individual field or property, yet biodiversity operates at a range of scales, from the parcel to the Ecoregion. To produce biodiversity benefits, the same measurement system needs to operate effectively at both the large scales at which nature functions and the smaller scales at which land management decisions that affect nature are made.

A measurement at one scale could contradict a measurement at another and it will never be possible to accurately account for each scale of importance. Therefore, the best biodiversity

Quantifying and verifying the biodiversity benefits of any one project or incentive program is nearly impossible to do directly.

measurement system will use the most appropriate scales for the biodiversity of interest, and account for interactions between these scales. Scale considerations present one of the most difficult challenges to overcome due to the increasing complexity they create. Existing systems for measuring biodiversity are not at the point where any one system can accurately capture biodiversity dynamics at landscapes and at sites, but moving toward more consistent measurement is an important step that will help improve the effectiveness of conservation investments.

Ecosystems are changing in increasingly unpredictable ways (Folke et. al., 2004; Millennium Ecosystem Assessment, 2005). Measurement systems need to support immediate decisions with information that is "close enough" and incorporate new information over time in order to adaptively improve those measurements. Focusing on the development of rigorous, useful measurement systems leads to a set of principles for measurement and incentive program design. One such starting point is a suite of best practices that can create tiered levels of information allowing the customization of a measurement system to localized conditions and new information.

Additional principles are listed in Table 2.0.

Table 2.0. Characteristics of a good biodiversity measurement system for incentives[2]

A. Encourages priority actions in specific locations consistent with regional conservation plans or strategies

B. Describes both current habitat quality and projected gains or losses in biodiversity from actions taken

C. Incorporates the landscape context of the site (e.g. location in a priority conservation area, potential threats, connectivity, patch size)

D. Is Valid:
   - i. Repeatable (i.e. if two people apply the metric to the same land, they get the same answer)
   - ii. Sensitive (i.e. Not all lands score the same, with differences reflecting actual variability in the biodiversity indicators being measured)
   - iii. Accurate (i.e. "good" sites score well; "bad: sites score poorly)
   - iv. Transparent (i.e. easy to understand indicators and relationship of indicators to an overall score)

E. Is practical, economical, and easy to use (e.g. can be applied on relatively small acreages by a trained technician in a day or two as appropriate to a program's objectives)

F. Is usable across multiple land and water ecosystem types

G. Provides tiered degrees of rigor to allow for uses across incentive programs and compliance markets

H. Plugs neatly into programmatic evaluations of effectiveness and national information on status and trends for biodiversity

I Is posted in the public domain for use by anyone without charge

[2] Adapted from Oregon SB 513 Working Group Report http://www.oregon.gov/OWEB/docs/SB513_final_report.pdf ; and Noss, 1990; Prahbu et.al,, 1999 (p 18).

2.2 A Framework for Building and Sustaining a Biodiversity Measurement System

The following sections describe the elements needed to quantify the biodiversity benefits of different conservation actions. The framework seeks to strike a balance between the tensions described above, providing standard elements where possible, and providing options where local flexibility is needed.

We use the analogy of a tree (see Figure 2.2), with its component parts, to describe how these different elements fit together in a system that selects a set of measurable indicators, turns those indicators into a metric that communicates the overall quality and function of land for biodiversity, validates the scores produced by the metric, and for incentive programs, places the metric into a program that reinforces the validity of the metric.

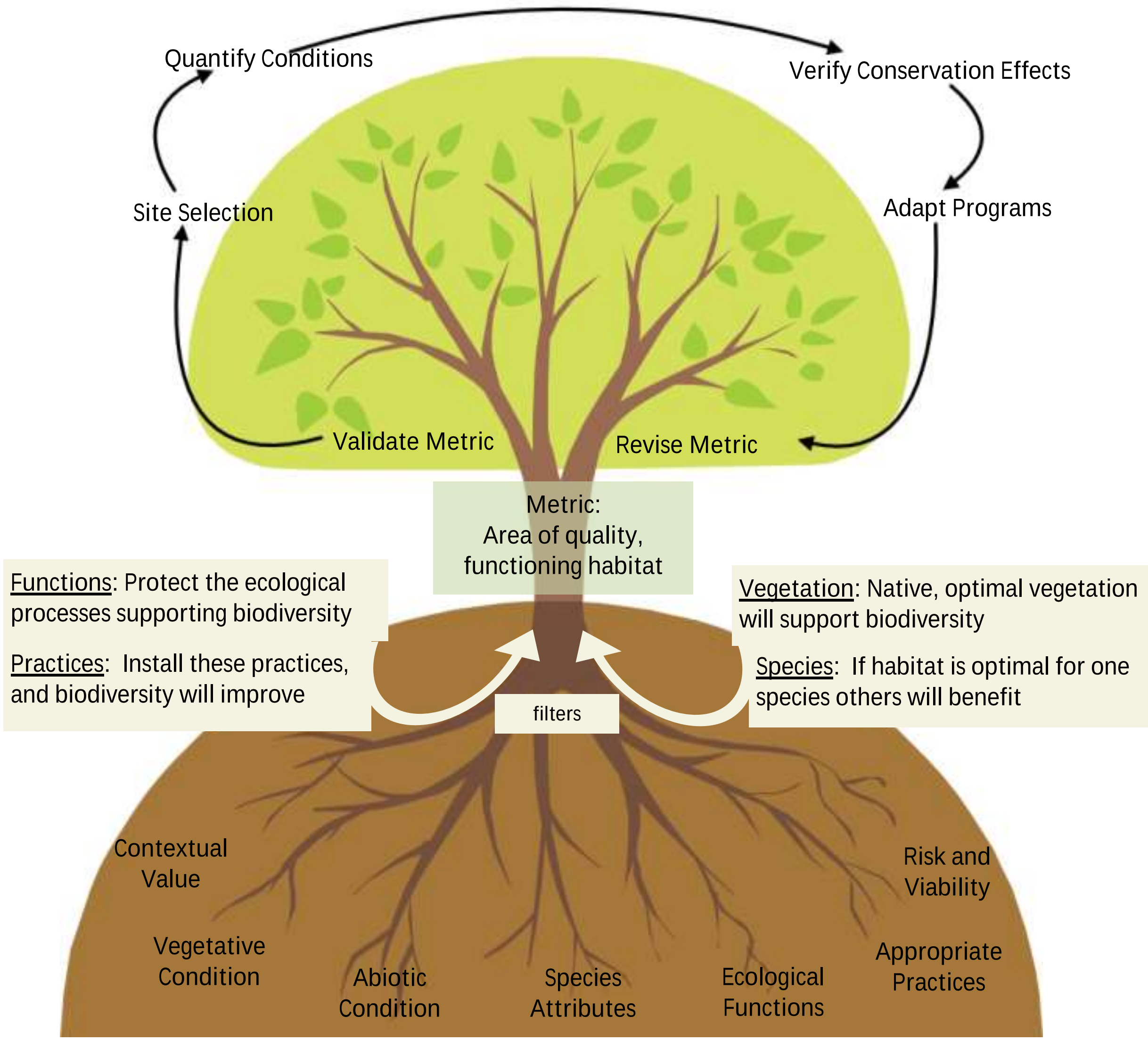
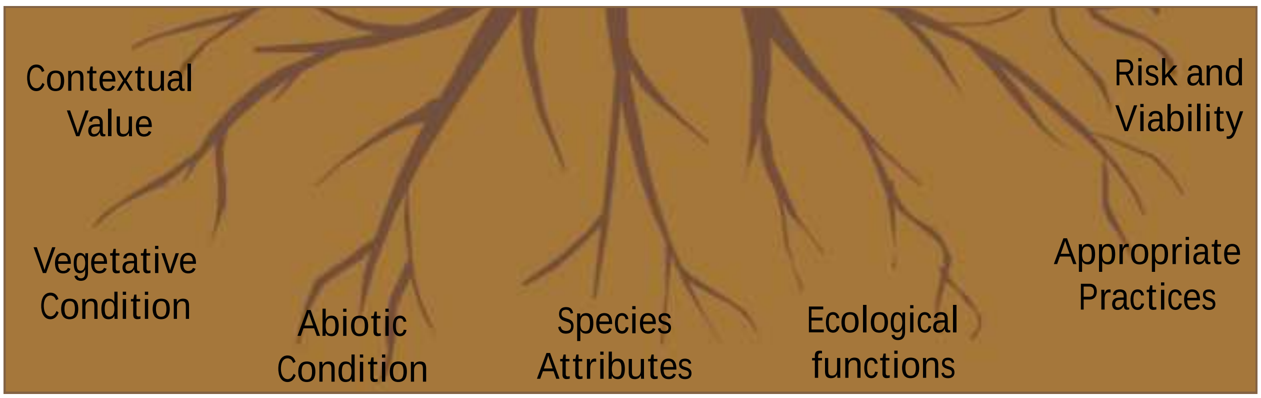


Figure 2.2: A framework for building and sustaining a biodiversity measurement system

2.2.1. The Roots leading to a Metric: Classes of Indicators

One can think of the roots of this tree as the classes of indicators that make up and lead to an overall metric for habitat quality and function. A good habitat metric should include measures from most if not all of these indicators.



A. <u>Contextual Value</u> (the value of a site to the broader landscape): Patch size, connectivity, and surrounding threats and stressors all affect the ability of any site to provide the supporting biodiversity functions needed for good habitat. Existing regional conservation strategies often synthesize this information into priority areas and actions for biodiversity.

A metric should be rooted in regional conservation strategies that make some effort to define conservation goals and targets. The best strategies will define spatially explicit areas on which to focus investment and areas on which to focus development so as to reduce impact. These two factors combined can lead to an increased net benefit to biodiversity.

A good set of focal or priority areas should fit most of the criteria below:

- Be based on overall conservation benefit, not just singular benefits for water, air, or biodiversity;
- Be mapped at a resolution necessary to make decisions between investment options;
- Have undergone some level of stakeholder review; and
- Have procedures in place to incorporate new information.

No metric should assess habitat quality on a single site in isolation from its surrounding landscape.

B. <u>Vegetative condition</u>: Vegetation is often one of the most visible indicators of the quality of habitat. Attributes such as percent cover, species composition, age classes of different strata, and other factors provide a lot of information about habitat condition. Most vegetation indicators are benchmarked to optimal or desired conditions (e.g. historic vegetation or current reference condition).

C. Abiotic condition: Soils, climate, and other abiotic factors have a significant influence on both habitat quality and the resilience of habitat condition over time.

D. Species attributes (populations & suitability of habitat for particular species): Many metrics start with an umbrella or keystone species (or group of species) and define optimal habitat for those species. In addition to the indicators already described, species-specific indicators may look at presence/absence of a particular species, population numbers, and features such as nesting structures or refugia that support species viability.

E. Ecological functions (evaluation of ecological processes): Increasingly, conservation biologists are examining ecological processes as the key to understanding habitat. If underlying processes like hydrology, natural disturbance regimes, and nutrient cycling have been altered, the condition and diversity of the habitat is more likely to change or decline over time. Measuring these processes has become easier in recent years as ecologists have defined more accurate proxies using visible indicators measured either on the ground or with spatial data from a landscape. Many of the 25 Tier 1 measurement systems reviewed try to capture the dynamics of ecological processes.

F. Appropriate Management Practices (whether the site is being managed suitably): The installation of a particular management practice or group of practices is a common proxy indicator of habitat quality. For practice-based indicators, there is an assumption or background knowledge that a particular practice will generate a specified biodiversity benefit. It is one of the most straightforward types of indicators to track over time, but relies heavily on the known effectiveness of practices. For simple actions (e.g. riparian forest planting), or where a scientific knowledge gap exists (e.g. floodplain reconnection), practice-based indicators can be useful. For more complex actions (e.g. restoring wetland hydrology), practice-based indicators may hide nuanced effects of an individual project.

G. Risk and Viability (site's likelihood to continue supporting biodiversity benefits over time): Many of the 25 Tier 1 measurement systems reviewed do not directly include indicators of risk and viability. In a world of invasive species, land conversion, and climate change, the long-term viability of a particular project is paramount. Risk can be assessed by looking at surrounding road densities, population growth rates, legal protection of the land, disease, genetic diversity, etc.

In a world of invasive species, land conversion, and climate change, long-term viability of a particular project is paramount.

Table 2.2.1 below presents sample measurements for the indicator classes listed above. The data collected for a particular program will depend on the objectives or requirements of those programs, but the many of the of the 25 Tier 1 measurement systems looked at similar indicators.

Table 2.2.1. Sample measurements for indicator classes

Indicator Class	Sample Measurement (s)
CONTEXT	
Connectivity	Proximity index; Historic and current vegetation maps
Priority	In a mapped priority (e.g. State Wildlife Action Plan, Ecoregional Plan)
Surrounding land use	Distance to each surrounding land use type
VEGETATION	
Natives	Terrestrial: % cover by strata or species, age classes, stem counts/density, species richness, target plant species presence Aquatic: % cover emergent/submergent/floating/other vegetation
Non-natives	% cover, invasive species presence
Bare ground	% cover
ABIOTIC	
Hydrology	Flow, depth/period of inundation, stream morphology, special features (e.g. springs, vernal pools, groundwater, open water/ponded)
Soil	Type, litter/duff layer depth, texture, drainage, erodability, stream
Geographic Features	Elevation, aspect, slope, microtopography
Disturbance	Fire return interval, wind regime, disease, flood regime
Climate	Precipitation
SPECIES	
Targets	Richness, presence, species counts, access to the site
Features	Sage, nests/dens, large wood, boulders
PRACTICE	
Crops	Irrigated/non-irrigation, type and rotation, soil conditioning
Inputs	Water, fertilizer, pesticide, phosphorous index/corn stalk nitrate
BMPs	List of practice implemented
Human Disturbance	Use, fragmentation, pollution
RISK	
Threats	Predators, invasive plants and animals, roads
Stewardship	Legal protection/ownership, existing use, ability to burn/flood

2.2.2 The Soil Horizons: Filters that Form indicators into a Metric

Following these indicator "roots" toward the trunk, indicators are filtered through underlying assumptions that shape how the indicators are organized into a metric. Many metrics are formed from the same indicators. Differences among metrics emerge based on the assumptions built into that metric, objectives of the specific program for which the metric is being used, and constraints that shape the organization of indicators into a metric. For any metric, different assumptions might be applied to different indicators. In reviewing 25 measurement systems, four dominant sets of assumptions emerged (See Table 2.2.2).

Table 2.2.2: Filters that Form Indicators into Metrics

Assumptions, Uses, Filters, Etc…	Vegetation	Native, optimal vegetation will support biodiversity
	Species	If habitat is optimal for 1 species, others will benefit
	Functions	Protect the ecological processes supporting biodiversity
	Practices	Install these practices, and biodiversity will improve

When indicators get filtered through one set of assumptions over another, different indicators are included and may be given different weights in the overall metric of habitat function. This "filtering" results from algorithms, weighting factors, logic rules and other ways a metric aggregates information from individual indicators into an overall index score for an area of high quality, functioning habitat. The four sets of assumptions are described below. In practice, different assumptions dominate at different stages of program implementation (such as site selection, benefit quantification, or ongoing verification and tracking). A detailed description of each assumption set is provided in Appendix F.

Vegetation-based metrics: A large number of metrics use the condition of vegetation as a proxy for habitat quality, comparing a project area to reference sites, states, or benchmark conditions. Vegetation-based metrics often assume that the natural or historical[3] composition and structure of vegetative communities are optimal for supporting the range of naturally occurring wildlife. 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 which becomes multiplied by the number of hectares conserved or impacted to produce a *habitat hectare*. The vegetation-based 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 approach), providing a framework to determine the attributes or characteristics of a reference state.

Many metrics use the condition of vegetation as a proxy for habitat quality.

[3] There is debate on what constitutes "historical" and even if historic vegetation is an appropriate reference point for current habitat and species dynamics.

When to use a vegetation-based approach
When the biodiversity functions of a site are tied very closely to vegetation, it makes sense to use a vegetation-based approach. For example, sagebrush cover and composition may be a more important indicator of healthy habitat than hydrology or other ecological processes. Vegetation-based approaches also make sense when an ecosystem type is rare and proximity/ connectivity of a site to remnant patches of similar, native vegetation is a driving factor defining habitat quality. In very dynamic systems such as floodplains, indicators of ecological disturbance regimes should be added to vegetation condition to assess habitat quality.

Species-based metrics: There are two general types of species-based metrics. In the first, most species-based metrics focus on the ecosystem characteristics that define ideal or optimum habitat for one or more target species. The metrics rank existing habitat relative to optimum conditions or relative to projected outcomes from restoration or mitigation activities. Habitat crediting systems that are driven by regulation such as the Endangered Species Act (ESA) 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. 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 the USFWS Habitat Evaluation Procedure, has been used in the U.S. for over 30 years (USFWS, 1980). In the second, metrics directly measure the presence or absence of a target species (e.g. Doherty et al., 2010), assuming that if individuals of the species occur on a site, then the site must be quality, functioning habitat. Both approaches are often used in combination with each other.

When to use a species-based approach
Species-based approaches can work well when a keystone or umbrella species associated with an ecosystem is also tied to a clear driver of demand or interest (e.g. an ESA listing). Species-based approaches often do not capture overall biodiversity benefits well when they target only the rare or sensitive species. In many cases, the relationship between habitat conditions needed for an indicator species as a proxy for overall biodiversity benefits is poorly understood. Conditions benefiting a keystone or umbrella species should be more likely to capture broader biodiversity benefits. There are cases when a program will have to use a species-based approach, or at least communicate biodiversity benefits in terms of a single species, because of demands made by a particular driver (e.g. ESA compliance).

Functions-based metrics: A functions-based metric is interpreted with respect to who or what benefits from that function (e.g. a species benefiting from the ecosystem service of habitat provision or an urban area benefiting from the ecosystem service of flood storage and delay). In defining functional habitat, this approach assumes relationships between ecosystem attributes and ecosystem functions can be identified accurately. The measurement systems reviewed here are all extremely similar in approach. They focus 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). They use mostly rapid, visual assessments of ecological attributes to characterize both the on-site and off-site processes considered essential to ecological function. The assumption is that the attributes they are measuring accurately and adequately describe and define the ecosystem function being performed.

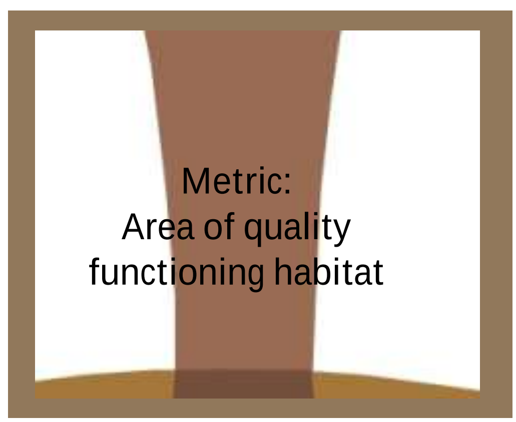
When to use a functions-based approach
Functions-based approaches focus more directly on processes, so these approaches may work best in areas likely to be affected by dynamic ecological change (e.g. habitat fragmentation, floods, disturbance, loss of habitat, etc.). If a program is concerned with functions beyond biodiversity (e.g. water quality), a functions-based approach is better suited to communicate a broader suite of ecological benefits. Functions-based approaches can also be useful in determining functional loss when habitats are degraded or impacted by human actions.

Practice-based metrics: Practice-based metrics are common across incentive and market programs. The approach generalizes the biodiversity benefits anticipated by prescribed practices (e.g. placing a conservation easement on a property or thinning a forest) as a proxy for achieving conservation goals. For example, USDA Farm Bill conservation programs provide incentives to landowners to adopt management practices that 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 of actions like fencing cattle from streams.

When to use a practice-based approach
Practice-based approaches can work well in situations where there is clear understanding of what practices an ecosystem needs to recover or stay healthy (e.g. removing invasives). Many Farm Bill programs target these straightforward practices with a track record of improving biodiversity. Conversely, practice-based approaches may be a good choice in ecosystems where rapid rates of change or scientific gaps prevent a more complex measurement system. There may also be systems where the actions of an individual landowner alone will have little measurable effect on a target biodiversity benefit. These high-uncertainty situations are where practice-based approaches can help.

2.2.3. The Trunk: An Overarching Metric

An overarching metric is used to communicate the overall biodiversity benefit of actions on a given site, providing a



common term to talk about the biodiversity value of a piece of land. It is difficult to develop and sustain a strong and accurate "metric". In many ways, one might look at a metric as a tree trunk of a solid, tall tree. The majority of the 25 Tier 1 measurement systems reviewed used a similar metric: an area of named habitat type, weighted by an index from optimal to poorest habitat quality and function. This metric is called different things by different programs (e.g. a “habitat hectare”, a “discounted service acre year”, or a “functionally weighted acre of sagebrush habitat”). There is a lot of information that feeds into this one metric. Not all measurement systems combine area with habitat quality and function. For example, the Oregon Rapid Wetland Assessment Protocol provides scores of ecosystem function without including acreage. Many incentive programs just report on acreage enrolled without predicting the habitat outcome. Some species-based approaches look only to breeding pairs or numbers of individuals. Others use a combination of species presence/absence and habitat quality.

2.2.4. The Supporting Branches: Validation and Ongoing Revisions

Indicators combined with assumptions can produce a solid metric, but they cannot sustain it. Metrics and measurement systems need to be supported by validation of the accuracy, sensitivity, repeatability, and transparency of the implemented metric.

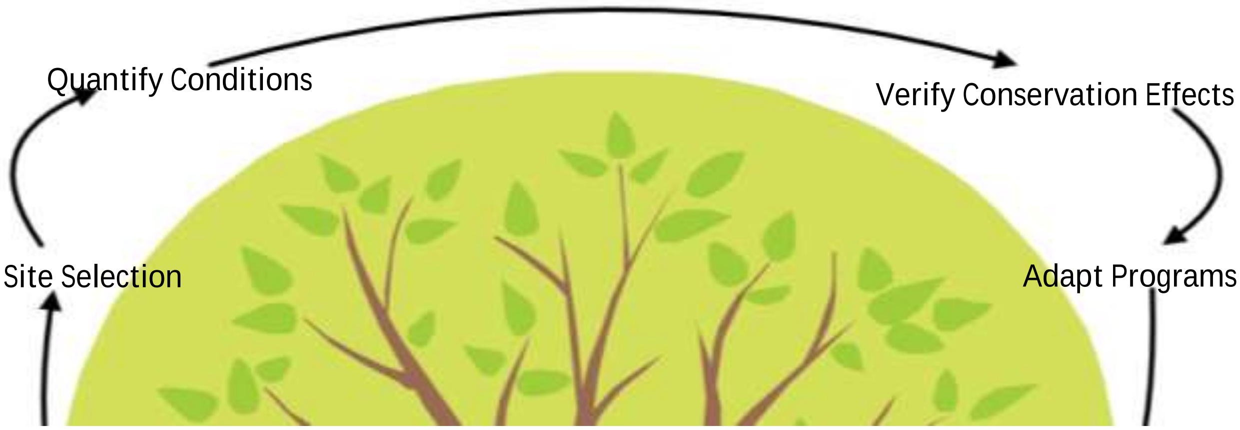
Accuracy tests whether a metric is coming close to capturing the desired outcome. This is the most difficult phenomenon to validate but can begin with matching metric output with best professional judgment on a sample of sites, or where extensive research has occurred in a system, seeing how metric output matches with more sophisticated studies of habitat quality or species-related information. Sensitivity is both how well a metric can capture differences between sites, and how much an individual indicator or group of indicators affects the overall score of a metric. Sensitivity can be directly validated, using a database of field data and Monte Carlo computer simulations. Repeatability may be the least often validated factor of a good metric. At a minimum, the Willamette Partnership tests repeatability using five equally qualified individuals calculating a metric on the same sample of five or more sites in order to compare their scores. The variation of metric scores between users (coefficient of variation) should be less than the variation across sites (Elkum and Shoukri, 2008).

Robust validation appeared to be a gap in most of the 25 measurement systems reviewed. Often the investment of time and resources goes into constructing a metric, and little is reserved for the initial validation or the ongoing revision of the metric as new information becomes available. This is partly because many measurement systems are early in their development and have not been applied broadly enough to get good

Robust validation was a gap in most of the 25 measurement systems reviewed.

validation data, but a conscious effort to validate metrics is needed. Updating metrics with new science and experiences from early application can be like maintaining good habitat—it needs consistent attention and adaptation. Each measurement system needs a protocol for taking project-level scores, experiences, and lessons learned and cataloguing those for predictable update cycles at the program level.

Keeping metrics up can be as dynamic as maintaining good habitat—it needs consistent care and attention.



2.2.5. The Leaves: Program Design Turns Metrics Into Real Biodiversity Benefits

The design of a mitigation, incentive, or investment program turns the indicators into benefits or credits. Program design does similar things for a measurement system, enabling a metric to guide implementation of projects on the ground. All elements of a measurement system can express themselves differently at different stages of program implementation. There are four stages of program implementation:

A. Site Selection (prioritize and rank the best places to implement conservation projects and avoid impacts): Throughout the country, regional and state conservation strategies that define priority areas and practices already exist. To increase the efficiency and effectiveness of incentive-based programs, site selection should be guided by these strategies. For conservation projects, measurement systems can be used to determine a project's eligibility for participation. For example, a measurement system might help define whether a conservation bank is located in an appropriate spot and eligible to sell mitigation credits. It could also help rank applications for the Wildlife Habitat Incentives Program or help determine payment rates for the Conservation Stewardship Program. For projects with impacts to biodiversity, measurement systems can help define standardized criteria for when impacts should be avoided and how much impact should be minimized before mitigation becomes an allowable option.

B. Quantify conditions (quantifying current conditions and predicting future outcomes): The merit of most measurement systems comes from their ability to quantify baseline habitat function and project future improvements from a project design. The difference between these two values forms the basis for calculating credits in a biodiversity banking context or defining compensation values in a payments for ecosystem services program.

C. Verify conservation effects (verifying conservation effects for individual projects): Measurement systems need to answer the question, "What did I actually get for my investment?" This question is answered during verification. Verification should happen over time. Measurement systems often articulate performance standards that a landowner or other project sponsor need to meet in order to get credit in a biodiversity market or meet contract requirements in other programs. These performance standards need to be connected back to the measurement system so that project-level information can inform programmatic conservation effects and needed revisions to the measurements themselves.

D. Adapt programs (adapt incentives to new information): Sound programs can always improve. Their measurement systems should support this search, providing information on which projects are performing well and which are not, what measures seem to capture biodiversity benefits most effectively, and how easy the system is for users to interact with. Adaptive management completes the cycle of a measurement system from indicators that are filtered through a set of assumptions and packaged into an overall metric of biodiversity outcomes. A quality measurement system that includes appropriate program design elements (such as verification and adaptive management) can help improve the effectiveness of conservation investments. The complete tree is presented on the next page.

Measurement systems need to **answer the question, "What did I actually get for my investment?"**

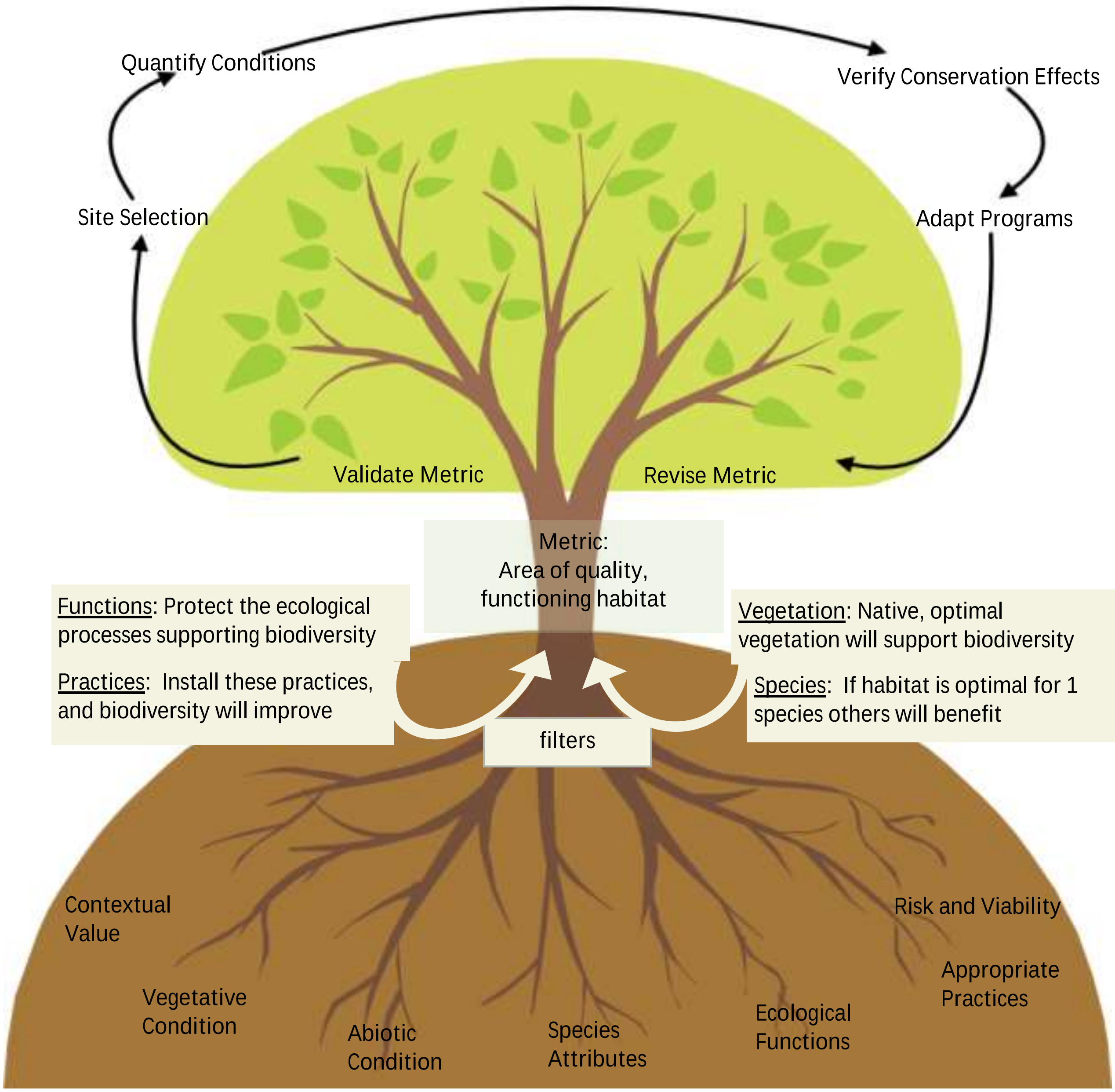


Figure 2.2.5: Measurement system framework revisited

2.2.6. The Whole Tree: A Case Study of the Voluntary Gopher Tortoise Habitat Crediting System

Putting all the elements together to make a successful measurement system can be challenging. The Voluntary Gopher Tortoise Habitat Crediting System for longleaf pine systems, which is being developed by the American Forest Foundation and the World Resources Institute with partners throughout the southeast is a case where a measurement system does pull together the elements described above. The goal of the Habitat Crediting System is to protect and enhance the longleaf pine habitat systems necessary to prevent further declines in gopher tortoise populations throughout its eastern range. This case study is included here because out of all the 25 Tier 1 measurement systems, the Habitat Crediting System was the most thoroughly documented. Case studies were also completed for the Ecosystem Mitigation Approach and the Uniform Mitigation Assessment Method. Those case studies are presented in Appendix G.

The gopher tortoise is currently listed as endangered in its western range and threatened in its eastern range. The tortoise is considered a keystone species because it requires the undisturbed sandy soils, canopy cover, and other habitat elements necessary to support other longleaf-dependent species. According to crediting system developers, what makes good longleaf pine habitat for gopher tortoise makes good habitat for a broad range of species (personal communication with World Resources Institute, Senior Associate Todd Gartner, November 2010; Florida Fish and Wildlife Conservation Commission, 2011). The crediting system is designed for use in a voluntary conservation banking system, pre-compliance with the Endangered Species Act. The case study below describes the measurement system proposed for use.

The Habitat Crediting System did not re-invent any wheels. It pulled from some of the best measurement systems to create a highly credible and robust protocol that worked for its own program uses.

The Roots: Classes of Indicators

The habitat crediting program is built on the rationale that a holistic approach to habitat conservation and management will better address the primary causes of declines in gopher tortoise populations - land use change and forest loss - while also addressing the spectrum of other species that use the longleaf pine ecosystem. The gopher tortoise metric defines ideal habitat condition as a forest dominated by an open pine canopy, preferably longleaf, with target understory conditions (herbaceous food plants and open, sunny areas for nesting and basking) and well-drained sandy soils for burrowing. It lists best practices for habitat management and outlines program requirements for long-term viability/ sustainability. The methodology for calculating habitat credits awards points based on the conditions of a broad suite of indicator classes.

The *landscape context* of a proposed crediting site gets scored on attributes such as its adjacency to other gopher tortoise habitat,

> Maintaining high quality habitat requires a long-term strategy and funds to deal with threats like invasive species.

surrounding land use (forest, rural, developed), and its level of protection. Fragmentation and connectivity characteristics are also evaluated. At the *site level*, both biotic and abiotic characteristics are assessed for suitability of gopher tortoise habitat. For *vegetative condition*, points are awarded for canopy composition and cover, mid-story and understory composition, herbaceous cover and percent cover of invasive plants. Under *abiotic conditions*, the site is rated based on the soil type (texture and drainage characteristics) and the local hydrological conditions.

Either the presence of gopher tortoises or adjacency to lands with proven gopher tortoise populations and limited barriers to movement are criteria for project eligibility. *Species attributes* such as population trends and the presence and status of burrows are also part of the monitoring requirements under the protection agreement.

The ability of a site to burn is one of the most significant factors shaping good quality gopher tortoise habitat. Other *ecological processes* are assumed to be co-benefits of a well-managed forest as system developers believe that biodiversity benefits measured by the Habitat Crediting System should be tangible to buyers.

Individual *practices* are not specified, but at minimum, implemented practices must result in verifiable benefits such as the protection and maintenance of key gopher tortoise characteristics (as defined by the indicators above) for the life of the project.

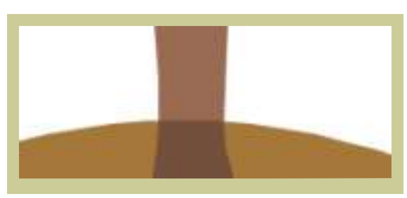
Risk and viability are assessed in a number of ways within the Habitat Crediting Program. Major threats to viable gopher tortoise populations are identified and sites are scored according to their degree and characteristic.

For example, imported fire ants threaten the reproductive success by preying on eggs, and invasive plant species threaten foraging resources. Broader considerations in the long-term viability and effectiveness of a site in conserving gopher tortoise populations include:

- Requirements for a minimum project size
  - 250 acres which is the minimum acreage to support the minimum manageable assemblage of 80 tortoises
- Legal and financial parameters
  - Agreement and Management Plan finalized and signed by all parties
  - Conservation Easement conveyed and Endowment secured

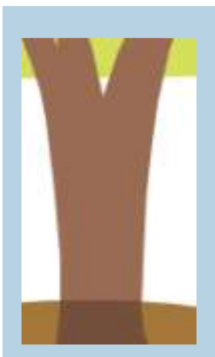
The Soil Horizons: Turning Indicators Into Metrics

The Habitat Crediting System assumes that optimal conditions for gopher tortoise will translate into healthy longleaf pine habitat. Through this species-based lens, the measurement system looks at the interplay between ecological functions, appropriate practices, and other classes of indicators. Each of these indicators receives a score ranging from 0 to 5 (with 5 being optimal for tortoise habitat and long term viability). Individual scores for



each indicator are summed and that total is used as a multiplier against property acreage to calculate the number of credits of verifiable gopher tortoise habitat generated by the assessment area. Collectively, the indicators describe the conditions for good gopher tortoise habitat.

The Trunk: Metric



Biodiversity benefits in the Habitat Crediting System are expressed in the form of habitat credits. A credit is a tradable unit of habitat benefit which enables habitat preservation or restoration to have a monetary value. Credits are sold to mitigate impacts to species and/or species' habitats and are based in functional acreage, which is weighted based on ecological factors, priority locations, and other variables as described above.

The Branches: Validation and Ongoing Revisions

The gopher tortoise system is still in its drafting phases. The first of three phases is complete and lays out the framework and protocol for generating habitat credits. The second and third phases will test the framework and protocol and include preliminary transactions between buyers and sellers as on-the-ground forest management practices are implemented. The final phase will focus on system monitoring, verification and adaptation, additional credit transactions, and documentation of project impacts for the purposes of framework expansion and replication. The results of this pilot project will be fully transparent and widely shared.

The Leaves: Program Design

The gopher tortoise program design establishes the rules and protocol for the calculation of credits, sales, and management of the system.

<u>(A) Site selection for Gopher Tortoise</u>
The overall goal of the Habitat Crediting System is to provide a net conservation benefit (i.e. no net loss or a net gain of habitat) for the gopher tortoise and associated species and habitat. Following USFWS mitigation guidance (USFWS 2003), the crediting system will support the hierarchy of avoidance first, then minimization, then compensatory mitigation for offsetting unavoidable adverse impacts to gopher tortoises and their habitat. The eastern range of gopher tortoise does not currently have a conservation plan or framework. However, a Candidate Conservation Agreement (CCA) and a recovery plan have been developed for the western range where gopher tortoise is listed as endangered. The recovery plan is over 20 years old. Conservation banking guidance is also available for the listed range, which is referenced and considered in several sections, as well as state permitting and mitigation requirements in Florida (USFWS, 2009b).

To be eligible for participation in the voluntary Habitat Crediting System, a property must have an easement on it, be located within a designated service area (defined by soil types, habitat ranges, and clear demand), and be greater than 250 acres in size. Crediting system developers are working with stakeholders to build a database and tools that will help identify priority areas for mitigation. The landowner must also demonstrate proof of funds or an agreed upon plan to secure funds to cover long-term costs. A management plan must be in place with clear strategies describing how conservation actions will be implemented and how they will result in desired outcomes for site condition. Credits offered for sale must result from "additional" conservation activities, not onsite management that is already required through other transactions or commitments, whether voluntary or mandatory.

(B) Quantifying Conditions/Predicting Future Outcomes

Monitoring for compliance with program rules and for biological/ecological effectiveness is an essential component of the Habitat Crediting System. Achieving and maintaining net conservation benefits for at-risk species must be demonstrated through measurable results. Methods of evaluation and monitoring are being determined and are expected to be quantitative and sufficiently rigorous to determine biological effectiveness of the Crediting System. The same methods used to quantify baseline conditions in terms of species' numbers and habitat function will be used to track changes in baseline conditions over time to determine whether ecological goals of the Crediting System are met. To strike that balance between precision and practicality, the program hopes to be able to run a credit calculation on a 1,000-acre property in one to two days. It is anticipated that the Longleaf Alliance, in coordination with The Nature Conservancy, will verify credits produced by landowners.

(C) Verifying conservation effects

Projects will be guided by a "habitat management plan" that documents 1) the strategy for generating and protecting the longleaf pine habitat credits offered for sale; and 2) a monitoring plan that establishes performance benchmarks and informs any shifts in strategy required to preserve habitat values. The management plan will also include pertinent baseline and inventory information and a description of the endowment necessary to carry out management in perpetuity. Ecological performance standards, once developed, should be clear and measurable with timelines. The credit seller will be responsible for all management activities necessary to restore and/or maintain suitable habitat conditions on the project site as described in the Agreement and management plan. Verification of results will likely take place once a year for the first three years and then every two to three years. Ideally, verification activities will be merged with monitoring of the easement.

(D) Program Adaptation

Throughout its evolution, the Habitat Crediting System will be flexible enough to include new ecological information and understanding of gopher tortoise ecology and the longleaf pine system as well as to adapt to the changing environmental policy in the U.S.

The gopher tortoise/longleaf pine crediting approach has pulled from some of the best experiences of other habitat crediting approaches to create a highly credible and robust protocol for use. Though it has not yet been extensively validated or implemented in practice, the pieces are in place to test the effectiveness of this type of measurement system to produce verifiable biodiversity benefits for the gopher tortoise and longleaf pine ecosystem.

2.2.7. Summary Trends in 25 Assessed Measurement Systems

What's working? While most of the 25 Tier 1 measurement systems reviewed for this report are still in development or in the early stages of being piloted, there are several common elements contributing to their success or potential success in producing credible and effective conservation outcomes.

- Emerging measurement systems are striving for outcome-based metrics. They are deliberately designed to measure the effects of specific place-based management strategies on specific place-based conservation targets. Outcome-based metrics introduce a level of complexity beyond existing practice-based approaches used by many government incentive programs (e.g. WHIP). This trend raises two questions, 1) do outcome-based metrics lead to greater accuracy or improvement in conservation actions, and 2) how cost-effective and practical these tools are compared to existing practice-based metrics?

Missing elements of biodiversity metrics may have little to do with the science itself, but more with validating their efficacy over time.

- Most of the measurement systems reviewed use rapid visual assessments that can be carried out i) on an average site in hours, not days, ii) with minimal measurement instruments and with simple techniques, and iii) by users with training in aerial photo/map interpretation, vegetation sampling, and plant identification. Rapid visual assessments are accessible to a broader range of users, and are more likely to be used and applied to multiple sites than more complex, resource- demanding approaches.

- Measurement systems are increasingly documented in standardized protocols that define the rules, methodologies, field data collection guides, and reference material that improve consistent application among users, between sites spatially, and among sites over time. Standardized protocols and documentation build greater confidence in analyses, projections, and adaptive management strategies.

- Consistently, the target users for measurement systems are not landowners themselves, but conservation district staff, technical service providers, and the other professionals most likely to be implementing conservation actions on behalf of landowners. A system's documentation, technical guidance, and field protocols are directed at this group.

- During the verification stage of a project, performance standards help track progress of a conservation project as it moves toward its full potential for supporting biodiversity. More measurement systems are defining performances standards that are linked directly to the indicators and measures used to predict a site's full potential. These emerging standards are relatively well established in theory and becoming more so in practice.

- Measurement systems are also including more measures across scales (from landscape context to on-site condition), providing additional information on how well biodiversity is functioning.

What's missing? Most measurement systems are being developed for specific objectives, and in some cases, in anticipation of regulation or other drivers that will promote their use (e.g. endangered species listings). These narrow design parameters can create weak spots in measurement systems:

- There is a lack of independent validation of the effectiveness of different approaches at meeting conservation objectives.

- Each measurement system contains embedded assumptions that need to be tested. On the scale of precision and practicality, the metrics necessarily trend closer to practicality. Each type of measurement system assumes that the indicators measured and the relationships between indicators that quantify ecological conditions are closely based in reality. There needs to be more testing of these assumptions by independent third parties or as part of comprehensive adaptive management programs.

- Most measurement systems have been developed with funding from government or non-profit sources representing a significant investment in research and development. Development costs, from proof-of-concept to pilot implementation of the protocols on the ground, run in the hundreds of thousands of dollars. There is currently very little data on operational costs for implementing and running these tools, although many of the systems using rapid visual assessments provide time estimates for assessment completion which can help with cost estimates. Data on cost effectiveness will help prioritize efforts for streamlining existing processes and will help focus limited dollars on where their effect will be greatest. However, cost-effectiveness will vary according to the monetary value of conservation credits and debits which is dependent on supply and demand for these products.

Many of the missing elements of biodiversity measurement systems may have little to do with the science itself, but more with validating the efficacy of measurement systems over time and investing in the learning necessary to adapt these systems to new information.

III. Getting to a Usable Measurement System

Getting to a usable measurement system is not as prescriptive as painting by numbers. Instead, it involves managing people and timely information to coalesce around a shared vision of what functional, high quality habitat looks like and what ecological future the measurement system is helping to achieve. The section below describes the process steps and logistics of building a good metric and how a measurement system can be built hierarchically so it can meet the different requirements of various program uses. Throughout the section, gaps and options are identified where USDA and other agencies can facilitate measurement system construction, operation, and maintenance. Ideally, these process steps will sit within a nationally consistent framework for building measurement systems, underneath which localities can customize systems for their unique environments and uses.

3.1 Standardizing a Process for Building Biodiversity Measurement Systems

As hard as it may be to standardize measurement systems, many groups go through the same steps to build a measurement system and just address those steps in different ways. By following the seven steps below, public agencies and private partners building biodiversity markets and incentive programs should be able to streamline development of their measurement systems.

Step 1. Define conservation goals, target users, and uses of measurement system.

There was broad agreement among Technical Group members that any measurement system needs to begin with a shared understanding of conservation objectives and uses. Without this, it is difficult to direct decisions towards clear goals. Getting to a shared understanding of objectives is as much a social and political process as it is a technical one.

A group should ask questions like:

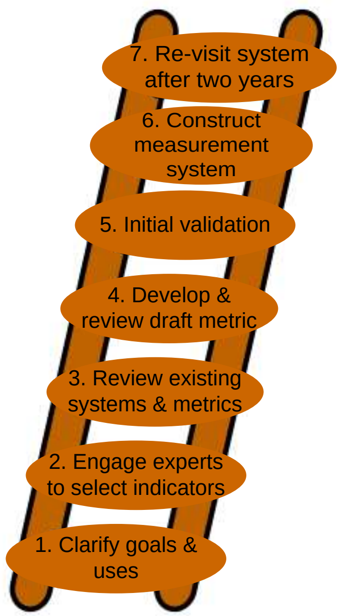
- What actions are needed to sustain biodiversity in a watershed or landscape? For what purposes?
- Where are the most important places to focus investment?
- Where are the most important threats and stressors coming from?

Several sources can help answer these questions. Each state for example, has a State Wildlife Action Plan, Nature Conservancy Ecoregional Assessment, endangered species recovery plans, a natural heritage program with biodiversity data, GAP data and other GIS resources.

Step 2. Engage subject-matter experts to target ecosystem functions and define operational indicators of a healthy ecosystem.

Having technical experts (e.g. specialists on a target habitat), potential users of the measurement system (e.g. landowners or developers), and those who must approve or certify the measurement system (e.g. U.S. Fish and Wildlife Service, NOAA Fisheries, Army Corps, U.S. EPA, etc…) engaged early in the process is important. After introducing the goals and intended uses of the measurement system, ask subject matter experts to individually answer the question, "What does high quality, functional habitat look like?" The Willamette Partnership has found that this question results in a fairly

Figure 3.1: Process for building a measurement system



complete list of relevant indicators, helps to kick-start consensus on how those indicators should be measured, and even reveals some of the relative weights of and relationships among indicators. Early on it is also important to ask, "If there were $X million available, what are the most important conservation actions we could take to protect and restore this habitat? What development actions should be avoided?" Answers to these questions provide anchors to ensure that the measurement system is incentivizing the right actions on the ground.

Step 3. Review existing systems and metrics.

> Ask subject matter experts to individually answer, **"What does high quality, functional habitat look like?"**

Once that initial engagement occurs, measurement system developers can focus on a search for existing tools that might be helpful. First, ensure that there are no other approved, usable measurement systems already in place. Even if an existing metric is not an exact fit for the desired use, consistent approaches to measurement are important, and sacrificing some initial utility for sharing maintenance costs and standardizing methods may pay off over time in terms of lower costs and better information. Look to metrics designed for similar program uses, even if the habitat type is different than the target habitat being considered. It may be easier to translate wetland mitigation systems to upland prairie mitigation than to translate a sage-grouse monitoring protocol into a measurement system for sagebrush mitigation. To the extent possible, look to reliable spatial datasets around which a measurement system can be built. Relying on these datasets (so long as they are maintained and of high quality) can increase usability of a measurement system.

> Even if an existing measurement system is not an exact fit for a use, consistent approaches to measurement are important.

Step 4. Develop and review draft metric.

Developing a draft metric is difficult to do in group settings. It may be most efficient to have one lead developer who checks in with relevant experts during the drafting phase. This may not be possible if conflict around uses of the overall measurement system are high. Once a draft metric is prepared, it should be brought back to subject-matter experts and program users for review and comment. Revisions can be made to the metric in preparation for validation in the field. Depending on group consensus and the technical complexity of a metric, there may need to be several rounds of revisions.

Step 5. Conduct initial field validation of draft metric for accuracy, repeatability, sensitivity, and cost-effectiveness.

Field validation is a critical step and should be done methodically. Measurement system developers should select a large enough sample of sites to cover a diversity of possible habitat conditions. Resource constraints are likely to limit the number of sites that can be included, but groups should target more than ten sites to validate accuracy and at least five sites and five testers to validate repeatability. See Section 2.2.3 for methods to validate metrics. There also needs to be some validation of cost-effectiveness. How long does the metric take to apply in the field? Is it steering action toward high priority places and impacts away from those same places? Is it setting up an economic situation where stakeholders will be willing to participate? Validation should be continuous, providing information to inform revisions in Step 7.

Step 6. Construct the measurement system, which includes a final metric, documented assumptions, and a program design.

With validation results in hand, measurement developers will want their subject-matter experts and users to make a set of final revisions. As the measurement system is being polished and packaged, it should include the associated metadata, so outsiders can look into the system and see how development decisions were made and which assumptions drive the measurement system.

As the measurement system is being polished and packaged, every system should have the associated metadata.

Step 7. Re-visit measurement system after two years of field use for potential revisions.

Most likely, any measurement system will need revisions after the first projects are run through it. Some of these revisions could be made immediately, but they could also be catalogued after two years of experience. It is important to explicitly design adaptive management processes as part of measurement systems so that new information and experience from early applications can be used to constantly improve them.

These seven steps could take six months to work through or they could take years depending on the availability of existing information and the levels of trust among users.

3.2 Building a Consistent Biodiversity Measurement System That Works Across Programs

This is a challenging goal, but there are ways to begin standardizing measurement systems. Ultimately, measurement systems should be constructed hierarchically, tiering different intensities of measurement to different program requirements. Federal agencies, working with other agency and private sector partners, need to reach agreement on an overall framework that can be adapted to different programs and local needs while nesting at multiple scales. For the first tier of this framework, agencies might identify five to ten indicators of high quality habitat that every program should include in its measurement systems. For consistent and accurate reporting, the indicators would need to be applied at a similar scale, collected on the land in a similar way, and expressed as the same output.

Ultimately, measurement systems should be constructed hierarchically, tiering different intensities of measurement to different program requirements.

At the second tier, measurement systems might use rapid visual assessments that can be applied on a given project in a day or two. This level of measurement might be used for voluntary markets, Farm Bill programs, or regulatory offset programs with a high degree of understanding of how specific practices link to biodiversity benefits.

In the third tier, sites might be measured intensively. This might include long-term plots for monitoring vegetation condition, conducting fish and wildlife inventories, or detailed water quality monitoring. Elements of this detailed work might be required for some regulatory offset programs. It could also be applied to a subset of projects within a program to monitor effectiveness and inform adaptive management. Generally though, this third tier of measurement would only be used in the riskiest transactions with the highest potential benefit or impact for biodiversity. A large acreage, multi-million dollar land acquisition might use this third tier to ensure the biodiversity value of the acquisition. A large wind farm or pipeline project might use a similar level of intensive measurement to quantify how impacts can be avoided, minimized, and then mitigated.

To ensure programs are effectively channeling funds to improving on-the-ground conditions, programs should aim to maximize the percentage of every dollar going into conservation activities on the ground. Regular evaluation of transaction costs would aid in assessing their benefit to overall program effectiveness. The Technical Group suggested that future work include definitions of best practices for data collection at each of the tiers in the measurement hierarchy.

IV. Other Actions to Ensure Incentive Programs Succeed

To be successful, the best measurement systems need a supportive environment, a good program design, and well-planned program operations. This section shifts from the characteristics of a usable measurement system to options where USDA and others can facilitate program design, operation, and improvement.

4.1 Engage Public Agencies and the Private Sector to Help Programs Succeed

Many markets and other conservation efforts fail because there is no supportive environment for them. Federal agencies can go a long way toward building this environment. As a first task, there needs to be continued work across federal and state agencies to secure support of biodiversity markets as one important type of incentive mechanism. Ideally markets are developed through collaborative processes and formal agreements among primary partners. Although some agency staff persons are generally supportive of the concept of biodiversity markets, they need to know that their leadership supports their spending scarce staff time to advance these markets. These programs will be most successful in specific regions or ecosystems, where agencies are already working together. The private sector also needs to be engaged in new ways to work alongside agencies as partners throughout the process of designing, delivering, and revising conservation programs.

Agency staff are generally supportive of biodiversity markets, but they need to know that their leadership supports them.

4.2 Provide Tools to Local Areas to Assess Incentive Program Readiness and Feasibility

Before localities develop measurement systems, reporting protocols, and registries mentioned in Section 2709 of the 2008 Farm Bill, they will need ways to evaluate whether their area is well suited to a market-based solution. The USDA Office of Environmental Markets could provide tools for local areas to assess the viability of a biodiversity market or other incentive program. A screening checklist could help people think through whether there are clear goals, if there are legal obstacles to implementing an incentive program, how many landowners might be willing to participate and what drives their interest, and why buyers or investors would participate and what they would be willing to pay.

The key barrier to pre-compliance markets is the lack of assurances that **actions taken prior to listing will "count"** if a species gets listed.

4.3 Clarify Regulatory Guidance on Biodiversity Markets

Reforms are needed across agencies to facilitate biodiversity market approaches. The U.S. Fish and Wildlife Service, with its mission to work collaboratively with stakeholders to conserve, protect, and enhance fish, wildlife and plants and their habitat, and its regulatory role in species conservation, could play an important role, providing clarity and certainty for those building biodiversity markets, especially pre-compliance markets.

In the species banking realm, several years have passed since USFWS issued its 2003 guidance on conservation banking. In that time, many new banks have come online and banking practices have evolved. USDA and USFWS could work together to issue joint guidance, particularly for banking of habitat for species imperiled but not yet federally listed (e.g. gopher tortoise or sage-grouse). As many imperiled species have state protections or interest, state agencies may also need to be involved. Joint guidance would combine USFWS regulatory authority with USDA's direction to develop market guidelines under the 2008 Farm Bill, its relationship with landowners, and the financial resources of the Farm Bill.

The easiest way to initiate this guidance might be to focus on two USDA Natural Resources Conservation Service (NRCS) initiatives already underway (sage-grouse and longleaf pine). Regional USFWS offices could develop consistent approaches for pre-compliance conservation banking with NRCS as the federal action agency. These regional test cases can also support integration of Farm Bill programs and biodiversity markets. The key barrier to pre-compliance markets is the lack of assurances that actions taken prior to listing will "count" in the event a species become listed. These regional test areas could identify options (e.g. existing conference opinions) for providing those assurances.

> Federal agencies should strive to endorse a national biodiversity measurement framework.

The issue of regulatory clarity extends beyond U.S. Fish and Wildlife Service. Reforms are needed across agencies to facilitate biodiversity market approaches. With a national framework in place to guide measurement systems and biodiversity incentive programs, federal agencies could use their investments to drive state-level action and reform at regional offices of federal agencies. For example, USDA could use a "race to the top" concept to incentivize states to build policies and regulatory reforms needed for biodiversity incentives to thrive.

The Department of Education and other federal agencies have used this concept successfully to catalyze state-level policy changes that inform national approaches. In order to compete for a dedicated pot of federal conservation dollars, a state would need to have necessary agreements from regulatory agencies, stakeholder-approved protocols for delivering biodiversity incentives, and a measurement system consistent with the national guidance provided.

4.4 Enable High Quality Biodiversity Measurement Systems

USDA and other federal agencies need to play an active role in guiding consistent measurement system development in regions across the country to push toward high quality and operationally viability incentive programs over time. Federal agencies could leverage multiple public and private dollars to cooperatively finance measurement system development and avoid duplication of effort. As a condition of this funding, every measurement system would have common outputs, but tiered data collection requirements depending on uses across conservation programs. Measurement systems would need to be consistent with national guidance and connected to regional conservation strategies with prioritized places and practices.

With a national measurement system framework in place that could be adapted to local regions, it would be important for federal agencies and others to strive toward endorsing one measurement system for a given ecosystem on a particular region. In sagebrush country for example, if the goal is consistent measurement of sagebrush habitat across incentive programs, it can be counter-productive to build five separate measurement systems for biodiversity.

USDA and other federal agencies can also support existing national habitat classification systems, spatial data, and benchmarks that can lower transaction costs of measurement systems. For example, whether using Ecological Site Descriptions or NatureServe classifications, agencies working with experts like NatureServe and The Nature Conservancy should select the most relevant system to classify habitats on a given project. This classification would drive which indicators to look at, and how to roll those indicators up into a metric of quality habitat. There also needs to be a common way to benchmark metrics. If historic, ideal, or desired conditions for a project are unknown, it becomes difficult to predict future biodiversity benefits. Federal agencies, in partnership with others, could develop a national set of reference conditions and sites. The Ecological Sites Description work is moving in this direction, but can be targeted to areas likely to see market or other incentive investments. Additionally, if USDA and other federal agencies can facilitate national datasets (e.g. putting NatureServe rare species data into publically usable formats, creating a national map of historic vegetation, or leveraging LiDAR to measure vegetation) at a resolution fine enough to make site-level decisions, costs of implementing metrics will go down, and consistency of metrics will go up.

4.5 Provide Technical Assistance for Developing Measurement Systems

Building measurement systems can be complex. USDA should consider funding the training of technical service providers, local extension agents, and some of its NRCS Technology Center staff to act as “extension agents” for measurement systems. Cooperative Extension Service staff and others could serve this roll as well, helping groups quickly launch markets and other incentive programs. USDA could also facilitate transfer of experiences from other regions in several ways:

- Provide education to emerging programs on how (the steps and process) they can get from where they are to a functional market or incentive program in the near future;
- Provide guidance on the elements an incentive program needs to succeed and operate effectively over time;

- Make existing tools, technology, expertise, and experiences available to new NRCS Conservation Innovation Grant (CIG) recipients and other grantees; and

- Provide guidance to third parties working directly with landowners to better discuss the risks and benefits of markets and other incentive programs.

One of the major gaps identified in compiling this report is the lack of documentation and ongoing support to maintain measurement systems. There is little documentation of the scientific assumptions behind metrics, or validation of every metric at some level. USDA could require that all metrics created with its funds document some of these assumptions and also provide funding or technical resources to help validate metrics over time. To organize this documentation in a standardized way, there needs to be the GIS-equivalent of metadata. Metric development should not be a static process. Measurement systems need to be adaptively managed, but there are often few resources to do this.

One of the major barriers keeping measurement systems from being more consistent is a lack of documentation and ongoing support to maintain metrics.

Programs currently funding measurement systems (e.g. CIG Grants, National Science Foundation, or USEPA's Office of Research and Development) could hold a percentage of funds to support the ongoing validation, upkeep, and integration of metrics.

4.6 Facilitate Sound Program Design

Biodiversity metrics are only one element of a successful market or incentive program. Good program design can steer activity toward the desired actions, places, and behaviors necessary to protect and enhance biodiversity. Some of this is science, but the rest deals largely with how risk is allocated amongst different parties and the environment itself.

Once a program is identified as viable, designers need to answer a number of questions. The more federal agencies can provide guidance or answers to these questions the better. Some questions include:

- What are the priority actions to incentivize? For biodiversity, should preservation of ecological processes be prioritized over restoration? Is translocation of animals or plants acceptable?;
- Where are the most important places to invest?;
- What landcover and land ownership types are eligible (e.g. can public lands participate)?;
- What is the appropriate default trading area (e.g. ecoregion)?;
- For species-focused programs, does the land need to be occupied by the target species or not?; and
- What should the avoidance/minimization criteria look like?

The eligibility criteria and framing questions will make it easier for a program to select or develop the best metric to quantify biodiversity services. Once a credit is quantified, someone needs to verify that the site is providing those outcomes necessitating questions like:

- Who does verification (e.g. third parties, landowners themselves, agencies)?;
- How often does verification happen (e.g. every year, every five years)?; and
- What gets verified and who pays for it (e.g. practice implementation, outcome)?

Conserving biodiversity is a long-term endeavor, longer than a 5-year EQIP contract. Stewardship requirements have increased for conservation banks, demanding easements, non-wasting endowments, and even some long-term performance standards. These requirements caused uncertainty on long-term costs and risk. There needs to be some clarity, particularly in the face of climate change or other dynamic threats, about what levels of stewardship are expected. This includes asking:

- Are fixed conservation easements the best tool, or are more flexible easements that “roll” with the habitat more appropriate?
- If endangered species “leave” a site, or biodiversity shifts, is that a failure?
- Who is best suited to do long-term maintenance and how much of an endowment is adequate?

Some technology tools exist to track credits (e.g. RIBITTS) or conservation projects (e.g. Conservation Registry), but none of these tools are linked together in a central database system that can be used to answer questions like:

- Where are projects happening and what actions are they implementing?; and
- What are our collective investments accomplishing?

A centralized tracking system is also a key component of layering multiple incentive programs onto the same lands or stacking multiple credit types. Federal agencies should know whether EQIP dollars are being spent next to wetland mitigation dollars, both to leverage multiple funding streams and to avoid inadvertently subsidizing biodiversity impacts. All federal agencies need to make project information available in a centralized way for the public to track conservation investments.

The monitoring done at a specific site for project compliance is different from monitoring to track status and trends across ecosystems and landscapes. Piles of data are collected on individual projects, but not currently in a way that adds up to a national picture of their effectiveness. The GIS and research arms of U.S. Department of Interior (DOI), USDA, EPA, working with private partners could provide guidelines on monitoring so information is taken from projects, rolled up into program measures, and

Piles of data are collected on individual projects, but not in a way that adds up to a national picture of their effectiveness.

then across programs to form a national picture. If implemented, these guidelines could more clearly tie incentive programs and listing/delisting decisions, and they could set goalposts for when incentive programs might be labeled successful. Imagine the fundraising thermometer outside an elementary school that gauges progress toward a commonly held goal.
There are too few conservation dollars available not to be constantly looking for synergies across programs. In an ideal world, regulatory and incentive programs would be directed at shared goals, guided by regional conservation strategies. Synergies can also be facilitated if new rounds of innovation funding (e.g. Conservation Innovation Grants) encourage use of existing tools.

4.7 Kick-start More Real World Examples of Biodiversity Markets and Incentives

Often, the major barrier to biodiversity markets and incentive programs expanding to scale is lack of demand for the biodiversity benefits provided by landowners. USDA can do a lot to expand that demand. Many of the Farm Bill programs touch biodiversity directly. In the next Farm Bill, Congress could link these programs more directly with State Wildlife Action Plans or other regional conservation strategies. Programs like the Wildlife Habitat Incentives Program and Conservation Stewardship programs already allow for prioritizing investments based on these strategies. This would improve the performance of USDA investments for biodiversity while still achieving the core goals of each program. Additionally, a percentage of each Farm Bill conservation program could be reserved for the purchase of “verified conservation outcomes” or the credits measured by validated metrics. Rather than investing up-front in a practice that should produce a positive outcome, these dollars would purchase outcomes that exist and have been measured.

Outcome-based measures of biodiversity could also assist the Council on Environmental Quality in promoting their recent Environmental Impact Statement (EIS) guidance on mitigation, particularly tied to Findings of No Significant Impact. In the biodiversity markets context, EIS documents can earn a Finding of No Significant Impact if projects implement mitigation measures. This is a potential source of demand for biodiversity conservation, and can be promoted with other federal agencies with potential mitigation obligations (e.g. Department of Defense, Department of Transportation, and Army Corps of Engineers). There need to be examples that test many of the options in this report.

Current conservation initiatives such as the sage-grouse and longleaf pine projects might provide valuable opportunities to test integration of measurement systems, new regulatory guidance, and incentive program designs. There are also a number of multi-stakeholder programs close to fruition that with a small push could generate some great examples of high quality measurement systems linked with biodiversity markets and other incentive programs. This “push” might include holding a percentage of CIG funds to re-invest in previously funded CIG projects to amplify their effects and transfer innovations to other areas. The next section details some of the actions that could be taken in two test areas: Sagebrush and longleaf pine ecosystems.

V. Connecting Options to Real Places & Real Actions

Both the sagebrush/sage-grouse and the longleaf pine/gopher tortoise multi-stakeholder conservation initiatives currently underway provide excellent opportunities for testing many of the options in this report. Both are grappling with how to link together priority areas, stakeholders, conservation actions, and measurement systems in a way that engages all local, state, and federal regulatory agencies involved in decision-making. Some level of standardization in both the process and tools could go a long way to increasing the speed and effectiveness of these conservation strategies.

Sage-grouse Initiative

The greater and Gunnison's Sage-grouse are iconic species of the sagebrush steppe. Sage-grouse are indicators of the condition of western sagebrush habitats, and they are "landscape species" requiring large swaths of un-fragmented habitat to survive. Growing demand for domestic sources of energy, housing, food, fiber, and recreation are placing overwhelming pressure on sagebrush ecosystems. These pressures are causing land conversion, fragmentation, and ecosystem degradation.

The USFWS has classified both the greater sage-grouse and the Gunnison's sage-grouse as candidate species. They are warranted for federal listing under the ESA but are currently precluded by higher priorities. Landscape-scale, collaborative conservation efforts are essential not only to prevent their federal listing, but also to recover the species to sustainable levels.

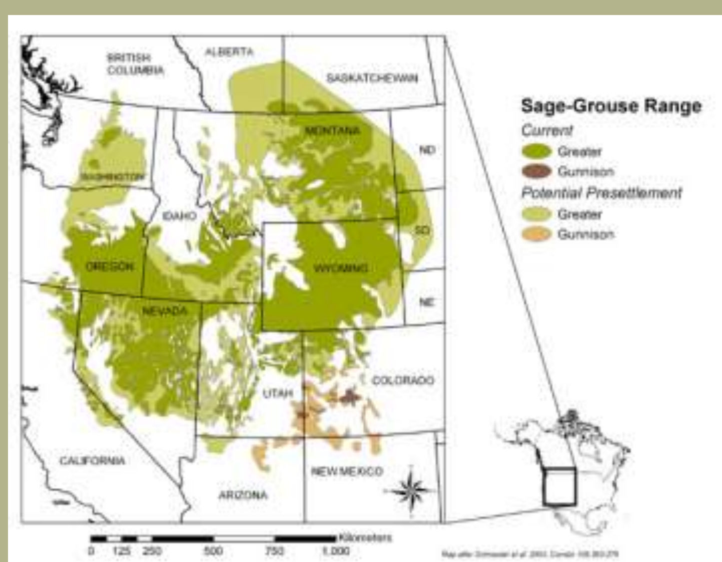


Figure 5.1. Distribution of Greater and Gunnison Sage-grouse (USGS, 2011).

Fortunately, these species have been the focus of extensive research and conservation over the past few years. In 2010, NRCS launched its Sage-Grouse Initiative, targeting $16 million to producers to install practices beneficial to sagebrush habitat, and adding another $23 million in 2011. Federal dollars have also been invested in the development of metrics through Conservation Innovation Grants. States have invested significant conservation and planning dollars, for example, through the development of local sage-grouse plans. Non-profit organizations have also invested significant resources in strategies to reduce impacts of energy development, science, incentives, and other initiatives. Sustaining and building upon this momentum is key to finding range-wide solutions to recovery. A more coordinated approach across the range of the species could promote:

1. Private investment to supplement public investment;
2. Consistent application of permitting rules and planning tools; and
3. Consistent species and habitat assessment and monitoring tools that are applied in a coordinated, consistent approach across private and public land boundaries and between federal and state agencies.

Options for achieving this goal include:

1. Interagency endorsement of a regional conservation strategy that can both guide conservation investments to areas of greatest benefit, and steer development siting away from priority conservation areas;
2. Market-based incentives that encourage private investment in habitat restoration as well as private landowner participation in species recovery;
3. Regulatory assurances drafted by USFWS and/or state agencies that provide certainty for pre-compliance conservation banking;
4. Support for the increased use of offsets, within the mitigation hierarchy, by federal agencies and private developers of residual impacts to reach net zero impact or net benefit; and
5. Agreement on a common measurement system for habitat benefits and impacts applied consistently across sage-grouse range and incentive programs. This can be built by drawing upon metrics that are pre-existing or currently under development.

In most cases, these actions could be accomplished under the auspices of existing stakeholder and agency processes. Many of the options in this report could be tested at an interagency level in sagebrush country, demonstrating how policy, measurement, and adaptive management can improve conservation effects across programs.

Longleaf Pine Ecosystem/Gopher Tortoise Initiative

The longleaf pine ecosystem spreads across nine states in the American Southeast. Urban development, habitat conversion to fast-growing pine plantations, invasive species, and fire suppression are threatening an already shrinking forest resource and placing open pine-obligate species such as the gopher tortoise at greater risk. The gopher tortoise is federally listed as threatened in the western portion of its range and has been petitioned to list in the eastern portion. It relies on healthy pine forests, and is an umbrella species for other longleaf-dependent species. With over 80% of land in the southeast in private ownership, restoration and protection strategies for the longleaf pine habitat must include the active participation of forest landowners.

In 2008 the American Forest Foundation received an NRCS Conservation Innovation Grant for $194,000 to develop and implement a market-based habitat credit trading system for the gopher tortoise and associated species on private forestlands in parts of Georgia and Alabama, where the species is being considered for federal listing. The habitat crediting system is a voluntary, incentive-based system that awards potentially saleable “credits” to landowners who manage their land in a way that promotes or protects high quality gopher tortoise habitat.

Currently, there is no requirement to offset impacts to longleaf pine. If the gopher tortoise becomes listed, however, organizations like the Department of Defense and Department of Transportation whose activities result in the loss of gopher tortoise habitat will need to find ways to mitigate those actions. The goal is to develop a pre-compliance mitigation bank program that encourages the protection and restoration of longleaf pine habitat with assurances that the credits generated and purchased through the Habitat Crediting System would be recognized in a compliance scenario. American Forest Foundation and the World Resources Institute are currently working with USFWS to test this process, making it an ideal circumstance to test many of the options in this report. Some specific starting points are described below:

- Department of Defense or NRCS initiates consultation with USFWS, resulting in an agreement (e.g. conference opinion) covering a broad range of conservation investments in longleaf pine ecosystems, including pre compliance conservation banking, as the vehicle to provide assurances to early actors
- Stakeholders, with help from American Forest Foundation and World Resources Institute, complete a regional conservation strategy
- Stakeholders agree to a common measurement system for gopher tortoise habitat quality that links to the regional conservation strategy and works across Farm Bill programs, required mitigation, and voluntary investments from public and private sectors.
- USFWS adjusts its conservation banking system in the listed range of gopher tortoise to a habitat-based mitigation framework connected to the regional conservation strategy and the agreed-to measurement system for both listed and unlisted ranges.

VI. Conclusions and next steps

There are a lot of things that need to happen in order for biodiversity markets and other incentives to improve the way investments produce more conservation on the ground, but two of the largest remaining gaps include: 1) consistency across incentives for measurement systems and program designs, and 2) the number of landscape-scale demonstrations to fine-tune inter-agency coordination, regulatory certainty, measurement approaches, adaptive management, and landowner and demand-side participation.

Generally though, emerging measurement systems are striving for outcome-based approaches that achieve goals for both usability and scientific rigor. These measurement systems will be accessible to a broader range of users, and are more likely to be used and applied to multiple sites than more complex, resource-demanding approaches. Metrics are increasingly housed within standardized protocols that build greater confidence in analyses, projections, and adaptive management strategies. Measurement system developers increasingly understand they need to build metrics and tools that work across scales and across incentive program types.

There is still work do be done though. Most of these measurement systems are being developed for very specific objectives, and in some cases, in anticipation of regulation or other drivers that will promote their use (e.g. endangered species listings). These narrow design parameters can create weak spots in measurement systems. There is often a lack of independent validation of the effectiveness of different approaches at meeting conservation objectives. Many measurement system developers have not articulated a clear path for ongoing, adaptive management.

The options presented in this report are based on careful analysis of 25 existing measurement systems, and thoughtful conversation between a Technical Group of experts working to expand biodiversity incentives. In the near-term, some specific steps that could keep that conversation going include:

- Cooperation between U.S. Fish and Wildlife Service and USDA to generate joint guidance on pre-compliance conservation banking;
- For the sage-grouse and longleaf pine ecosystem initiatives, private partners could engage with NRCS to define early actions to generate landscape-scale demonstrations;
- U.S. Geological Survey, working with other federal agencies and private partners, could add definition to the options surrounding a nationally consistent framework for measuring biodiversity outcomes across incentive programs; and
- USDA could begin to identify ways existing federal funding sources could leverage investment in more coordinated measurement system development, validation, and adaptive management.

The Technical Group hopes this report provides a basis for federal agencies, state and local government, and private partners to work directly to build a nationally consistent framework for measuring the biodiversity benefits and impacts of actions taken on the land. The Group welcomes the opportunity for further discussion and articulation of the options presented here.

VII. References

Casey, F., Vickerman, S., Hummon, C. and Taylor, B. (2006). *Incentives for biodiversity conservation: an ecological and economic assessment*. Washington, D: Defenders of Wildlife.

Doherty, K.E., Naugle, D.E., and Evans, J.S. (2010). A Currency for Offsetting Energy Development Impacts: Horse-Trading Sage-Grouse on the Open Market. *PLoS One*. *5(4*), e10339.

Elkum, N. and Shoukri, M.M. (2008). Signal-to-noise ratio (SNR) as a measure of reproducibility: design, estimation, and application. *Health Serv. Outcomes Res. Protocol 8*, 119–133.

Florida Fish and Wildlife Conservation Commission. (2011). Retrieved April 11, 2011 from http://myfwc.com/wildlifehabitats/profiles/reptiles-and-amphibians/reptiles/gopher-tortoise/.

Folke, C., Carpenter, S., Walker, B., Scheffer, M., Elmqvist, T., Gunderson, L., and Holling, C.S. (2004). Regime Shifts, Resilience and Biodiversity in Ecosystem Management. *Annu. Rev. Ecol. Evol. Syst.* 35, 557-581.

Lubowski, R.N., Vesterby, M., Bucholtz, S., Baez, A. and Roberts, M.J. (2006). *Major uses of land in the United States, 2002*. Economic Information Bulletin No. (EIB-14). U.S. Department of Agriculture, Economic Research Service.

Millennium Ecosystem Assessment. (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis*. Washington, DC: World Resources Institute.

Noss, R. (1990). Indicators for Monitoring Biological Diversity: A Hierarchical Approach. *Conservation Biology,* 4 (4), 355-64.

Prabhu, R., Colfer, C. J. P. and Dudley, R. G. (1999). *Testing and Selecting Criteria and Indicators for Sustainable Forest Management*. Jakarta, Indonesia: Center for International Forestry Research.

Schamberger, M.L. and O'Neil, L.J. (1986). Concepts and constraints of habitat-model testing. Wildlife 2000 (J.Verner, M.L. Morrison, and C.J. Ralph, eds), The University of Wisconsin Press, Madison, WI, pp. 177-182

Shaffer, M.L., Scott, J.M., and Casey, F. (2002). Noah's Options: Initial Cost Estimates of a National System of Habitat Conservation Areas in the United States. *BioScience,* 52(5), 439-43.

Thuiller, W., Albert, C.H., Dubuis, A., Randin, C., and Guisan, A. (2010). Variation in habitat suitability models do not always relate to variation in species' plant functional traits. *Biology Letters*, 6, 120-123.

United States Fish and Wildlife Service. (1980). Habitat Evaluation Procedure Handbook. Washington, DC: Division of Ecological Services, U.S. Fish and Wildlife Service, US Department of the Interior. Retrieved December 15, 2010 from http://www.fws.gov/policy/esmindex.html.

United States Fish and Wildlife Service (2003). Guidance for the establishment, use, and operation of conservation banks. United States Department of the Interior. Memorandum to Regional Directors, Regions 1 to 7, and Manager, California Nevada Operations. Retrieved April 7, 2011 from http://www.fws.gov/endangered/esa-library/pdf/Conservation_Banking_Guidance.pdf.

United States Fish and Wildlife Service. (2009). Conservation Banking: Incentives for Stewardship. Retrieved April 7, 2011 from http://www.fws.gov/sacramento/es/banks/conservation_banking.pdf.

United States Fish and Wildlife Service. (2009b). Guidelines for the Establishment, Management, and Operation of Gopher Tortoise Conservation Banks. http://www.fws.gov/mississippiES/pdf/USFWSGopherTortoiseBankGuidance_27Jan2009.pdf. (accessed April 11, 2011).

United States Geological Survey. (2011). Conservation of Sagebrush Ecosystems and Wildlife. Fort Collins Science Center. Retrieved April 11, 2011 from http://www.fort.usgs.gov/resources/research_briefs/Conservation_Sagebrush.asp.

Vickerman, S., Cochran, B. and Primozich, D. (2009). *A Framework for Crediting and Debiting Biodiversity*. Defenders of Wildlife Technical Report. Portland, OR: Defenders of Wildlife. p.22.

VIII. Appendices (in separate volume)

Appendix A. Glossary of Terms

Appendix B. Technical Group Organizations

Appendix C. Measurement System Assessment Criteria

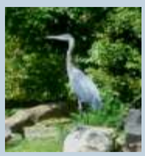
Appendix D. Measurement Systems Inventory

Appendix E. Conservation Banking Report

Appendix F. Typology of Metrics

Appendix G. Case Studies

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


APPENDICES

Willamette Partnership

A report funded by the U.S. Department of Agriculture,
Office of Environmental Markets
April 2011

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.

Contact:

Bobby Cochran, Willamette Partnership
2550 SW Hillsboro Hwy
Hillsboro, OR 97123
503-681-5112
info@willamettepartnership.org

Acknowledgements: Measuring Up was funded by the USDA. Office of Environmental Markets and guided by a stakeholder Technical Group made up of very knowledgeable and dedicated people and organizations listed in Appendix B.

The Willamette Partnership thanks everyone for all the hard and thoughtful work that has brought years of experience and discussion into Measuring Up.

Table of Contents

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
BioBanking	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.
http://www.environment.nsw.gov.au/biobanking/		
Habitat Hectares	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.
http://www.environment.gov.au/archive/biodiversity/toolbox/templates/pubs/habitat-hectares.pdf		
Ecosystem Mitigation Approach	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.
http://www.emri.org/PDF%20Docs/Adobe%20files/co%20cig%20report_reduced.pdf		

Measurement System Name	Lead Developer	Description
Native Vegetation and Scattered Tree Offsets Program	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.
http://www.pir.sa.gov.au/__data/assets/pdf_file/0003/30990/native_veg_policy.pdf		
Habitat Quality Index	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.
http://www.bio-west.com/services/wild_veg/wildveg_projects/HQI		
Bay Bank Bog Turtle Protocol	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.
http://www.thebaybank.org/downloads/bog_turtle_management_guidance_070610.pdf		
Utah Prairie Dog Recovery Program	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.
http://www.edf.org/documents/7328_Utah%20Prairie%20Dog%20Habitat%20Evaluation%20Guide.pdf		

Measurement System Name	Lead Developer	Description
Gopher Tortoise Habitat Crediting Program	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.
http://www.affoundation.org/ccs_conservation.html		
Habitat Suitability Index	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).
Recovery Credit System for Golden-cheeked Warbler	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.
http://www.edf.org/pressrelease.cfm?contentID=10907		
Delaware Comprehensive Assessment Protocol	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.
http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/DE_%20Comprehensive%20Assessment%20_v5.1.pdf		

Measurement System Name	Lead Developer	Description
Ecometrix Salmon Habitat Crediting Protocol	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.
http://willamettepartnership.org/ecosystem-credit-accounting/salmon/copy_of_salmon-habitat		
Oregon Wetlands Rapid Assessment Protocol	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.
http://www.oregonstatelands.us/DSL/WETLAND/or_wet_prot.shtml		
Counting on the Environment Upland Prairie Calculator	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.
http://willamettepartnership.org/ecosystem-credit-accounting/prairie		
Universal Mitigation Assessment Methodology	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.
http://www.dep.state.fl.us/labs/library/index.htm and http://www.dep.state.fl.us/water/wetlands/docs/mitigation/UMAM_Training_Manual_ppt.pdf		

Measurement System Name	Lead Developer	Description
Conservation Banking	U.S. Fish and Wildlife Service	Awards credits based on acres of habitat occupied by an endangered species and put under conservation easement.
http://www.fws.gov/endangered/landowners/conservation-banking.html		
Healthy Forests Reserve Program	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.
http://www.nrcs.usda.gov/programs/hfrp/proginfo/index.html		
Wildlife Habitat Incentives Program	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.
ftp://ftp-fc.sc.egov.usda.gov/MD/web_documents/programs/whip/2006/MD_WHIP_Plan_2006.pdf		
Qualitative Habitat Evaluation Index	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.
http://www.epa.ohio.gov/portals/35/documents/QHEIManualJune2006.pdf		
Rangeland Health Assessment Procedure	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.
ftp://ftp-fc.sc.egov.usda.gov/GLTI/technical/publications/IIRH_v4_8-15-05.pdf		

Measurement System Name	Lead Developer	Description
Habitat Evaluation Procedure	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.
http://www.fws.gov/policy/ESMindex.html		
Habitat Equivalency Analysis	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.
http://www.csc.noaa.gov/coastal/economics/habitatequ.htm		
InVEST	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.
http://www.naturalcapitalproject.org/InVEST.html		
New Zealand Risk Index Method	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		
Ohio Rapid Assessment Method for Wetlands	Ohio State Environmental Agency	Relatively fast and easy method for determining the appropriate category of a particular wetland (low, medium or high quality).
http://www.epa.state.oh.us/portals/35/guidance/wetland1.pdf		

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 *Sambucus* 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.

Literature Cited

Ecosystem Marketplace. (2008). Speciesbanking.com. Retrieved March 20, 2011 from http://speciesbanking.com/.

Environmental Defense Fund. (2010). Conservation banking in detail. Retrieved March 20, 2011 from http://www.edf.org/page.cfm?tagID=418&campaign=cci.

Florida Wildlife Commission. (2010). Mitigation Parks. Retrieved March 20, 2011 from http://myfwc.com/recreation/WMASites _mitparks.htm.

Madsen, B., Carroll, N., and Moore Brands, K. (2010). State of Biodiversity Markets Report Offset and Compensation Programs Worldwide. Retrieved March 20, 2011 from http://www.ecosystemmarketplace.com/documents/acrobat/sbdmr.pdf.

Sacramento Fish & Wildlife Office. (2009). Example Credit Evaluation Table.

Sacramento Fish & Wildlife Office. (2009b). Example Goldfields and Tadpole Shrimp Credit Evaluation Table.

Sacramento Fish & Wildlife Office. (2009c). Valley Elderberry Longhorn Beetle Conservation Bank Credit Release Schedule and Performance Standards.

Sacramento Fish & Wildlife Office. (2010). Valley Elderberry Longhorn Beetle Conservation Bank Credit Release Schedule and Performance Standards.

Wildlands, Inc. (2010). Ranch Wetlands Mitigation Bank: Yolo County, California: Long-term Management Plan.

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.

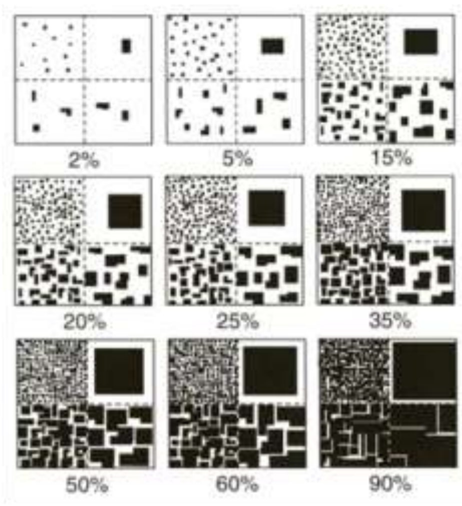


Figure F.1. Reference diagram for estimating percent cover from the Utah Prairie Dog Habitat Evaluation Guide (CITATION).

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 (Haufler 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.

References

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

Burgin, S. (2008). BioBanking: an environmental scientist’s view of the role of biodiversity banking offsets in conservation. *Biodiversity and Conservation*, 17(4), 807-816.

Gibbons, P. and Freudenberger. D. (2006*). An overview of methods used to assess vegetation condition at the scale of the site. Ecological Management & Restoration*, 7, S10–S17.

Haufler, J.B (Ed.). (2007). *Fish and Wildlife Response to Farm Bill Conservation Practices*. Technical Review 07-1. Bethesda, MD: The Wildlife Society.

McCarthy, M. A., Parris, K. M., Van Der Ree, R., McDonnell, M. J., Burgman, M. A., Williams, N. S. G., McLean, N., Harper, M. J., Meyer, R., Hahs, A. and Coates, T. (2004). The habitat hectares approach to vegetation assessment: An evaluation and suggestions for improvement. *Ecological Management & Restoration*, 5, 24–27.

Parkes, D., Newell, G. and Cheal, D. (2003). Assessing the quality of native vegetation: The 'habitat hectares' approach. *Ecological Management & Restoration*, 4, S29–S38.

Schamberger, M.L. and O'Neil, L.J. (1986). Concepts and constraints of habitat-model testing. In J.Verner, M.L. Morrison, and C.J. Ralph, eds, *Wildlife 2000.* Madison, WI: The University of Wisconsin Press. pp. 177-182.

Thuiller, W., Albert, C.H., Dubuis, A., Randin, C. and Guisan, A. (2010). Variation in habitat suitability models do not always relate to variation in species' plant functional traits. *Biology Letters*, 6, 120-123.

USDA Natural Resources Conservation Service. (2009). Conservation Programs and Practices for Your Land. [Brochure]. Retrieved December 15, 2010 from http://www.nrcs.usda.gov/programs/farmbill/2008/FB_Brochure_2008/Farm_Bill_2008_Brochure.html.

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.