PROJECT NO. C06(B) **COPY NO.___**

PROJECT C06(B):

DEVELOPMENT OF AN ECOLOGICAL ASSESSMENT PROCESS AND CREDITS SYSTEM FOR ENHANCEMENTS TO HIGHWAY CAPACITY

DRAFT FINAL REPORT

Prepared for

C06 Technical Expert Task Group (T-ETG) of
The Strategic Highway Research Program 2

Transportation Research Board
Of
The National Academies

Prepared by

Institute for Natural Resources, Corvallis, Oregon
NatureServe, Arlington, Virginia
Parametrix, Portland, Oregon
CH2M Hill, Portland, Oregon

October 2010

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FOREWORD

Avoidance, minimization, and mitigation efforts may not always provide the greatest environmental benefit, or may do very little to promote ecosystem sustainability. [An] ecosystem approach is a process for the comprehensive management of land, water, and biotic and abiotic resources that equitably promotes conservation and sustainable use---restoring, creating, enhancing, and preserving habitat and other ecosystem features in conjunction with or in advance or projects

Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects

This report describes an ecological assessment process to support enhancements to highway capacity. The process is designed to address the scientific and technical obstacles to integrated conservation and transportation planning advocated by the *Eco-Logical* approach to infrastructure development (Brown 2006) and more recent refinements to watershed permitting and strategic habitat conservation planning. The process spans long range planning, corridor planning, environmental review and environmental permitting with the objective of accelerating project delivery while improving environmental stewardship.

The foundation for the entire process is Cumulative Effects Assessment and Alternatives (CEAA). Using the latest geospatially explicit conservation planning methods, transportation agencies, and resource agencies can develop a shared conservation vision for areas likely to be affected by new transportation projects, resulting in a Regional Ecosystem Framework (REF). Within the CEAA process, guidance is provided on methods that can be used to enhance information about resources regulated under the Clean Water Act (CWA) and the Endangered Species Act (ESA) in order to reach early agreement with the resource agencies on resources that need to be avoided to reduce impacts and agree on mitigation priorities. The report also describes how to develop objective methods for calculating ecological values for resources that will be impacted to ensure optimal mitigation throughout the transportation planning and project delivery process.

The ecological assessment process, including the regulatory assurances and ecosystem crediting and valuation methods, are part of the Integrated Eco-Logical Conservation and Transportation Planning Framework developed by Strategic Highway Research Program 2 (SHRP2) project C06(A), *Integration of Conservation, Highway Planning, and Environmental Permitting Environmental Permitting Using an Outcome-Based Ecosystem Approach.* This report explains step-by-step how the ecological assessment process and strategies apply at each point in the decision making process.

The report concludes with a description of the interactive database that will make the tools, methods and case studies needed to use this process available to transportation planners and resource agencies through the *Transportation for Communities: Advancing Projects through Partnerships* (TCAPP) website, developed by the SHRP2 C01 project. The "Guidance for Integration of Conservation, Highway Planning and Environmental Permitting" prepared by the C06(A) project also incorporates our research results.

In 2002, the Surface Transportation Environmental Cooperative Research Program Advisory Board found that:

> *The current state of knowledge and the tools available for environmental assessment are inadequate to ensure informed and effective decisions on transportation and the environment (TRB, 2002).*

Americans expect new transportation capacity to be delivered in a way that enhances the natural and built environment. In 2006, this expectation was addressed by Congress in the SHRP2 Capacity program and its charge to develop approaches and tools for systematically integrating environmental requirements into the analysis, planning, and design of new highway capacity.

This research takes advantage of integrated electronic data collection, management and analysis methods using geographic information systems to integrate transportation planning and conservation planning at multiple scales in order to accelerate project delivery and improve environmental outcomes.

EXECUTIVE SUMMARY

The nine-step *Integrated Eco-Logical Conservation and Transportation Planning Framework* ("the Framework") is designed to support and promote integrated transportation and conservation planning while expediting transportation project delivery. This report addresses the scientific and technical processes needed for this integrated approach. A Cumulative Effects Assessment and Alternatives (CEAA) process provides the foundation. Within CEAA and the overall Framework, new regulatory assurance, environmental accounting, and crediting methods can be applied. We hope that this new Framework will foster agreement between transportation and resource agencies on conservation priorities and ecosystem service valuation in areas where new transportation projects are planned, improving transportation project delivery and conservation results.

The imperatives of climate change and the tight budgets faced by government at all levels make it vital that every dollar spent on environmental mitigation and restoration in transportation project development is money well spent. It is incumbent on us to steward both public tax dollars and natural resources to the greatest extent we can, to ensure that time and money are not wasted, and to ensure that what we are doing really contributes to the goals of species and ecosystem recovery and restoring and maintaining the integrity of the nation's waters while delivering needed transportation projects to serve community needs.

THE FRAMEWORK

Using the steps in the Framework, state transportation agencies (DOTs), metropolitan planning organizations (MPOs), and resource agencies work together during long-range planning to identify strategic transportation program needs, their potential environmental impacts and conservation opportunities in the state, ecoregion, or watershed. The Framework allows programmatic tools to be used to increase regulatory predictability during project development while furthering regional conservation goals. The Framework is a comprehensive, dynamic process that will promote the integration of regulatory and non-regulatory authorities and strengthen the opportunity to achieve ecosystem health. Through the integration of traditionally competing regulatory and non-regulatory authorities, this Framework can improve resource planning, enhance time and resource efficiency, and minimize redundancies in the decision making process.

CUMULATIVE EFFECTS ASSESSMENT AND ALTERNATIVES PROCESS

The CEAA process is based on and supports the Eco-Logical approach. The CEAA provides technical guidance to transportation and natural resource practitioners—helping them bring the right expertise, data, methods, and tools to the right stage of the transportation planning and project delivery decision making process. The result is better environmental outcomes through reduced impacts, identification of high quality mitigation and enhancement opportunities, and accelerated permitting through proactive inclusion of resource considerations early in the process.

Rather than a radical new approach, the CEAA process simply brings together a variety of well-tested methods, data, and tools into a cohesive ecological assessment framework. It addresses several long recognized needs: 1) the need to proactively consider ecological values early in infrastructure and land use planning processes and preferably at a regional scale; 2) the need for spatially explicit and sufficiently precise cumulative effects assessment throughout a region to provide useful information to guide alternatives development and mitigation planning; 3) the need for a collaborative structure for technical information development and maintenance to serve multiple planning purposes dynamically over time;

and 4) the desire to obtain better ecological outcomes from mitigation investments while meeting planning objectives.

Specifically, the CEAA process guides an ecological assessment that: 1) evaluates direct and cumulative effects on resources from any potential planning alternative or project, 2) assists in the identification or creation of alternatives, and 3) identifies the best mitigation and enhancement opportunities. The CEAA process supports a collaborative and scientifically rigorous process for avoiding and minimizing conflict, as well as identifying mitigation and enhancement opportunities.

It addresses several key questions in the transportation and conservation planning and project development process:

- What areas and resources will be directly impacted by transportation development?
- How will those resources be impacted cumulatively through the affected region?
- What areas could be used for mitigation?
- How can anticipated long-range regional mitigation needs be aggregated for maximum ecological benefit?

The CEAA is intended to be highly scalable to the time, resources, data, and expertise available, and can be used at the regional, corridor, or project level. Undertaking a CEAA requires working collaboratively with transportation and resource agencies and other stakeholders to agree on a set of targets and goals for an area of interest. As described in Eco-Logical, this process ensures that relevant expertise, data, tools and methods are considered in the development of a Regional Ecosystem Framework (REF). The REF can then be used to assess and guide transportation decision making at all stages of transportation planning and development, and allow impacts to be assessed and quantified early in the transportation planning and project delivery process.

Within this process, it is possible to begin at any transportation decision point and use the CEAA to help identify and incorporate the necessary questions, data, and analysis needed to support better environmental and transportation decision making. The online version includes references that provide in-depth reading on the concepts, and case studies that illustrate real-life applications, as well as useful technical tools and data sources to support its use and implementation.

The major outputs of the CEAA are:

- Unified map of transportation, land use, conservation, and restoration priorities.
- Maps of each potential transportation scenario that shows an assessment of direct and cumulative effects at a landscape level with supporting data.
- Identification of affected resources and the quantification of the cumulative effects for each transportation scenario being considered.
- Identification and evaluation of potential mitigation and enhancement areas within a region.

REGULATORY ASSURANCES AND ECOLOGICAL ACCOUNTING STRATEGIES

Within the overall Framework and the CEAA process, two strategies are critical. First, transportation planners and project managers must address regulatory requirements, ideally as early in the transportation planning and development process as possible. Second, environmental accounting strategies can be used to reach agreement with regulatory agencies on project impacts and mitigation requirements. Our project explored new approaches to regulatory assurances and environmental accounting and how they could be used within the overall Framework if transportation and resource agencies choose to do so.

Regulatory Assurances

Addressing regulators' needs is an essential part of the decision making process for all transportation projects. While obtaining complete regulatory assurances may be impossible, this report and the online database provide guidance on the information, tools and processes that can lead to faster decisions with improved environmental outcomes. The focus of our project is on regulations under the Endangered Species Act (ESA) and the Clean Water Act (CWA). We identified the aspects of current decision-making that provided the greatest concern for regulators at the national, regional, state, and local levels; and then developed a set of potential tools and information to address these concerns. Based on our research, we believe that, particularly for wetlands and endangered species, regulatory conflicts and delays largely result from transportation planners and regulators having insufficient, incomplete, or poor quality data.

There are two critical requirements for improved outcomes. The first is to provide the tools planners can use to identify potential impacts to regulated resources very early in the planning process – allowing them to avoid or minimize these impacts as much as possible. The second is to assure that any mitigation that must occur due to unavoidable impacts will provide effective, measurable, and high quality environmental outcomes for the impacted resources.

Problems under Section 7 of the ESA result both from the lack of certainty about the probability and degree that a project may impact a listed species and the lack of certainty as to how to design meaningful mitigation measures. We hypothesized that if done correctly, specific improvements in threatened and endangered species data can improve both transportation planning and species recovery efforts. We found that developing digital maps showing the probable distribution of listed species is feasible for all listed species, and has the potential to radically improve regulator and planner interactions.

Species distribution models using inductive modeling methods can create reliable maps that can be used by transportation planners early in the planning process, before significant investments have been made towards road design. The maps are also useful in identifying mitigation opportunities and assisting in recovery planning. The nature of the inductive maps makes updating them with new information relatively straightforward, and can allow regulators, if they choose, to easily modify the maps to make them more conservative if needed for Section 7 consultations for a particular species. Natural Heritage Programs have created these maps for many endangered and at risk-species in New York, Oregon, Florida, Wyoming and Virginia, and have been working with NatureServe and the U.S. Fish and Wildlife Service (USFWS) to develop a strategy for creating these data for all listed species in the U.S.

Improved information appears to be equally as important for improving transportation and conservation outcomes related to wetlands, streams, rivers and other resources regulated under the CWA. The majority of transportation agency interactions with regulators were on Section 404 compliance, which provides protections for wetlands, so information needs for wetlands was our research focus. As was the case with the ESA, data is lacking for avoidance and minimization and for mitigation. However, unlike the ESA, the data needs for avoidance are somewhat different from the needs for mitigation.

For avoidance, transportation planners need access to digital wetland maps covering the entire U.S. The National Wetlands Inventory (NWI) is the baseline database for the country designed for this purpose, but covers only about 80% of the country digitally -- and much of the NWI is based on imagery that is almost 30 years old. USFWS has been working hard to obtain the funding to complete this dataset, but with current protocols and funding level, it will be decades before the country has digital data that is sufficiently updated to be used by transportation planners and accepted by regulators as meaningful attempts at avoidance and minimization. Our research looked at case studies to create digital data where it was lacking in Oregon, and to improve it in Michigan and Virginia. We have identified strategies to create wetlands data for avoidance for the entire country within two or three years.

The primary data need for wetlands mitigation is the identification of priority wetland areas needing restoration, or a wetlands restoration and mitigation catalog for states. To be effective these need to identify mitigation needs for all watersheds, and need to be pre-approved by wetland regulators. The research identified methods for developing wetland catalogs based on a Regional Ecosystem Framework, piloted in Oregon and Virginia, focusing on methods that can be implemented widely in the near future. Similar efforts have been undertaken locally as a watershed approach in many areas of the country, with an effort to develop statewide priorities for Maryland. Many methods appear to be promising, although ways to integrate wetland priorities with other water quality needs are only beginning to be explored. The development of a wetlands mitigation catalog can significantly improve conservation outcomes, and also dramatically improve transportation project implementation, and developing standards for implementing this across the country is a critical need.

Ecological Accounting Strategies

The transportation industry has much to gain from being better able to understand and measure the relationship between transportation infrastructure and ecosystems. There are many ongoing efforts to improve ecological metrics and decision-support tools. However, the movement to adopt these tools into actual DOT decision-making has been slow. As a result, the transportation industry has not been taking full advantage of the opportunities that the use of better ecological metrics and decision-support tools can provide.

Transportation planning and permitting decisions require a clear measurement of impacts to understand available choices, but agreement on measurements to assess impacts and mitigation options can be difficult to reach. Additionally, as decisions are made in resource-specific processes, silos are created around each natural or ecological resource being managed. Our research addressed measurement needed to meet *existing* regulatory concerns and measures and take advantage of *emerging* requirements and stakeholder concerns developing around the concept of ecosystem services. Our communities rely on ecosystem services of many kinds to be economically prosperous, healthy, and safe. Measuring ecosystem services is increasingly seen as an important aspect of sustainability planning and an important tool in public engagement to communicate how and why we manage the natural environment the way we do.

Function-based crediting tools are measurements based on understanding the natural processes and benefits provided by natural and modified environments. This methodology is reflected in many of our current regulatory structures and in conservation planning. Ecosystem Crediting Tools generally deal with project-specific measurement issues such as mitigation quantities. However, tools within this class can provide a wide variety of benefits beyond merely calculating mitigation debits/credits. The tools we present in our online database go beyond regulatory compliance and into broader stewardship and sustainability through ecosystem service measurement.

A major focus of recent work within the world of ecosystem metrics is the effort to link and correlate the measurements at a landscape scale with measurement of similar resource issues at a site level. Applied in a transportation context that means being able to: 1) broadly understand and plan around a resource at a regional scale – identifying goals and desired outcomes for that resource; and 2) measuring specific outcomes for that resource at a site level in a manner that tells us something meaningful about the increment of change associated with a project's effect on the resource. In practice, linking the measurement scales provides the following outcomes:

- A better ability to maintain continuity between early transportation planning and project specific planning,
- Improved regional goal setting and a better ability to track the effect of specific projects on the progress towards those goals,
- A framework for understanding and presenting cumulative effects analyses,
- An improved understanding of the opportunity/need for using programmatic approaches and an improved ability to develop them.

Ecosystem metrics and decision support tools can be used in a variety of ways to improve the communication and decision-making in the project design and permitting processes. Ideally, this improvement starts by building off the program level opportunities described above. However, it also includes the following:

- Ability to use alternative analysis tools that can provide quantitative distinctions between alternative scenarios.
- A sound site-level ecological metric provides a basis for clearly measurable, quantitative, outcome-based performance standards, which can be an effective means of providing design engineers some much needed design flexibility while also providing certainty for impact targets.
- Good ecosystem metrics provide a means of better linking impact measurement to mitigation decisions.

Currently there are specific geographies (e.g., the Willamette Valley in Oregon, Chesapeake Bay region) and resources (e.g. wetlands) where market solutions are becoming increasingly viable. However, for all markets, credit demand is currently seen as the limiting factor to the broader, more extensive development of ecosystem marketplaces. In this circumstance, DOTs could play a significant role in shaping and creating market opportunities.

- A market solution requires a unit of measure that is used as the basis for the transaction. Increasingly, ecosystem market developers are exploring the use of improved ecological metrics to expand the scope and quality of market transactions. To access these markets, it will be necessary to incorporate these ecological metrics into DOT impact analysis.
- The need to pursue ecosystem market approaches could become increasingly important as CEQ pushes for increased stringency for the mitigation associated with Mitigated Environmental Assessments (better documentation, monitoring, etc.).

This approach to ecosystem metrics from the landscape scale to the site level, from alternatives analysis to outcome-based mitigation for specific projects, is addressed throughout the CEAA process. A separate step addressing use of crediting systems is in included in the Framework, providing specific guidance for transportation agencies on how to develop and use ecosystem crediting systems.

PILOT PROJECTS

After the Framework, including the CEAA and supporting strategies, was developed, we tested it in three pilot projects in Oregon, Michigan, and Colorado. Our objective was to see if the new approach would result in different decisions and outcomes or time and cost savings compared to the traditional transportation planning and project delivery system. We also sought to test the usability of the new processes. We found that our methodology produced similar results to traditional approaches in the evaluation and mitigation of direct impacts. Our approach showed the most difference in the results for cumulative impact analysis and selection of mitigation option, particularly at the transportation planning level.

DISSEMINATION

The Framework, including the detailed CEAA process and the supporting strategies for achieving regulatory assurances and using ecological accounting systems and credits, will be included in the TCAPPs' website. Our research developed an interactive database to support transportation and resource agencies. The database that will be integrated into TCAPPs includes a step-by-step guide with supporting documentation in the form of case studies, tools, data, expertise and other resources to assist practitioners in using all or part of the proposed new approach.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF TABLES

APPENDICES

ABBREVIATIONS AND ACRONYMS

CWA	Clean Water Act
CDMF	Collaborative Decision Making Framework
CEQ	Council on Environmental Quality
CEAA	Cumulative Effects Assessment and Alternatives
DEQ	Department of Environmental Quality
DOT	Department of Transportation
EA	Environmental Assessment
EAF	Ecological Assessment Framework
EBM	Ecosystem-Based Management
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
FGDC	Federal Geographic Data Committee
FHWA	Federal Highway Administration
FNAI	Florida Natural Areas Inventory
GAO	Government Accountability Office
GDP	Gross Domestic Product
LRTP	Long Range Transportation Plan
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
NOAA	National Oceanic and Atmospheric Administration
OSU	Oregon State University
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NPDES	National Pollutant Discharge Elimination System
NWI	National Wetlands Inventory
PES	Payment for Ecosystem Services
REF	Regional Ecosystem Framework
SHRP2	Strategic Highway Research Program 2
SME	Subject Matter Expert
STIP	Statewide Transportation Improvement Program
SWAP	State Wildlife Action Plan
TCAPPs	Transportation for Communities: Advancing Projects through Partnerships

TMDL	Total Maximum Daily Load
TRB	Transportation Research Board
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

1. CHAPTER 1: THE PROJECT APPROACH

1.1 RELATIONSHIP TO THE COLLABORATIVE DECISION MAKING FRAMEWORK AND PROJECT C06(A)

The SHRP2 Capacity program is charged to develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity. The foundation of this approach is the *Framework for Collaborative Decision Making on Additions to Highway Capacity* developed by the C01 Project. The nine-step *Eco-Logical* framework for integrated planning is tied to key decision points within the Collaborative Decision Making Framework (CDMF). Our *Integrated Eco-Logical Conservation and Transportation Planning Framework* (the "Framework") was designed to build on the *Eco-Logical* framework, allowing it to be integrated into the CDMF.

The C06(A) Project, *Integration of Conservation, Highway Planning, and Environmental Permitting Using an Outcome-Based Ecosystem Approach*, elaborated on decision points in the CDMF that involve regulated and non-regulated environmental impacts, such as wetlands, water quality, endangered species, wildlife, habitats, and cultural resources, building on the *Eco-Logical* framework. The C06(A) project also worked to solve the problem of getting assurances from regulatory agencies that transportation agency investments in environmental mitigation or restoration are accepted by regulatory agencies. Project C06(B) worked closely with the C06(A) project to address the issues identified by the regulatory agencies, obtaining better information about the regulated resources in order to obtain early agreement on resources to avoid and on robust, flexible, clear mitigation strategies. Our coordination with the C06(A) project should assure that the scientific and technical processes and strategies developed to support an ecological approach fit within existing and future institutional systems and address barriers to its wider adoption.

1.2 APPROACH

We began our work by developing a vision for integrated transportation and conservation planning (see Chapter 2). We then reviewed the literature and did detailed reviews and evaluations of existing ecological assessment tools and environmental accounting tools. The results of this work were included in our interim report and are included in the interactive database we have developed. The CEAA process was developed and integrated into the overall Framework. State and federal regulators were interviewed in order to identify and address the technical issues associated with obtaining regulatory assurances early in the transportation planning and project delivery process. State and local transportation agencies were interviewed to help develop step-by-step strategies for improving use of outcome-based environmental accounting and crediting systems. Once the CEAA technical guidance and supporting regulatory assurance strategy was developed, they were tested in three pilot states. Additional details on our approach are provided below.

Our approach integrated well-vetted and tested concepts from the disciplines of systematic conservation planning well described in Groves 2003, cumulative effects assessment, and the mitigation hierarchy (avoidance, minimization, mitigation, compensation). While integrating the scientific concepts from these disciplines, we developed technical guidance drawn from the spatial analyses and decision support practices. The intention was to describe a detailed hierarchy of integrated steps and substeps that could guide practitioners through the CEAA process but be flexible to their specific GIS platforms and available capacity and financial resources.

1.3 DEVELOPMENT OF THE FRAMEWORK

The *Integrated Eco-Logical Conservation and Transportation Planning Framework* was developed in collaboration with the C06(A) team. It was developed to closely follow the Eco-Logical framework while providing additional detail to make Eco-Logical implementable. These additional details were described in a hierarchical fashion with detailed technical levels to include the Cumulative Effects Assessment and Alternatives (CEAA) component. The Framework underwent a number of revisions based on review by a large number of consulted practitioners and our experience conducting the pilot projects.

The CEAA component originated from work done on another TRB research project (NCHRP 25-25 (54)) on regional cumulative effects assessment. The CEAA is more focused on ecological resources, where the earlier project attempted to address a broader set of resources and vulnerable human populations. The original work was modified to fit the Framework and provide further detail in the components of mitigation and alternatives development and ongoing adaptive management. See CEAA sections in Chapters 2 and 3 for more information.

1.4 ECOLOGICAL ASSESSMENTS TOOL SURVEY AND UTILITY ANALYSIS

Scientists have developed many methods for assessing ecosystem function over various geographic scales and timeframes. The challenge is to identify the methods that are most useful at various stages of the transportation planning and project delivery process in order to know what resources and functions are important, how impacts to them can be avoided and minimized, and if impacts are unavoidable, how they can be mitigated most effectively. To identify methods appropriate for use at various key decision points in transportation planning and development, we developed a tool survey protocol.

The tool survey protocol included the methods for searching for tools, evaluating tools for their relevance and utility and characterizing tools in a database suitable for long-term use in an interactive database. The survey built on considerable existing knowledge regarding tools available to conduct ecological assessments including cumulative effects analyses. It also drew on tool surveys by the Ecosystem Based Management (EBM) Tools Network. The EBM Tools Network supplied the team with characterizations of 171 tools that were already integrated into an online database (http://www.smartgrowthtools.org/ebmtools/index.php), some of which were included in our survey.

We worked from the EBM Tools Network evaluation protocols, added to it, and created a working list of criteria and questions to develop the tools and methods included in the Ecological Assessment Framework. The database of tools developed through this protocol was conducted by reviewing the tools documented in the EBM Tools Network, reviewing the tools that were referenced in many of the articles and research cited in the literature review, and by using our team's knowledge to evaluate the tools.

The tool evaluation database consists of decision support tools, ecological and conceptual modeling tools, transportation-sector specific tools that have broad applicability and state-specific ecological and conservation data query tools. Some tools listed are best described as methods to organize information or integrate certain steps into a larger planning process.

Each tool in the database was evaluated within the context of the overall Framework and the process tasks and key decisions included in the templates that support the Framework. There is no ecological assessment "supertool" capable of conducting all computerized analyses necessary for regional ecological and cumulative effects assessment; therefore, we have developed a "toolkit" that combines multiple tools to support an information workflow through all levels of transportation planning and project delivery. The following assessment criteria and questions were developed against which potential tools were assessed for their utility at various stages of the transportation planning and project development process:

1. *Was sufficient information available to correctly characterize a tool?*

   For some tools, adequate information could not be obtained to describe it adequately.

2. *Does the tool have documentation?*

   Documentation can take many forms but it should be clear and readily accessible. It should clearly state who created the tool (the originator), what the tool was designed to do, was it created for a particular focal ecosystem, what information or inputs the tool needs, and how the tool creates useful outputs for the user(s).

3. *Does the tool originate from a credible source?*

   The majority of tools encountered online come from well known governmental, private, or non-profit institutions. The existence of a user community also lends credibility to the tool.

4. *Is the tool maintained?*

   Too often, tools are created and released but not maintained over time. Since technology and methodologies change, tools can quickly become obsolete. Some of the documented methods were older but applied more generally to well-established planning processes (such as NEPA).

5. *Has the tool been used in the field?*

   Ideally, all tools have been used in a planning process and contributed to a successful outcome. However, some tools lack any type of field testing and therefore the outputs of these tools are unknown. In some cases, there was no information on how particular tools have been used.

6. *Is the tool useful for integrated conservation/transportation planning?*

   If the tool did not appear to add value to an integrated ecological assessment method in the transportation context, it was eliminated.

If the tool did not meet all criteria, it was eliminated from the database. Forty-two tools are included in the database out of a total of approximately 70 tools surveyed (for a list of the tools surveyed see Appendix F). In the final evaluation stage, we defined and cross-walked information about the tools utilizing key steps in the overall Framework.

1.5 REGULATORY ASSURANCES AND DATA QUALITY

Transportation practitioners seek methods for identifying potential impacts to regulated resources as early as possible in the planning process so that impacts can be avoided or minimized. They also share the desire of regulatory agencies to assure that any mitigation required due to unavoidable impacts provides effective, measurable, and high quality environmental outcomes for the impacted resources. Through the planning and project development process, transportation planners seek to avoid conflicts and delays caused by disagreements with regulatory agencies about project impacts and mitigation requirements. For wetlands and endangered species regulation, the literature and the work of the C06(A) team shows that insufficient, incomplete, or poor quality data is usually at the root of the problem.

1.5.1 **Data Quality Issues: The Clean Water Act**

To address wetlands regulators' concerns, we consulted with state and federal wetland managers to determine what types of regulatory certainty can be provided in states with widely differing quality of wetlands digital data. The status of wetlands information is quite variable across the country so we diagramed a workflow with data and tools that integrate the U.S. Fish and Wildlife Services' (USFWS) nationally available National Wetlands Inventory (NWI) database with the process for refining and augmenting that information to assure the digital data is complete enough for regulators to feel comfortable assuring that transportation planners can avoid all important wetlands.

Our workflow had two primary objectives. First, it more accurately characterized the wetland values impacted by transportation improvements and identified opportunities to replicate those values by protecting and enhancing wetlands throughout the analysis region. The focus of this is to assure that sufficient data showing the current distribution of wetlands exists and is available to transportation agencies early in the planning process, and that this data is of sufficient quality and standards such that it will meet the needs of the regulatory agencies. Second, it identified locations where wetland mitigation sites correspond with overall conservation priority areas.

The result of this work was to identify and obtain regulatory approval for a set of Wetland Mitigation Priority Areas, or a Wetland Restoration and Mitigation Catalog. This catalog can then help direct the locations of mitigation banks, and allow transportation agencies to expedite approval of mitigation options. Lastly, the project evaluated other aspects of the Clean Water Act, particularly those related to water quality, including non-point sources, runoff, and total maximum daily loads (TMDLs). The focus here was that the restoration or enhancement of wetlands offers potential (secondary) improvement to water quality in water bodies exceeding water quality standards.

1.5.2 **Regulatory Assurances and Data Quality Issues: The Endangered Species Act**

Most information on listed species locations currently exists in the form of observations, instead of habitat and predicted distributions. The occurrence of species is highly sensitive and, as a result, is not readily shared with transportation agencies or the public. The project tested the possibility of transforming these highly sensitive maps showing precise known locations of federally listed species into slightly more generalized, public domain maps showing places where these species are likely to occur or where their habitat needs to be protected using inductive modeling methods.

1.6 **ECOSYSTEM SERVICES ACCOUNTING AND CREDITING**

Over 120 methods of accounting for and valuing ecosystem services were reviewed (Appendix G). Based on the principles and criteria, no single method emerged as a readily available option for use in transportation planning and project delivery given the wide variety of resource types and ecosystems. To respond to this lack of a single tool, the project developed a step-by-step process for use by any transportation agency. The process provides a way to self diagnose needs, identify candidate tools and develop custom tools if needed. The accounting strategy, and a first iteration of credit design, was tested with the pilot study agencies through a series of interviews in which participants were led through a focused discussion of the assumptions and structure of the proposed credit design.

The accounting strategy is included in the Framework, particularly in Step 6 and will be included in the TCAPPs website. The website will: enable peer review of tools and methodologies for use in measuring and valuing ecosystem services; share information among stakeholders about current, emerging, and potential ecosystem services tools, projects, and markets; and create networks among interested and active groups to drive development of effective oversight for ecosystem service tool development.

1.7 **PILOT PROJECTS**

The technical guidance developed by our research includes recommendations and supporting case studies on the successful use of data and tools in integrated planning. It is meant to streamline decision making and support natural resource and transportation practitioners as they begin to adopt a more integrated approach to decision making in planning and project implementation.

We tested the technical guidance to see if using this new approach to ecological assessment in transportation planning and project development would result in: 1) different decisions and outcomes, 2) significant savings in time or funding, and 3) additional refinement of the C06(B) technical guidance. Our testing focused on testing the technical aspects of an integrated planning process, and not on the 'collaboration building' part of a planning process, although collaboration building is essential to the success of the technical aspects of the Framework. We decided that testing the technical guidance on a transportation project, rather than a transportation plan, would yield a more quantitative and accurate comparison of the new approach to the traditional approach of assessing an area for project development, since a transportation project is generally more detailed and spatially explicit. But in the end, we learned in two of the pilot states (Michigan and Colorado) that it was critical to compare the pilot test results with the original results of planning efforts in the area in order to adequately test the guidance geared towards improving planning level decisions.

In preparation for conducting the pilot tests, the team developed and documented the approach (See 'Approach to Testing C06(B) Technical Guidance', Appendix D) that would be used by all three team in testing the C06(B) technical guidance. This document also included the criteria used for selecting the projects or areas where we would conduct the three pilot tests. In our proposal, we suggested doing pilot testing in Florida, Oregon, and Virginia, but because the Florida and Virginia DOTs could not participate in our project due to budget constraints, we selected Colorado, Michigan, and Oregon. These two states were selected because our team included staff from the Colorado and Michigan state agencies and because there was interest in this research by the DOTs in these states.

Initially we set up meetings with key state and federal agency staff from the transportation and natural resource communities in Colorado, Michigan, and Oregon to introduce our initial research results. Then using our selection criteria and input from the agency participants, selected a project in each state to conduct the testing. The three projects that were selected were: 1) the I-25/US 85 project in Colorado, 2) the St. Joseph county section of US 131 project in Michigan, and 3) the Pioneer Mountain – Eddyville project in Oregon. Each state had different levels of experience integrating conservation considerations into their transportation decision making processes, and different available ecological data and spatially explicit conservation plans. In addition, each project represented a different landscape setting: the Colorado project was set in an urban landscape, the Michigan project was set in an agricultural landscape, and the Oregon project was set in a forested landscape.

The results of our pilot tests showed the most differences in the areas of cumulative impacts and the selection of mitigation options, especially when comparing our results to the results of planning in the states. See Appendix D for details.

1.8 SYMPOSIUM

The C06(A) and C06(B) project teams held an invitational symposium on September 15-16, 2010 in Boulder, Colorado. The results of our research were presented to a group of 55 local, state, and federal transportation agency and resource agency officials experienced in integrated transportation and conservation planning. The resource agency officials also presented new approaches that they are using to integrated conservation planning and permitting and reflected on lessons they have learned in reference to our Framework. Break out sessions provided feedback on the Framework and suggestions for implementation actions. These discussions informed our final report, especially the conclusions and recommendations.

2. CHAPTER 2: THE ECOLOGICAL ASSESSMENT PROCESS IN TRANSPORTATION PLANNING

2.1 INTRODUCTION

The advantages of an ecosystem approach to sustaining and restoring ecological systems and their functions have long been recognized (Eco-Logical and 1995 CEQ MOU). Transportation agencies and the FHWA have worked with resource agencies over the last two decades to use this approach in planning and delivery of new transportation facilities. Unfortunately, it has not been as broadly adopted as it should be, given its benefits for project streamlining and environmental outcomes.

The FHWA Report *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects* provides the basic framework for using an ecosystem approach in transportation planning and project delivery across individual agency jurisdictional boundaries and encourages an outcome-based approach to conservation. However, *Eco-Logical* does not provide the tools needed to implement the principles. This project fills that gap by providing the tools needed for the ecological approach. The C06(A) project identified existing barriers to adopting the integrated ecosystem approach and opportunities for future implementation as summarized in Table 1.

Table 1. Barriers and Opportunities

Barriers	Opportunities
Inability to access other agency and NGO environmental data and plans	New tools for publishing data and harvesting others agency and organization's published data
Lack of integrated and agreed upon conservation priorities across agencies	New methods for integrating conservation priorities in the Great Lakes, Chesapeake Bay, the Willamette Valley Oregon, and Virginia
Lack of local, regional and national geospatial data for environmental data and plans	Potential for new standards and funding to develop regional and national environmental data
Inability to agree between transportation and regulatory agencies on the scientific validity and adequacy of planning level analysis in providing regulatory predictability at the permitting stage	New models for predicting the locations of listed T&E species with capacity to expand these nationwide. New spatial data, tools, and knowledge to map wetlands and identify wetland priorities. New models for identifying potential water quality implications for road development projects very early in the planning process
Ability to quantify the anticipated impacts of transportation projects	New decisions support tools to look at cumulative impacts of developing in watersheds or ecoregions
Lack of agreed upon measures to quantify ecosystem functions important to transportation planning and development	EPA Ecosystem Services Partnership, USDA Office of Ecosystem Services and Markets, and programs such as the Natural Capitol Project, the Bay Bank and the Willamette Partnership interested in developing measures. Scientific interest in developing pilot models and algorithms for attributing areas with these values.
Lack of transparent and integrated scientific peer review of metrics, methods and protocols	Ecosystem Commons peer review process drawing upon university and agency research capacity

The C06(A) research identified three key scientific and technical barriers to using the Eco-Logical approach to transportation planning and development:

- Lack of integrated and agreed upon conservation priorities across agencies
- Lack of accepted data standards and geospatial data and lack of access to environmental data and plans
- Lack of agreed upon methods to quantify the impacts of transportation projects on ecosystem functions.

Our research addresses these barriers by developing a new Framework supported by enhanced information about regulated resources and improved ecological accounting methods.

2.2 **VISION FOR AN INTEGRATED SYSTEM**

The vision underpinning this research was to develop a scientifically-supported, outcome-based approach that would facilitate efficient and effective transportation planning, regulatory decision-making and capacity development while maximizing opportunities for the long-term conservation and enhancement of ecosystem functions at multiple scales.

We envisioned an ecological assessment and crediting approach that would:

- Provide transportation agencies the toolkit they need to collaborate with resource agencies, local governments, NGOs, and others to simultaneously meet conservation and transportation goals/priorities during the decision-making process;
- Provide the environmental regulatory assurances that resource and regulatory agencies and transportation agencies need to make earlier decisions and investments in the transportation planning and project delivery process; and,
- Integrate regulatory compliance within and across agencies.

We envisioned a specific, yet flexible, approach that could be customized and embraced by transportation and resource agencies and would result in sustained institutional change that encourages transportation agencies to adopt environmental stewardship policies enhancing ecosystem and hydrologic functions and maximizing the benefits of their investments.

Our approach focused on regional ecological priorities, multi-resource ecosystem measurement and accounting systems, and achieving improved, measurable environmental outcomes. It is:

- Linked to the key decision points in the Collaborative Decision-Making Framework developed by SHRP2 through guidance relevant to environmental regulatory compliance processes that identify policy questions; data development and management needs; analytic tools; case studies/best practices; and, references;
- Scalable, flexible, regionalized, and compelling to agencies regardless of their experience with environmental management systems; and,
- Designed to maximize the likelihood of beneficial environmental outcomes from all stages of transportation planning and project development.

Our approach allows for: expedited transportation development; cross-agency understanding and incorporation of conservation goals and priorities early in the transportation decision-making process; reduced legal challenges and costs; and sustainable and systematic ecosystem restoration and mitigation outcomes.

2.3 THE NEED FOR INTEGRATED CONSERVATION AND TRANSPORTATION PLANNING

The key objective of this research is to develop a workable ecological assessment method and template that can and will be used by transportation planners working in diverse physical environments and with varying existing data availability. While there is a large body of research on all of the themes, this project focuses on the integration between the existing models, tools, and processes needed in order to use them effectively in transportation decision making from long-range planning through project permitting.

Since passage of the National Environmental Policy Act (NEPA) in 1969, transportation agencies developing projects with federal funds have been required to consider the impacts of their projects on the environment. New transportation facilities must also meet the requirements of dozens of other federal, state and local environmental and land use regulatory requirements (Dale et al 2000; Luther and Bearden 2003; Phelan and Phelan 2007b). Two key issues developed as transportation agencies implemented these regulatory requirements for new capacity projects: (1) determining when in the transportation planning and project development process to prepare required environmental analyzes and apply for permits; and (2) determining how to avoid duplication of effort and inconsistent requirements under different laws and regulations.

Traditionally environmental resource and permitting agencies have little involvement in the transportation planning process when alternatives are developed and compared, waiting until a specific project solution has been selected before becoming involved. As a result, planning decisions are often questioned and revisited in the NEPA process delaying delivery and adding cost. This problem was recognized as early as 1975 by the National Cooperative Highway Research Program (NCHRP). The 1975 NCHRP report also recognized the disconnection between the disaggregate level of data analysis and impact predictions at the systems level planning stage versus the project development stage.

At the heart of the suggested reforms is the idea that an environmental review process that runs concurrently with or at least overlaps with agency planning processes would increase efficiency, provide better information for planning and less litigation as a result of greater opportunities for public participation (Tripp and Alley 2003). The former head of CEQ, James L. Connaughton, strongly supported this approach, noting the need to share documentation and maintain databases of information from prior environmental reviews. (Connaughton 2003). Such an integrated approach is expected to move beyond traditional approaches of avoiding, minimizing and mitigating impacts of transportation projects to use ecosystem approaches to provide environmental benefits and promote ecosystem sustainability (Brown 2006).

Amekudzi and Meyer in NCHRP Report 541 surveyed state transportation agencies and metropolitan planning agencies to assess how they consider environmental factors in their system planning. Survey respondents indicated that only some of the data types needed for considering environmental factors in transportation planning were available. Respondents also noted a lack of appropriate planning analysis tools. Reviewing the various types of tools (geospatial databases, remote sensing, impact modeling, decision analysis and simulations), the authors concluded that new tools should be able to provide more and better information to decision makers at the planning level in order to protect environmentally sensitive areas. They developed a conceptual framework of transportation systems planning and project development to show where environmental factors could be incorporated to improve the process, overcoming the past disconnection between the planning and project development stage. The study showed that environmental considerations can be included throughout system planning and project development (Amekudzi and Meyer 2005).

In 2006, eight federal agencies and representatives of four states published *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects* (Brown 2006), building on the earlier MOU on ecosystem management. *Eco-Logical* presents an integrated planning framework that incorporates an ecosystem approach to environmental mitigation agreements and adaptive management through performance measures. As discussed above, our research builds from Eco-Logical to provide the scientific and technical procedures and methods needed to support use of the new integrated Framework.

2.4 CUMULATIVE EFFECTS ASSESSMENT AND ALTERNATIVES

The Cumulative Effects Assessment and Alternatives (CEAA) process is tightly coupled with and fully integrated into nearly all steps of the Framework. The CEAA provides a hierarchy of substeps for implementing relevant components of the Framework and they are further supported by:

1. Literature citations that provide references to peer reviewed and other works for additional reading on the steps.
2. Case studies/examples from real-world applications of the concepts to illustrate how they have been accomplished.
3. Tools, focusing on software for spatial modeling and assessment that can be used to streamline the application of the steps in a GIS.

The CEAA steps are described in the Framework (see Chapter 3) and further described in the online tool (see Chapter 5). A brief description of the key processes and products of the CEAA is provided below along with a discussion of challenges and suggestions for successful implementation.

2.4.1 CEAA Goal and Products

The goal of the CEAA is to support all types of transportation and land use planning by conducting thorough ecological cumulative effects assessment and development of alternatives that reduce resource impacts and assist in achieving regional conservation goals. The key products for achieving these objectives are shown in Table 2.

Table 2. Key Products of the CEAA Process

1. Regional Ecosystem Framework (REF) which consists of:
    a. The list of resources included.
    b. A database of viability requirements and responses to a variety of land uses, transportation features, and other disturbances as well as conservation practices for each resource or priority conservation area.
    c. A map that synthesizes existing achieved conservation areas and identified, but not yet achieved, conservation priority areas from accepted sources. The map can be supplemented as needed with individual resource distribution maps to provide complete coverage of the list of resources.
2. Transportation alternatives assessment and refinement which consists of:
    a. Quantitative assessment of the impacts of alternatives individually and cumulatively with other land use and conservation actions.
    b. Support for developing alternatives that meet both transportation and conservation objectives.
3. Mitigation support which consists of:
    a. Quantification of resource impacts for all alternatives.
    b. Identification of compensation sites that can provide for the required mitigation and provide the greatest contribution to regional ecosystem objectives.
4. Adaptive planning and management which consists of:
    a. A partnership structure for dynamic information sharing.
    b. A technical approach for integrating new resource information and status with project development decisions for dynamic updating of the status of conservation objectives.

2.4.2 Intended Applicability of the CEAA Process

Recent advances in data quality and decision support systems and computing power enable "NEPA-level" assessment at all stages of the transportation planning and design process whenever transportation improvements can be characterized spatially (whether coarsely or at fine scales). Therefore, this process should be applicable to Long Range Transportation Plans (LRTPs), Corridor Plans, and Project Design. Our emphasis and intended application is LRTP in keeping with study objectives for moving resource consideration and mitigation planning to the long range planning phase as opposed to putting it off until project design. We believe this technical guidance is applicable for all transportation agencies and their MPO partners but we acknowledge many agencies, especially many smaller MPOs and perhaps most state resource agencies, currently lack the capacity to implement the template in its ideal form. We provide suggestions and alternatives for lower capacity agencies below.

2.4.3 Relationship to NEPA

This technical guidance will provide support for creating Environmental Assessments (EAs) and Environmental Impact Statements (EISs) consistent with guidance for a tiered EIS process developed by the Federal Highway Administration (FHWA) through their Legal Guidance on Integration of Planning and NEPA Processes (FHWA 2005) and in Appendix A to 23 CFR Part 450 (72 Fed. Reg. 30 pp. 7223-7286, Feb. 14, 2007). An objective of this study is to move analysis traditionally conducted at the project phase of the transportation development process to the planning phase to streamline project delivery by identifying and mitigating expected impacts much sooner in the process. This CEAA process provides several outputs useful for NEPA processes and products. First it identifies environmental resources and environmentally sensitive areas and including existing natural resource conservation areas and the outputs of natural resource planning efforts. It also explicitly and quantitatively conducts cumulative effects assessments for plan alternatives by incorporating all reasonably foreseeable actions in the area such as regional and local growth and development plans and projections (and numerous other cumulative effects factors). The Appendix A guidance assumes that analyses of environmental effects at the planning stage will not be sufficiently current or detailed for NEPA, but fully implementing the CEAA steps is capable of producing sufficient analyses if desired. The CEAA process also supports decisions and documentation for eliminating alternatives and generating plan alternatives to avoid impacts as much as practicable. It enables assessment results and comments to be used to create a preferred alternative and quantify impacts and, if necessary, mitigate resource impacts.

2.4.4 **Scale**

This template is meant to be applied at any scale ranging from states and ecoregions to municipalities and corridors. Differences in scale suggest differences in information sources and levels of precision (e.g., that data covering large regions is often of coarser scale). Therefore expectations for the level of precision of products from the spatial analyses should be consistent with the level of precision of the data inputs (i.e., expectations/needs for precision of results should be lower for larger regions compared to smaller corridor/MPO analyses). However, the advent of species distribution modeling and robust desktop computation capability are reducing the extent/precision effect and creating data that are applicable at multiple scales across broad extents. This does not eliminate the need for on-the-ground observation for projects, but should narrow the scope of site surveys to the resources that have reasonable probability of occurring on the site.

2.4.5 **Partnership Coordination**

Because an REF by definition is a synthesis of the work of many contributors, many organizations should be involved in deciding how to create it. It is unlikely that the REF will be created and maintained, however, without strong central coordination. The role of the coordinator is to identify the key sources of information and science needed to build and maintain the REF and to engage the responsible organizations in the REF partnership. Because the REF is initially developed for the transportation planning process (to be useful in many applications), it may be appropriate for an MPO or DOT to take the lead role. However, it may be more appropriate for a resource agency, such as the State Wildlife Action Plan (SWAP) coordinator, to assume the lead role due to the REF focus on natural resources. Leadership and partner roles in conducting the CEAA, especially creation and maintenance of the REF, generated considerable discussion at the C06 symposium. Several participants suggested that larger MPOs would have the strongest motivation and coordination capability.

2.4.6 **REF Guidance**

This component of the CEAA process was drawn directly from Eco-Logical. It was described there as: *A REF consists of an overlay of maps of agencies' individual plans, accompanied by descriptions of conservation goals in the defined region (Brown 2007).* This definition could result in an incongruous product, by trying to combine both conservation and development plans and goals. For clarity, we define the REF as a spatial and non-spatial database of resources and scenarios with planning objectives and conservation criteria. The REF contains the spatial distribution of information that characterizes:

1. Current actual development, established conservation area, and their attributes.
2. The conservation priority areas of the resource partners (e.g., resource agencies and NGOs) with attributes that specify the individual resource (e.g., species) contained in those priority areas, individual resource distributions and their conservation goals and requirements.
3. The development plans for "action" agencies (transportation and other infrastructure and land use). These tend to be less certain and more dynamic given shifting agency and societal objectives and available implementation funding.

Resources which the partnership considers important to represent in the REF may need to be represented by individual resource distribution maps, rather than encompassed in priority area maps. The resources component of the REF should be as objective as possible, based on quality mapping and robust scientific processes involving subject matter experts (SMEs) for the required resources. The REF process keeps the three components (current situation, conservation priorities, planned development) separate and intersects them at those times when a cumulative effects assessment is needed to support decision making.

2.4.7 **Limitations and Challenges in Using the CEAA Process**

As with most innovations and activities requiring broad partnerships, the key challenges to adoption tend to be institutional, political, and financial rather than technical. Those issues are being addressed by other research programs, e.g., SHRP2 C06(A). We focus on the technical and scientific limitations and challenges of the CEAA and provide suggestions for overcoming these. Three challenges to the technical process are addressed below.

2.4.7.1 **Data Availability and Quality**

Lack of quality data is becoming less and less of an excuse to not do good resource assessment. While perfect data will never be achieved, more and better data are available every year. However, the perfect should not be the enemy of the good. The REF partnership focus on making the best use of has available data while it develops the strategy and funding mechanisms to obtain better data. Frequently, the data from conservation NGOs is overlooked, but it may represent some of the best available information. Two specific data content and quality challenges and suggested solutions are the scale and spatial specificity of SWAPs and the lack of coverage for some important resources in conservation plans.

The state wildlife action plan should form a key component of the REF. Sometimes SWAPS are non-spatial or too coarse to support transportation planning. As of this writing, most states seem dedicated to mapping priority areas for their SWAP and increasing the spatial resolution to support implementation. Other plans may exist to fill this role wholly or partially in the interim, such as work by large national or regional conservation NGOs and some natural heritage programs. When no conservation priority area plans exist at the needed level of resolution, the partnership should decide if it will be more efficient to downscale existing coarse-scale plans or create an interim product from existing data on individual resources. The SWAP and other partners' plans can still provide important guidance on the resources to be considered, resource priorities, general areas of conservation importance, and perhaps even resource retention goals. To create a more resolved spatial-priorities map, an alternative is to use an existing high resolution natural landcover/habitat maps, such as those produced by the USGS Gap Analysis Program, to identify large intact natural habitat areas and augment them with other data, such as the natural heritage program occurrences of imperiled species and ecological communities and state resource agency maps of important game species habitat, to identify natural vegetation areas containing important resources.

Conservation priority areas do not cover some important resources and maps for such resources are often based on incomplete observation points. This is a very likely situation especially since many SWAPs did not address plant species and many species distribution maps only exist as point observations. Techniques described above that can help address the omission of resources in conservation priority maps can also address this problem. The lack of complete geographic distribution maps for individual resources can be addressed using predictive distribution models. The USGS Gap Analysis Projects produced moderate confidence models for most terrestrial and aquatic vertebrate species and some developed models for other species. Other projects in states or regions may have produced other higher confidence models for particular species. The REF program/partners may also be able to use contemporary tools and methods to create the necessary models which are achievable with much less effort than in the past, as discussed below.

2.4.7.2 **Science and Subject Matter Experts**

As with data, science is imperfect and incomplete. Few species have been studied sufficiently to provide empirical values for viability (e.g., retention goals, minimum required occurrence sizes, etc.) which form the bases in the CEAA for determining cumulative impacts. Our process must, therefore, rely on subject matter expert (SME) judgment. This reliance on expert judgment can present defensibility issues in the planning process even though it is frequently accepted in other resource planning processes subject to NEPA. SMEs need to be accepted by the partnership. They often are found in government agencies, academia, and NGOs and other organizations outside those providing plan inputs to the REF. EPA NEPA guidance (EPA 2010) describes cooperating agency roles related to their expertise in the environmental issues being addressed. We follow this accepted approach but move it forward into the spatial analytical age by including quantitative values for viability assessment. The NGO conservation community has been using this approach for many years. Sources for further guidance are found in the CEAA online resource links. While a fair amount of uncertainty around quantitative values will exist (which should be documented), we believe this approach provides more rigor and defensibility than typical approaches for conducting assessments at the planning level (and likely for project level assessments as well).

In the near-term, the REF partnership needs to agree on the degree of scientific rigor acceptable for the REF applications. It may be reasonable to conclude that the bar for planning should be lower than for project assessment (full NEPA process) where the number of considerations is fewer and more precise information can be collected and more rigorously analyzed. The objective is to provide a far better and more precise assessment at the planning phase than traditionally done while not hamstringing it with impracticable requirements. Education of partners and stakeholders in the use and value of SME judgment will be needed to achieve the objectives of streamlining project delivery by moving considerations to the planning phase. Uncertainty in scientific knowledge should also contribute to agreements about triggers for additional analyses at the project phase. The partnership should also agree on acceptable sources of scientific information and should develop a scientific research needs assessment and strategy for the mid- to long-term to fill critical gaps.

2.4.7.3 **Technical**

Many of the technical challenges and limitations of the past have been overcome with improved computing power and creation of decision support tools to automate a considerable amount of the CEAA process. The remaining technical challenges are addressed below.

Creating robust analyses understandable to decision makers and stakeholders: With the availability of more and better data and robust spatial analyses techniques and tools, analyses and products are becoming highly complex and more difficult to describe and explain. We suggest a hierarchical form to the products of the CEAA process that start with the binary presentation of "problem not a problem" and then allow users to drill down through the information to further detail as needed. For example, a result from a cumulative effects assessment may indicate an incompatibility between a resource and a proposed action (there is a problem). Further investigation may reveal the resource is not legally protected, but the action would prevent achieving of the resource retention goal. Identification of the specific resource and the amount of area impacted can then help identify possible on, or offsite, mitigation options that could be pursued with interested REF partners.

<u>Integrating and maintaining information from distributed sources</u>: This can be a particular challenge for obtaining, integrating, and managing expert input on the resources. Such experts are usually distributed among many organizations and over wide geographic areas. Creation of a simple online location where their information can be input can ease the burden on everyone for information collection and management. Using this approach makes their information reusable for multiple applications.

<u>Integrating dynamic processes and information</u>: Dynamic data can include data that is updated frequently and or that represents dynamic phenomena. Study and modeling climate change is increasing and beginning to produce large amounts of such data which can affect the REF (species/ecosystem change and migration) and assessment of additional important stressors on the resources. The REF partnership should explicitly address what information should be included and how it should be used in updates to the REF and assessment.

2.4.8 **Suggestions for Low Capacity Agencies**

Ideally, transportation planning processes will build the necessary partnerships and funding needed to conduct the CEAA process, ongoing updates, and adaptive management. If the transportation agency and REF partners lack capacity to implement the process, it is possible to use a significantly scaled back approach which can rely on SME involvement or be automated through a statewide system (existing or under development in a growing number of states). For the long term, however, such processes ultimately may require more staff time and may produce less reliable/defensible results. This approach also loses the opportunity to gather expert knowledge in a reusable database to apply to other plans/projects in the region.

An alternative process to that described in the CEAA process in its most minimal form entails overlaying (graphically with hard copies or through a GIS) proposed LRTP alternatives with the State Wildlife Action Plan and or other spatial conservation priority maps for the resources of interest. Areas of potential conflict would be graphically identified and SMEs would identify resources that might be impacted and make an expert judgment about the significance of the impact and options for mitigation.

This approach is currently common in project assessments and such functionality is supported through tools such as Florida's ETDM online system for project evaluation. States could replicate this capability to assist low capacity transportation organizations by providing a system which would contain all of the necessary resource layers and the capability to overlay maps. The only technical requirement then for the transportation agency would be to provide their LRTP to the state system for assessment. This alternative approach would accomplish the rudimentary need for comparing the LRTP to the resources, but it falls far short of the recommended process in terms of ability to quantify cumulative effects and to support a full cycle of LRTP option development, assessment, selection, mitigation, and implementation.

The lack of resource agency capacity can be mitigated somewhat by involving science-based NGOs but in the long run, more capacity for resource agencies to routinely engage with transportation planning activities will be required for integrated conservation and transportation planning to succeed. This will require internal capacity building and training in methods and tools.

2.5 REGULATORY ASSURANCES

Addressing regulators' needs is an essential part of the decision making process for all transportation projects. While obtaining complete regulatory assurances may be impossible, we focused on identifying the aspects of current decision-making that provided the greatest concern for regulators at the national, regional, state, and local levels; and then developing tools or information to address these concerns. Based on our research we believe that, particularly for wetlands and endangered species, regulatory conflicts and delays largely result from transportation planners and regulators having insufficient, incomplete or poor quality data. Transportation practitioners seek methods for identifying potential impacts to regulated resources as early as possible in the planning process so that impacts can be avoided or minimized. They also share the desire of regulatory agencies to assure that any mitigation required due to unavoidable impacts provides effective, measurable, and high quality environmental outcomes for the impacted resources.

The keys to success are to: 1) Use the best data you can obtain or collect, early in the planning process; 2) Stay in touch with regulators – contact them early and often, throughout planning and implementation; 3) Take advantage of existing conservation planning work, completed by federal agencies, state agencies, universities and conservation organizations; and 4) Link conservation planning with your regulatory protection work, but understand that regulators must focus on their specific resource of interest. We developed new strategies for data integration and modeling that can be used in the CEAA process to improve the likelihood of obtaining regulatory assurances throughout the transportation planning and project delivery process.

2.5.1 Improving Wetlands Data

Section 404 of the CWA is the key national regulatory mechanism to assure wetlands are not continually lost. The program is also the nation's, states', and communities' primary mechanism to restore natural resources, especially to replace lost aquatic functions. In a 2007 report, ELI estimated that private and public expenditures for compensatory mitigation under §404 of the CWA come to about $2.9 billion annually (Environmental Law Institute 2007). These funds represent more than three quarters of all natural resources mitigation expenditures nationally and constitute the primary source of funds to restore wetlands and watersheds across the nation.

While some progress has been made in restoring and compensating for the loss of aquatic functions, to date, much of the mitigation has not led to the creation, restoration, or conservation of important wetland habitats, resulting in a system that does not completely avoid losses and that is largely unable to be proactive (Gardner 2009). The current system also lacks a sufficient emphasis on avoiding or minimizing project impacts. Some of these inefficiencies stem from a lack of practically accessible data, that regulators would consider sufficient for the proactive analysis and early commitments that could maximize DOT investments in conservation or restoration of significant areas, to help achieve watershed goals. Later decision making and sub-optimal mitigation outcomes result because resource agencies often feel they cannot effectively consult earlier, absent key information about the resources in question.

Major concerns of wetland regulators include:

- Assuring the most significant or vulnerable wetlands are protected.

- Being confident that the locations of most significant wetlands are known in advance so that they can be avoided if possible; and impacts are minimized if unavoidable.
- Assuring that high-quality and appropriate wetlands information is used in assessment tools.
- Having methods for addressing prioritization of sites for mitigation.
- Assuring that mitigation results in high-quality wetlands creation and/or measurable enhancement equivalent to habitat lost.

To address wetlands regulators' concerns, we consulted with state and federal wetland managers to determine what types of regulatory certainty can be provided in states with widely differing quality of wetlands digital data. The project initially focused on the states of Michigan, Oregon, and Virginia. The status of wetlands information is quite variable across the country so we diagramed a workflow with data and tools that integrate the USFWS's nationally available National Wetlands Inventory (NWI) database with the process for refining and augmenting that information to assure the digital data is complete enough for regulators to feel comfortable assuring that transportation planners can avoid all important wetlands.

2.5.1.1 **Improving Wetlands Data for Avoidance and Planning**

The primary need is to improve the quality of wetlands data by improving its spatial accuracy, currency, and content. Our research studied how to develop wetland data in states without high quality wetlands digital data, expanding on USFWS's NWI and other national databases. We developed with a practical and efficient process for refining and augmenting that information to express wetland type, status, ecological integrity, and biodiversity value. Specifically, we developed methods to accelerate digitizing wetland maps and create wetland mitigation and restoration catalogs. In July 2009, the Federal Geographic Data Committee (FGDC) endorsed a new wetlands mapping standard for the U.S., which provided for standard mapping protocols for wetlands (USEPA 2007). Any major data improvements provide the opportunity to assure that the new FGDC national wetlands mapping standard is applied to these data.

Currently, the national information for wetlands is maintained in the USFWS NWI. The NWI represents a major investment of the U.S. government, yet it remains incomplete and underfunded. Figure 1 below shows the status of national wetlands data in the U.S. from the NWI annual status report.

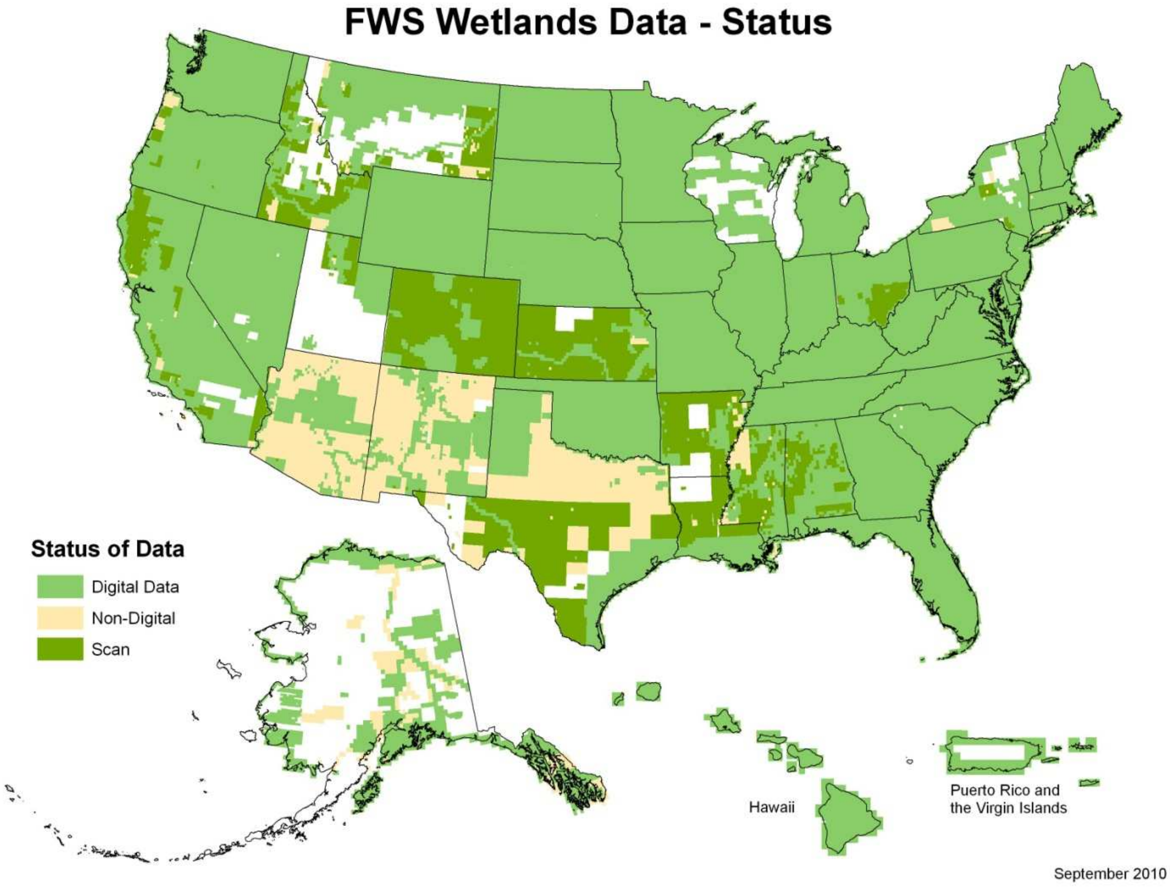


Figure 1. 2010 Status of Digital Wetlands Data for the United States in the NWI

According to the NWI, approximately 80% of the U.S. has digital wetlands data available for the country. In addition to the fact that 20% of the country has no digital data, much of the other data that is digital is based on wetlands that were mapped from imagery taken in the 1980's, meaning it may be significantly out of date. Whether it is actually out of date or not is largely immaterial, since the perception that this data is neither comprehensive nor reliable prevents transportation agencies from obtaining any type of regulatory assurances by using this data early in the planning process for avoidance and minimization of potential impacts.

A major barrier to the improvement of this data is the cost to digitize the remaining paper maps, to incorporate scanned maps, update the NWI using current standard methodologies, and to develop new digital data in the areas such as Utah, southern Montana, and Alaska, where no old paper NWI maps exist. The EPA has been working in Montana, Colorado, Oregon, and California, through state wetlands program development grants, to improve this information. However, the current estimates to update and complete these maps by the state wetland regulatory agencies average between 1.5 and 2 million per state.

Oregon Case Study

Oregon provides a helpful example of what can be done. Until 2005, Oregon had only about 20% of the state available digitally. Figure 2 below shows the distribution of digital data in Oregon as of 2006 in red, with the red along the border with California, Washington, Nevada, and Idaho coming from the adjacent states. While the overall costs to complete digitizing and updating the state were estimated at $1.5 million, a partnership of agencies including the Oregon Geospatial Enterprise Office in the Department of Administrative Services, the Oregon Watershed Enhancement Board, and Oregon State University decided that a digital wetlands coverage was essential, and took on the task of scanning and updating the available data.

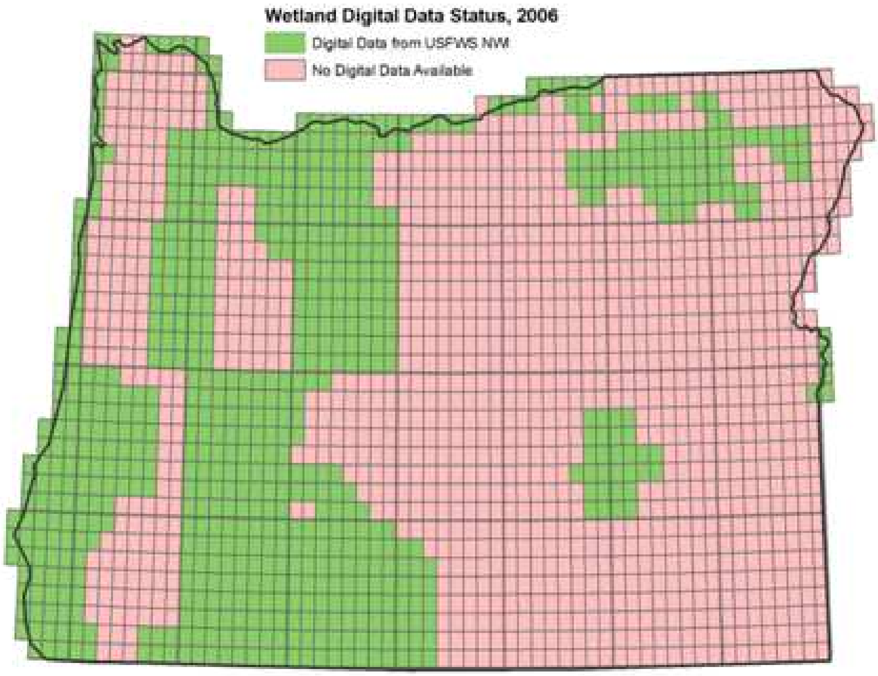


Figure 2. State of Wetlands Digital Data in Oregon from 2006

After an investment of about $300,000, including $170,000 provided to the GIS Mapping Center at the Oregon Prison Industries, and $130,000 to the Oregon Natural Heritage Information Center through a grant from EPA and the Murdock Charitable Trust, the entire state now is available digitally. Figure 3 below shows the current status of the state.

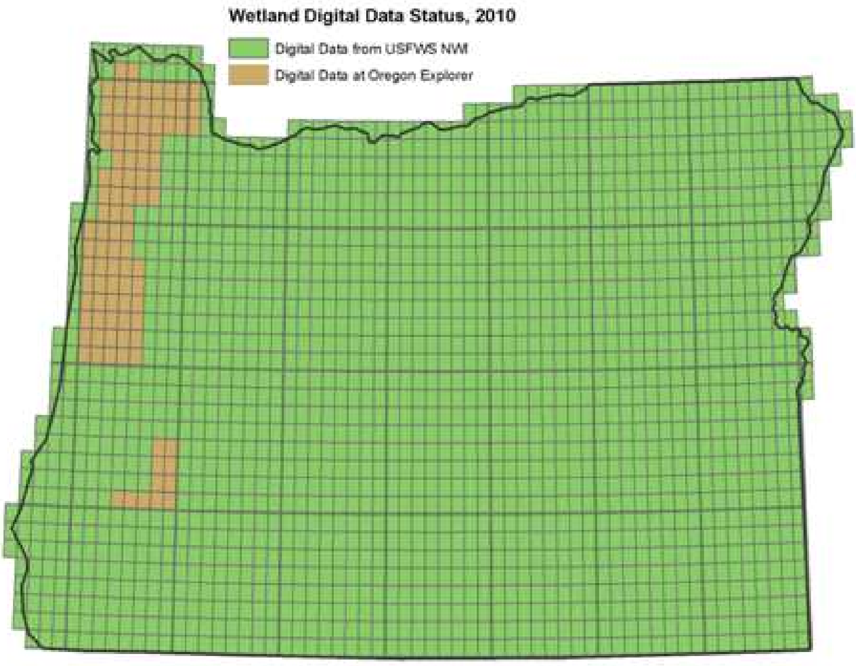


Figure 3. Status of Digital Wetlands Data in Oregon from 2010

This case study is included because having the wetlands digital data is such a critical component of the proposed methodology; and it demonstrates that obtaining this data can be done quickly and somewhat affordably. Providing the data digitally allows transportation agencies to use it in long-term planning, and also allows for the creation of wetland mitigation and restoration catalogs, which is the second key data need.

Michigan Case Study: Wetland Functions

A consortium of partners lead by Ducks Unlimited have been working to update the Michigan NWI data, which while statewide, was both somewhat out of date and limited to basic NWI data. Their methodology involves using spatial data, modeling, and some imagery analysis to attempt to develop functional attributes for all of the wetlands in the state. The functional data provides valuable information which can assist in identifying the importance of the wetland, and the value of the wetlands for mitigation and restoration. The data was used in the Michigan St. Joseph Watershed Pilot to test the overall transportation planning methodology proposed in our research (see Appendix D 6).

This approach helps address the need for statewide and comprehensive functional wetlands data. Wetlands functions are difficult to measure, but if acceptable information can be obtained, it can both improve the quality of the wetlands data, improve the ability to compare changes to wetlands over time, and potentially improve mitigation implementation by addressing wetland ratios. However, developing this type of data is more expensive than the simpler methods described above for Oregon, or in Appendix D 8 in Virginia, costing approximately two million dollars to complete the state.

Based on the current national status map shown in Figure 1, the majority of the wetlands mapping remaining needs to take place in the western states, primarily Utah, Colorado, Montana, Texas, Idaho, Arizona, and New Mexico. The blank areas in Wisconsin represent an area where the state's maps differ from the USFWS NWI, but high quality digital data is available. The Natural Heritage Programs in Colorado, New Mexico, and Montana are working to complete the mapping and digitization of wetlands in these states using wetlands program development grants from EPA, but remain 4-6 years from completion. Idaho Heritage worked at this for a while, but has stopped. There are no ongoing efforts to complete the mapping in Utah, Texas or Arizona, and in these states, a federal agency, an NGO or program from another state may need to complete the mapping. Once digital data is available nationally, the country has the potential to identify mitigation priority sites, or a mitigation and restoration catalog for all states, with sites located in each watershed.

2.5.1.2 **Improving Mitigation Implementation and Outcomes**

The inability to implement mitigation for unavoidable wetland losses is probably the greatest obstacle to transportation project development in the many wetland-rich areas of the country. Our research indicates the best way to overcome this obstacle is to identify a relatively comprehensive set of mitigation priority sites, or a mitigation and restoration catalog. This needs to be completed for all areas in which transportation development is likely to occur, and include at least one and, if possible, a few sites located in each watershed. Some states are working to develop comprehensive catalogs, and these pilot methodologies are described below.

Oregon Pilot Wetlands Mitigation Catalog

The Institute for Natural Resources' Natural Heritage Program has developed a pilot effort to create a wetlands catalog in the Willamette Valley. It was done quickly and cooperatively with limited public funds. Oregon Heritage worked with The Wetlands Conservancy, a local NGO, to develop a set of priority wetlands based on an integrated REF created by an interagency cooperative effort. Lead by The Nature Conservancy (TNC), the Oregon Parks and Recreation Department, the Oregon Department of Fish and Wildlife Service, Oregon State University, the University of Oregon, and other partners worked together to integrate the results of five assessments covering the Willamette Basin. These included: the TNC Ecoregional Portfolio's based on their conservation assessment (Floberg et al 2004), The Willamette Basin Futures study, completed by multiple universities in the Willamette Ecosystem Research Consortium (Baker et al 2004); Oregon's Greatest Wetlands (The Wetlands Conservancy 2005); Willamette Greenway project (Bauer 1980); the Oregon Conservation Strategy, Oregon's state wildlife action plan completed by ODFW (Oregon Department of Fish and Wildlife 2006); and a series of recovery plans and assessments focused on federally listed species, including the northern spotted owl, coho, Chinook, and steelhead salmon, the Oregon chub, Fenders blue butterfly, and four vascular plant species.

This effort did not involve setting conservation goals or gathering new information. It was relatively straightforward and inexpensive, although assuring that all the parties were willing to accept the resulting map took over 6 months. Figure 4 below shows the resulting synthesis map, and some of the pieces that made it up.

The wetlands mitigation catalog was identified using conservation opportunity areas identified the synthesis map as the primary footprint. Heritage Program and Wetlands Conservancy staff then identified those areas in the footprint with potential for wetlands: sites with wetland soils in areas that were farmed, weedy, or otherwise needing restoration, areas with existing wetlands that had become separated by some types of disturbances, or areas with historic wetland losses. Wetlands priority areas were identified in every 8-digit watershed, to assure there would be mitigation sites close enough to be considered on-site to any likely development. The resulting map was presented to the state and federal wetland regulators in a meeting as a draft, and was slightly modified based on their recommendations. This case represents the quickest and simplest method identified for setting wetland mitigation and conservation priorities and was rapidly accepted. Because it was accepted so quickly by the regulatory community, additional assistance from an EPA Wetlands Program Develop Grant has been obtained to help complete the catalog for Oregon.

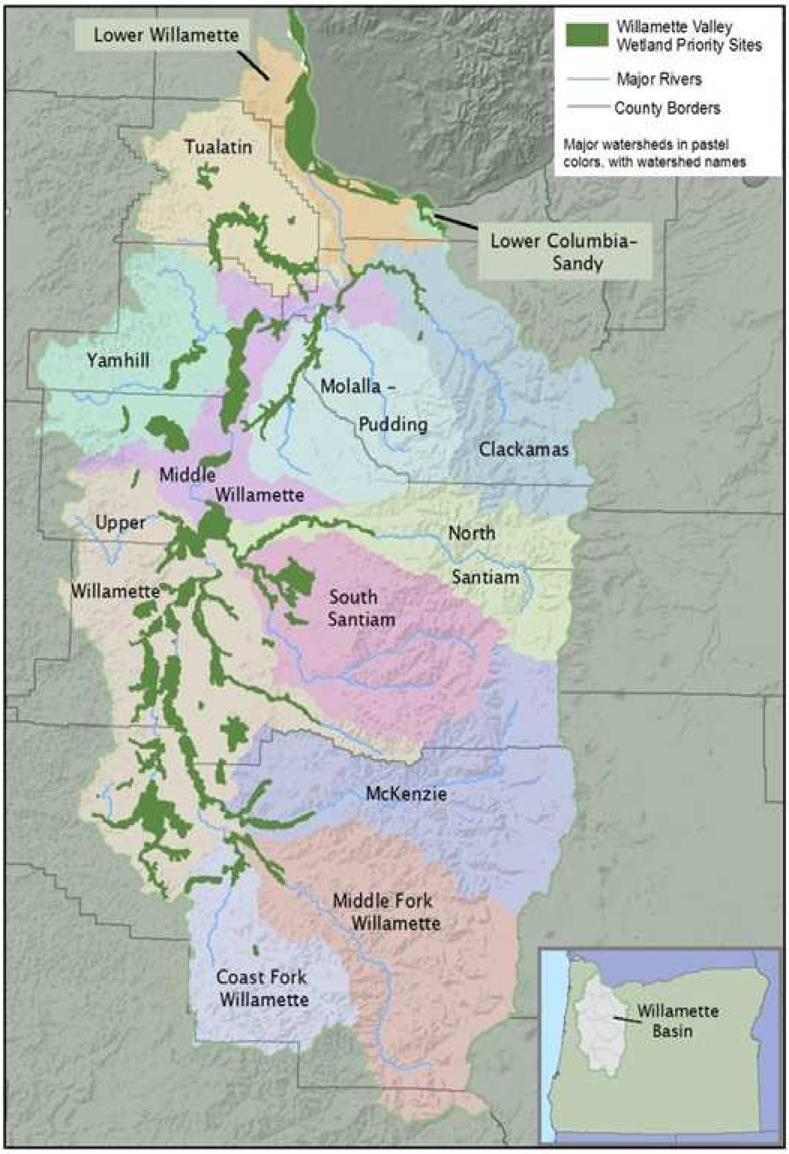


Figure 4. Willamette Basin Wetlands Mitigation and Restoration Catalog

Virginia Pilot Mitigation Catalog

The Virginia project was completed as part of this research. The Virginia Natural Heritage Program, in the Virginia Department of Conservation and Recreation, had an existing wetland restoration catalog they developed based on internal conservation priorities. This catalog was limited enough that many watersheds lacked any priority mitigation areas, and the catalog was not frequently used by either Virginia DOT or Virginia DEQ. As part of this research, they tested a method to develop wetland priority sites that both represented the best places for wetland conservation, and the best sites to meet overall water quality restoration needs, using only spatial data that is most likely available across the country. Their work was tested in an 11-subwatershed pilot area covering the Lower Pamukey River basin in central Virginia. Data was used to expand existing NWI data to assure that as many existing and historic wetlands as possible were included in the analysis, looking at an array of datasets. Details of this methodology are included in Appendix D 8. Priority sites were identified with land ownership parcels included, so that the catalog could be displayed by priority wetland and by priority land parcels. The resulting sites were ranked based on their importance for conservation, their ability to address water quality needs, adjacency to existing mitigation banks, and restoration potential.

2.5.2 Including Clean Water Act Sections 301, 303 and TMDLs in Catalog Planning

The project team also evaluated other aspects of the CWA compliance, particularly those related to water quality, including non-point sources, runoff, and total maximum daily loads (TMDLs). Our focus here was on the fact that the wetlands restoration or enhancement offers potential (secondary) improvement to water quality in water bodies exceeding water quality standards. Water quality impacts due to roadway runoff, impacts to water quality limited streams based on decreased shading, and increased deposition of nitrogen or phosphorus appear to have data or tools available that could be incorporated into the overall CEAA process.

Initial exploratory work was done with the Natural Capital Project hydrology staff and researchers from the EPA's Western Ecology Division to identify tools and data available to characterize 303(d) attributes spatially. Initially, our team was unsure if it would be possible to use the Water Quality module of INVEST, but a trial was done as part of this project. EPA is also testing methods which may allow for more rapid assessments and approvals of needed mitigation.

The initial focus of the Virginia Wetlands Catalog research had been to directly incorporate water quality data to both expand the catalog, and evaluate the effectiveness of the various identified sites at addressing identified water quality limitations. Virginia was able to use water quality data to prioritize the catalog, but not as a method for selecting priority mitigation sites. In Oregon, the team also explored using TMDL and water quality limitations in prioritizing the restoration and mitigation catalog in the Willamette Valley of Oregon. However, in both Oregon and Virginia, the water quality evaluation was completed independently from the wetland catalog development. A future area of research would be to test methods of developing a catalog of restoration and mitigation opportunities that simultaneously evaluated wetland and water quality attributes.

2.5.3 The Watershed Approach and Other State Efforts

The "Watershed Approach" is a method identified in wetlands mitigation rules developed by the U.S. Army Corps of Engineers (USACE) in cooperation with the EPA (EPA 2008; Eli 2007). While these rules are relatively general, a number of organizations and localities have undertaken efforts to demonstrate the watershed approach. EPA and USACE staff have tested the approach in the central Maryland, and believe they can implement it throughout the state. The approach has also been used in watersheds in Delaware, Minnesota, Tennessee, and Montana. The approach is quite similar to overall approach we have developed, involving collecting spatial data, identifying priorities, and working with partners to determine the most important areas for restoration and conservation.

The watershed approach has focused on assuring that partnerships are developed with a myriad of local organizations, governments and the public, making them relatively easy to implement, but more time consuming and expensive to develop. To date, most demonstrations of the watershed approach have been developed locally, with a local government or NGO as the driver of the analysis and implementation.

Assuring comprehensive and readily acceptable mitigation sites are identified and, if possible, pre-approved by the regulatory community in any state is a key to gaining early regulatory assurances. Any of the methods tested will meet the goals of the transportation and regulatory community, provided they involve an analysis of a relatively comprehensive wetlands dataset; some analysis of overall conservation priorities, preferably in an REF; and an identification of mitigation opportunities.

There would be advantages to creating standards for the development of statewide wetland mitigation catalogs, but wetland standards can be difficult, and this would not be critical to obtaining regulatory certainty. The fastest and most straightforward method would involve building on existing efforts in the states where these are ongoing, and identifying a straightforward method, based on the Virginia, Oregon, or Maryland work, for rapidly creating a statewide catalog in other states.

Regardless of what method is chosen, moving from existing wetland banks to a system based on priorities is not going to be simple. Grandfathering in existing sites is likely essential. Similarly, methods that rely on wetland functionality to further identify mitigation needs and opportunities will have to be addressed. The clear obstacle to better transportation and conservation outcomes is the lack of a reasonable and comprehensive set of pre-approved mitigation sites. As is the case with all issues related to planning and information, the lack of perfect data should not be allowed to stop progress, which is especially important in developing methods and tools used in a regulatory framework.

2.5.4 **Improving ESA Data**

Most of the uncertainty that endangered species regulators have is caused by lack of information on the probable distribution and habitat of these species. While good information exists on known populations, the fear of losing an unknown but potential important site for a species is a major barrier to many permits. The probable or potential distribution is also the most important data to adequately assess impacts and plan for protection and recovery.

2.5.4.1 **Developing Inductive Species Maps for Federally Listed Species**

Most information on listed species locations currently exists in the form of observations, instead of habitat type and predicted distributions. Species occurrence is highly sensitive information and, as a result, is not readily shared with transportation agencies or the public. In addition, observation data is almost always shown and distributed with buffers that reflect the accuracy or certainty of the individual occurrence. As a result, the older, less accurate data shows up as large buffers covering large areas, while more recent and more accurate data is smaller, with limited buffers. Figure 5 below shows the federally listed species occurrences from northwestern Oregon, and how large the uncertainty buffers are for some older records. The system was designed for project review by regulators, but works poorly with electronic decision support tools.

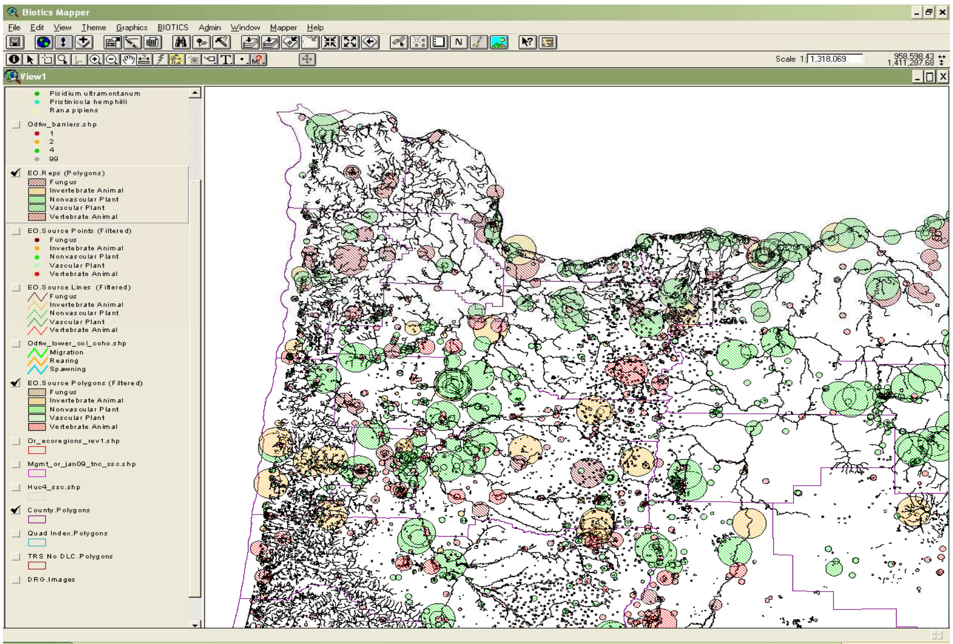
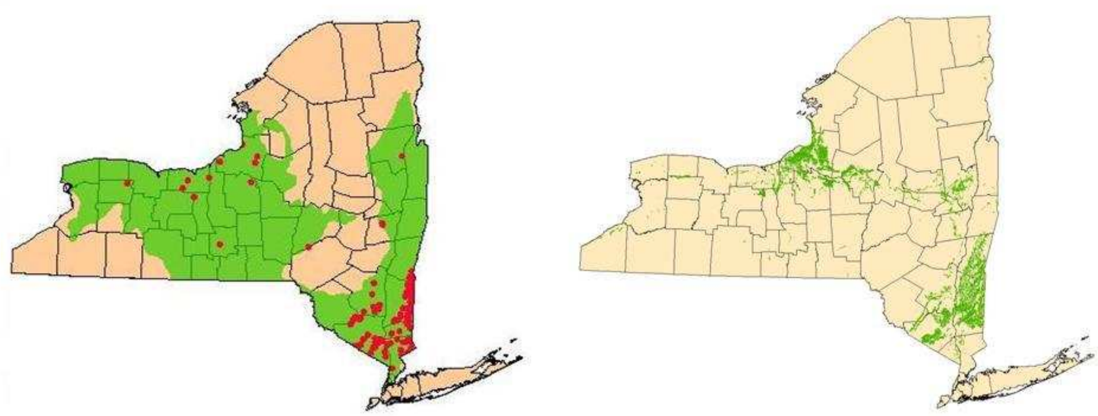


Figure 5. Map of Federally Listed Species Occurrence with Buffers in Northwest Oregon

We tested the possibility of transforming these highly sensitive maps showing precise known locations of federally listed species into slightly more generalized, public domain maps showing places where these species are likely to occur or where their habitat needs to be protected. This built on the on-going work in Oregon, New York, Florida, and elsewhere in the Natural Heritage network to develop high resolution predictive species maps that did not have the sensitivity of observation data.

In order to develop regulatory assurances for endangered species issues, the project team met with USFWS Endangered Species staff in Florida, Oregon, and Virginia. Presentations were made on the previously developed models in Florida and Oregon. Models were used to create detailed maps of potentially occupied habitat which would add known occurrences and legally designated critical habitat to create data which could be used in decision support tools and the overall Framework.

These new data are called, species distribution maps. The work to date has focused on three primary areas: 1) working with regulators to determine how to assure the data would achieve the project goals; 2) defining methodology, steps and costs for developing the data across the country; and 3) addressing issues related to standards, linking the data to the Framework, data security, and data distribution and maintenance. The difference between the two approaches is illustrated by Figure 6.



Maps showing traditional (left) and species distributions (right) of the bog turtle in New York. Red dots indicate occurrences and the green on the left map are the ecological subsections in which they occur. (*Courtesy of NY Natural Heritage Program*.)

Figure 6. Comparison of Traditional and New Distribution Maps for the Bog Turtle

Using the data from the Natural Heritage Network's Biotics species observations database, and new software for modeling species predictive distributions (DOMAIN, Random Forest, Maximum Entropy), predictive distribution maps of listed threatened and endangered species were developed which better represent where species might be. They also can significantly reduce the size of areas requiring potential inventory for endangered species. The models can be used not only to define potentially occupied habitat, but most significantly, through probability analyses, areas which are not potential habitat for any listed species. Figure 7 below shows a detail of the bog turtle map, showing how the probability of occurrence can be identified, and used to create maps for both Section 7 review and recovery planning. We have developed a series of detailed methodology questions related to data development, and a list of answers from researchers at institutions that have developed these models.

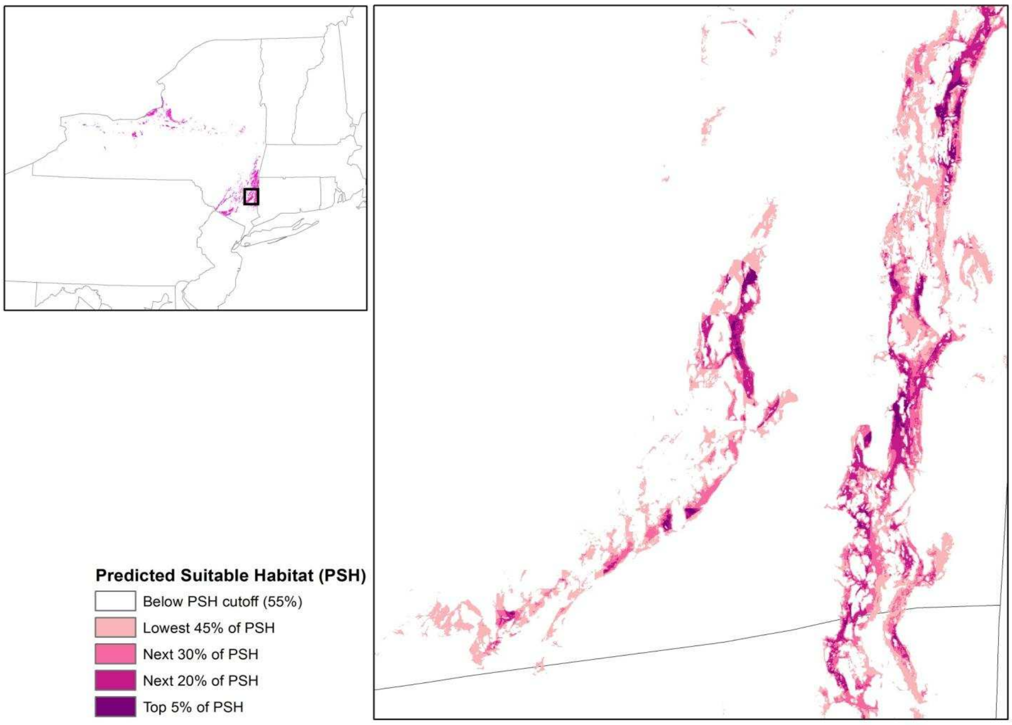


Figure 7. Map Showing Inductive Distribution Probability for Suitable Habitat of the Threatened Bog Turtle in New York

New York has spent the most staff time building at-risk species models using inductive modeling methods, with over 250 species mapped in the state. Oregon also has done extensive research on inductive models, developing models for very rare species to help the timber industry address their Sustainable Forestry Initiative certification requirements. However, Oregon has completed only 8 species models for listed species and has 15 remaining. Florida is the only state in the U.S. which has completed models for all listed species, although Florida Natural Areas Inventory (FNAI) would like to update their models to use the new techniques and standards developed by Florida and Oregon. Wyoming and Montana have expanded their capacity to create high resolution maps of species distributions, while work is beginning in Colorado, New Mexico, Wisconsin, and elsewhere.

USFWS has been using similar, but simpler, models to derive critical habitat for use in listing species under the ESA or recovery plans. As a result, regulators are familiar with them and understand their potential utility. In addition, USFWS is developing a Section 7 decision support tool that focuses on analyzing impacts based on spatially mapping threats identified in listing and recovery documents and integrating the actions. The current USFWS tool requires distribution information and would be significantly improved using inductive models. In proactive parts of the transportation planning framework, planners could inductive models to avoid probable distributions of endangered species and target other (improbable) areas of occupation for potential transportation infrastructure development.

2.5.5 Endangered Species Mitigation

While ESA mitigation may not be as prevalent as wetland mitigation in transportation implementation, it remains a major focus. The inclusion of a programmatic approach to project planning and implementation is identified in Eco-Logical and a major goal for ESA implementation by both the USFWS and NOAA Fisheries. The development of comprehensive species distribution maps will assist in developing and creating priorities for the development of programmatic approaches. A completed REF, with information on identified threats and recovery needs for all known or predicted federally listed and proposed species clearly identified, is also essential.

Integrated wetlands and ESA mitigation catalogs have been developed for vernal pond species in the central valley of California, in southwestern Oregon, and in south Florida. However, these examples were developed primarily focused on the needs of one or several listed species which occurred in wetland habitats. A number of programmatic efforts focusing on listed fish and their streams have also been developed by both NOAA and USFWS. All of these efforts require an analysis of recovery needs and critical habitat. This data currently is not readily available, and represents another critical information need. While only NOAA and USFWS can develop these data, integrating available maps, and including critical habitat and recovery goals digitally in planning criteria for the REF and for all transportation plans can be done by state and local agencies. Including this information in the inductive species distribution maps provides the best opportunities for obtaining regulatory acceptance.

2.5.6 Assuring Planning Data is Up-To-Date and Meets Regulatory Requirements

Addressing data distribution infrastructure needs and how the data can best be incorporated into the Framework has yet to be done. The Framework needs to be better developed for this to be done efficiently. We will evaluate the Biodiversity Exchange Network, based on EPA's successful Water Quality Exchange Network, as a potential tool for data distribution. To date, the new network is unable to share spatial data. The Utah Natural Heritage Program was funded to develop a functional node with a geo-database, but the end date of the project has been extended until August of 2010. Utah continues to believe they will have a usable methodology.

One of the goals of this research is to assure internal data sharing of newly developed models within the natural heritage network and the regulatory agencies and to assure that the models provide regulatory certainty. Another goal remains to assure protocols and software exists to allow programs to provide their data through web services to transportation agencies and other partners. The advantage to providing data through web services is that the primary data manager is electronically and automatically publishing their data for web sites to harvest. Data security can be built in, but applications using web services receive constantly updated data. We will tailor this on-going effort to meet the needs of transportation planners and support the CEAA process.

2.6 ECOLOGICAL ACCOUNTING

2.6.1 The Problem of Consistent Measures

Conservation planning and regulatory efforts strive to protect our communities and the environment from choices that may damage them, intentionally or unintentionally. At the same time, we are expected to only limit these choices as much as is needed – and no more. These goals are classically in conflict in our public efforts. In transportation, we are charged to provide a certain level of infrastructure while safeguarding the environmental resources we affect. Outside of the environmental management world, planners and administrators rely on many common measures to gauge progress towards goals and objectives and make new decisions. We track job gains and losses, the income of households, the gross domestic product (GDP), unemployment, poverty, and educational attainment. For transportation, we assess numbers of daily trips and levels of services.

In the environmental realm, however, it is much more difficult for us to evaluate how much of a resource or habitat we need to protect, and how well we are doing. We are also challenged to communicate this to the public and elected decision makers. Often we do not know whether our choices have been good until too late. The federal environmental legislation of the 1970's, and a complementary state laws, has made us worry about the environment, but 40 years later we have learned that managing crises of pollution or extinction is not the most efficient way to achieve our environmental goals. We still struggle to measure, communicate and assess our progress toward conservation and restoration as well as prove our compliance with environmental goals. Even within our regulatory structures, we lack a meaningful way to connect restoration or recovery goals to choices made at a site level. The best we have been able to do is track a patchwork of resource-specific performance measures – but without understanding how they connect to programs, regulations, or budgets.

A new set of measures could accomplish the following goals:

- Provide status and trend information;
- Allow us to link budgets to choices in order to understand efficiencies and progress;
- Translate high-level planning and regulatory goals to site-level decisions; and
- Communicate effectively with stakeholders, decision-makers, and each other.

The federal government has wrestled with concerns about environmental metrics since the 1970's. A 2005 GAO report tracks this history and the efforts on a national level to measure and communicate environmental conditions and trends. Starting in the 1970s, the National Academy of Science identified that the highest priority for managing the environment is to create a centralized federal monitoring program. Since then 16 bills or resolutions have passed Congress calling for this or attempting to solve the problem (U.S. Government Accountability Office 2005).

Progress on tracking the environment has focused largely on single-resource questions. This can be pollutant- or species-based or based on acres impacted, as areas burned. Or it can be resource-based in terms of tons of fish caught or board feet harvested. Today the federal government spends at least $600 million, every year, on monitoring the conditions and trends in our environment (U.S. Government Accountability Office 2004). State and local governments spend an additional unknown amount to track the environment. The challenge is that none of these measures has remained consistent or been integrated longitudinally to provide a basis for developing new management strategies, theories, or comprehensive assessments. We often end up with databases that are unable to speak to one another, thus unable to be shared, or to inform decision making. The inability of ESA recovery plans to provide help in developing Section 7 or 10 consultations is just one example of the resulting dysfunction.

Measurement systems for assessing and quantifying the environment historically have been developed to meet regulatory requirements, with various goals in mind. The metrics that have emerged from the CWA illustrate the multiplicity of measurements and requirements. The CWA includes pollutant measurement systems developed to track individual pollutants, including chemical and physical pollutants. Along with its state analogs, it also generated a measurement system for wetland units based on acres, popularly known as "no net loss."

Finally, to assess the progress in remediating pollution of waterbodies, the CWA also fostered the development of indices of biological integrity. Thus, three unique, unrelated, and specialized measurements have been developed all with the same goal of returning waterbodies to a healthy state. In addition, other regulatory drivers working towards improving the health of the environment and ecosystems include the ESA, Clean Air Act, Natural Resource Damage Act, and many state laws that require their own measurements. The multiplicity of regulatory requirements continues to be a challenge for transportation project delivery.

In many contexts, the measurement systems and regulations overlap biologically, but the overlap is not reflected in the policy and regulatory realms. Even if the science suggests that managed resources should coexist, their regulation rarely coexists. For example, a wetland adjacent to a stream with ESA-protected fish may come into a regulatory conflict as mitigation or restoration required by regulations may not be allowed to serve both resources. In all such measurement systems, metrics have been based on single resources or species as a key to capturing the health of the entire system. Population numbers, pollutant loads, or acres of habitat have driven most regulatory systems. The recurrent problem is that the narrow focus on a single resource frequently comes at the expense of other resources.

This challenge has led to calls for a common set of units that can be measured with a bundled or stacked credit system. Stacking efforts have focused on attempts to identify common sets of functions and indicators to allow for relationships between regulated resources to be understood (Oregon Department of Transportation, 2007). To date these efforts have been limited to the ecological features included within a regulatory system. However, other biodiversity and natural features are important to consider in assessing human impacts on the natural environment, and include the role the environment plays in protecting and providing for human communities. For example, properly functioning floodplains protect against flooding and improve water quality.

Environmental measures include tools or methodologies for assessing specific impacts or benefits from actions on the landscape. Crediting systems are also needed to evaluate alternatives, assess impacts at project sites, and evaluate benefits from conservation or restoration actions. Crediting includes both the positive credits from beneficial actions and debits from impacts that harm the environment, and must be consistent whether used for measuring impacts or benefits. The primary goal for any crediting system is to capture the environmental impacts or benefits in a common unit that bridges different activities, times and geographies as appropriate.

We developed an ecosystem service accounting methodology for a Department of Transportation to self-diagnose the need for a system, identify existing crediting options, and if needed select a method for developing a custom crediting system (see Chapter 3 for details). These measurements may be used to provide the basis for credits or debits in a compensatory mitigation context, or to evaluate design alternatives that best avoid or minimize impacts.

2.6.2 **Ecosystem Services and Transportation Planning**

The need to better understand society's dependence on natural services and goods has led to the increased study of ecosystem services and the opportunity for ecosystem services to structure new management tools. The ecosystem services literature in the U.S. dates back to Aldo Leopold and conservation biology writers in the early and mid-20th century.

Ecosystem services are the goods and services that human communities depend upon for health, safety, and economic prosperity. These goods and services are often grouped into the general categories of provisioning, regulating, cultural, or supporting services (Daily et al., 2009). Provisioning services include more common conceptions of goods from the natural world such as food, fiber, and fuels. Regulating services include the natural features and functions that protect communities from flood, fires, and storms. Other services that are just as important, but often hard to capture are those that provide us aesthetic, cultural, and recreational values. This classification system is opposed by those arguing for a more integrated view of how services interrelate and combine naturally (Fisher et al., 2009).

The use of methods for estimating ecosystem services has been the subject of some debate. One concern is that ecosystem services fail to ensure protection of biodiversity by focusing environmental policy attention on services whose values to humans are more widely understood (Kremen and Ostfeld, 2005; Vira and Adams, 2009). The concern stems from the way services are defined. Because their value is tied to human use and consumption, it is feared that some natural functions necessary to support biodiversity, but lacking a human consumer, will be lost or undervalued. Through much of the ecosystem service literature, there is an underlying assumption that if ecosystem services are preserved, then biodiversity will also be protected. Research on the correlation between services and biodiversity has only recently begun. Some early results suggest that the correlation between ecosystem service provisioning and biodiversity is positive, but it may not be strong in many cases (Chan et al., 2006; Benayas et al., 2009).

A second concern is that many valuations based only on ecosystem services are based on large area analyses that do not directly support local decision making or implementation (Nelson et al., 2009). Some valuation systems rely on large area economic analyses that allow for both a broad scope and set of services to be considered, but which are difficult to disaggregate to a local level (Costanza et al., 1997). A related argument against ecosystem services providing an economic valuation system is that while they provide an important policy analysis tool, use of these valuations for projects or sites fail to be sensitive enough to measure the difference between small areas of environmental benefit such as one would find in the design of highway infrastructure.

Much of the related literature focuses on valuation methods based on a monetary value. These valuations include replacement value, avoided costs, and contingency or willingness to pay methods (Apogee Research, 1996; Wilson and Carpenter, 1999; Kolstad, 2000). All of these economic methods result in a valuation of services and goods. Framing environmental decision making with this economic based valuation of ecosystem services allows for decisions to be assessed in the common unit of monetary value. The resulting values also allow for comparison with other non-environmental program activities, allowing for a cost comparison between environmental and other expenditures. The challenge for this methodology is that often the economic valuations depend on external economic factors. For example, the value of a natural feature such as a floodplain requires a measurement of costs of rebuilding a structure for the flood plain itself to be valued. This scenario leads to a floodplain deep in a wilderness having no value because its ability to protect homes is nonexistent without the presence of human development.

The third challenge to ecosystem service valuation is that species- or service-specific measures lack integration across both the number of services and the areas studied (Nelson et al., 2009). These valuation studies often select a critical service and limit study to a specific area or watershed. While these studies provide the local level data and policy implications, they are limited in how they assess other values in the larger watershed or ecosystem context. The results leave policy makers with no new way to understand tradeoffs across the environmental values and across a landscape.

3. CHAPTER 3: THE INTEGRATED ECO-LOGICAL CONSERVATION AND TRANSPORTATION PLANNING FRAMEWORK

3.1 INTRODUCTION

The *Integrated Eco-Logical Conservation and Transportation Planning Framework* ("Framework") is designed to provide technical support for implementing *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects (Eco-Logical)* — a guide and "permission document" signed by eight federal agencies in 2006 to encourage federal, state, tribal and local partners involved in infrastructure planning, design, review, and construction to use flexibility in regulatory processes to achieve greater environmental benefits. Specifically, Eco-Logical establishes the conceptual groundwork for integrating plans across agency boundaries, and endorses ecosystem-based mitigation that addresses highest priority needs for the watershed, species, or ecological community. Our Framework provides more detailed technical guidance for practitioners to use in implementing this ecosystem approach to decision making that considers multiple resources. The Framework addresses and integrates the cumulative effects assessment and alternatives (CEAA) process with partnership development, regulatory assurances, and ecosystem services crediting strategies.

Cumulative effects assessment and alternatives The CEAA process is the starting point for conducting ecological assessment by evaluating the cumulative effects on resources of one or more plan or project scenarios, allowing and supporting conflict identification and creation of alternatives. It also provides the ability to quantify impacts, which is needed for further steps in the regulatory processes and mitigation actions. The CEAA process can also integrate proposed mitigation actions to provide and maintain a dynamic reporting of regional resource goal achievement or gaps. This process only addresses the spatial analyses components for quantifying impacts and identifying mitigation opportunities.

Regulatory assurances strategies integrate with the CEAA process by adding information on *data standards* (what data is needed by regulatory agencies) and *new predictive modeling methods* for species and habitats that are acceptable to regulatory agencies. The purpose of having regulatory assurances strategies is to allow a practitioner to move from regional scale analysis to the level of information and analysis needed by the permitting agencies.

Ecological accounting strategies help direct transportation-related mitigation and other transportation-related decision making to support high priority conservation goals. Specific tools are provided to address impacts at the project level, while tying avoidance and mitigation actions to broader conservation plans. These steps can be used within the Framework or as a stand-alone process/strategy.

Partnership development strategies developed by the C06(A) project are included throughout the Framework.

These four components of our Framework have been integrated into a 9-step process (see Table 3 for an overview and the following sections for details). The steps of the Framework are aimed at guiding state transportation agencies (DOTs), metropolitan planning organizations (MPOs), and resource agencies in working together to identify strategic transportation program needs and potential environmental conflicts or conservation opportunities in the state, ecoregion, or watershed. Thus, the Framework supports the development of programmatic approaches to increase regulatory predictability during project development while furthering achievement of regional conservation goals. It is a comprehensive, dynamic process that will promote the integration of regulatory and non-regulatory efforts and strengthen the opportunity to achieve ecosystem health. Through the integration of traditionally competing regulatory and non-regulatory processes, this

Framework can improve resource planning, enhance time and resource efficiency, and minimize redundancies in the decision making process.

Table 3. Steps of the Ecological Assessment Framework

Step	Purpose
Step 1: Build and Strengthen Collaborative Partnerships, Vision	Build support among a group of stakeholders to achieve a statewide or regional planning process that integrates conservation and transportation planning.
Step 2: Characterize Resource Status. Integrate Conservation, Natural Resource, Watershed, and Species Recovery and State Wildlife Action Plans	Develop an overall conservation strategy that integrates conservation priorities, data, and plans, with input from and adoption by all conservation and natural resource stakeholders identified in Step 1 that addresses all species, all habitats, and all relevant environmental issues.
Step 3: Create Regional Ecosystem Framework (Conservation Strategy + Transportation Plan)	Integrate the conservation and restoration strategy (data and plans) prepared in Step 2 with transportation and land use data and plans (LRTP, STIP, and TIP) to create the Regional Ecosystem Framework (REF).
Step 4: Assess Land Use and Transportation Effects on resource conservation objectives identified in the REF	Identify preferred alternatives that meet both transportation and conservation goals by analyzing transportation and/or other land use scenarios in relation to resource conservation objectives and priorities utilizing the REF and models of priority resources.
Step 5: Establish and Prioritize Ecological Actions	Establish mitigation and conservation priorities and rank action opportunities using assessment results from Steps 3 and 4.
Step 6: Develop Crediting Strategy	Develop a consistent strategy and metrics to measure ecological impacts, restoration benefits, and long term performance – with the goal of having the analyses throughout the life of the project be in the same language.
Step 7: Develop Programmatic Consultation, Biological Opinion or Permit	Develop MOUs, agreements, programmatic 404 permits or ESA Section 7 consultations for transportation projects in a way that documents the goals and priorities identified in Step 6 and the parameters for achieving these goals.
Step 8: Implement Agreements and Adaptive Management. Deliver Conservation and Transportation Projects	Design transportation projects in accordance with ecological objectives and goals identified in previous steps (i.e., keeping planning decisions linked to project decisions), incorporating as appropriate the programmatic agreements, performance measures and ecological metric tools to improve project.
Step 9: Update Regional Integrated Plan/Ecosystem Framework	Update the effects assessment to determine if resource goal achievement is still on track. If goal achievement gaps are found, reassess priorities for mitigation, conservation, and restoration in light of new disturbances that may impact the practicality/utility of proceeding with previous priorities. Identify new priorities if warranted.

3.2 THE NINE STEPS OF THE FRAMEWORK

A summarized version of each step of the Framework is provided in the 'boxes' below followed by a narrative that focuses on the application of the technical components contained in each step. Note that substeps of the Framework that focus on the 'collaborative building' components of the Framework (as opposed to the four components outlined above) are not addressed in the narrative below since they are not the focus of our C06(B) research.

3.2.1 Step 1: Build and Strengthen Collaborative Partnerships, Vision

Step 1: Build and Strengthen Collaborative Partnerships, Vision

Purpose:

Build support among a group of stakeholders to achieve a statewide or regional planning process that integrates conservation and transportation planning.

Outcomes:

- Developing a shared vision through mutual understanding, appreciation, and documentation of transportation agencies' and resource agencies' overall goals, priorities, processes and major areas of concern within a specified planning region (i.e., state, watershed, or other ecologically based region).
- Creating mutual understanding of significant land use issues that may impact agency goals and mitigation needs.
- Establishing or reinforcing partnerships through formal agreements on roles, responsibilities, processes, and timelines.
- Identifying opportunities and criteria for using programmatic consultation approaches to better address transportation and conservation planning needs.

Implementation Steps:

1a. Identify preliminary planning region (e.g. watersheds, eco-regions, and/or political boundaries). Drivers may be environmental factors such as water quality needs or 303(d) listings, species' needs, watershed restoration needs, or rare wetlands.

1b. Identify counterparts and build relationships among agencies, including local government and conservation NGOs (stakeholders).

1c. Convene a team of stakeholders, share aspirations, define, and develop commonalities. Build an understanding of the benefits of a watershed/ecosystem/ recovery planning approach and develop a shared vision of regional goals for transportation, restoration, recovery, and conservation.

1d. Record ideas and develop MOU on potential new processes for increasing conservation, efficiency, and predictability.

1e. Initially explore funding and long-term management options to support conservation and restoration actions and long-term management.

Technical Considerations:

- Integrated Approach - Decide on high level approach to implement an integrated planning process that most effectively captures transportation effects on species and ecological functions at the landscape scale.
- Types of Resources - What are the types of resources to include? Consider federal, state, local regulated and non-regulated resources (connectivity needs, migratory and declining species).
- Boundaries - Considering ecological as well as political boundaries, select the area for evaluation of direct and cumulative impacts, restoration opportunities, and selection of mitigation sites (i.e., area evaluated for mitigation may be larger than area evaluated for direct impacts).
- Streamlining - What are the repetitive and relatively standardized project activities conducted by the DOT that could be addressed through programmatic approaches?

3.2.1.1 Technical Implementation of Step 1

Step 1a. Identify Preliminary Planning Region

A boundary is needed to identify the region in which resource and development considerations will be analyzed. In establishing the region boundary, there are several considerations. There is no perfect assessment region but selecting planning boundaries consistent with regional or MPO boundaries can be suitable. For ecosystem assessment the main considerations are:

1. The ability to recognize patterns for ecosystems and biodiversity related to their distribution, regional connectivity, and natural disturbance.
2. Opportunities for offsite mitigation
3. Technical limitations in terms of data precision and choice of tools (further addressed later).

Consulting data that significantly extends beyond the MPO for example, can still allow for these considerations while limiting the extent of spatial analyses to the jurisdictional boundary. For example, NatureServe's Global Rank of Imperilment assigned to most species considers the global extent and threats to species. This information can be used for selecting and prioritizing species for consideration and establishing important criteria and objectives without requiring spatial analyses throughout the species range. Once a planning region boundary is selected, share it with regional partners to assist in identifying appropriate data and expertise. Select the most precise boundary that can be represented with spatial data to reduce inaccuracies and confusion when intersecting it with fine scale data.

Ecosystem Crediting Aspects: Step 6B below includes a review of institutional and organizational issues and concerns to include at this stage of the overall process. Reviewing the participant's perspective in new environmental measures and management choices begin at this step. Efforts may involve assessing the history of interactions, impacts, or mitigation and setting a new vision based on better performance goals. Defining the physical, natural, and policy boundaries of the measurement system is critical and occurs in this step as well.

3.2.2 **Step 2: Characterize Resource Status**

Step 2: Characterize Resource Status. Integrate Conservation, Natural Resource, Watershed, and Species Recovery and State Wildlife Action Plans

Purpose:

Develop an overall conservation strategy that integrates conservation priorities, data, and plans, with input from and adoption by all conservation and natural resource stakeholders identified in Step 1 that addresses all species, all habitats, and all relevant environmental issues.

Outcomes:

- Compiling existing data and plans into a refined map that identify areas for conservation and restoration action to use as the basis for a REF and cumulative effects analysis.
- Developing an understanding of historic/long-term trends, priorities, and concerns related to aquatic and terrestrial species and habitats in the region.
- Identifying any gaps in data or plans that may need to be addressed separately and identifying modeling or assumptions to be used to address these gaps.
- Obtaining commitments and schedule for delivery of data and modeling to fill gaps.

Implementation Steps:

2a. Identify the spatial data needed to create understanding of current (baseline) conditions that are a by-product of past actions and understand potential effects from future actions.

2b. Prioritize the specific list of ecological resources and issues that should be further addressed in the REF or other assessment and planning.

2c. Develop necessary agreements from agencies and NGOs to provide plans and data that agencies use in their own decision making processes. Agreements should allow data to be used to avoid, minimize, and advance mitigation, especially for CWA Section 404 and ESA Section 7.

2d. Identify data gaps and how they will be addressed in the combined conservation/restoration plan. Reach consensus on an efficient process for filling any remaining gaps.

2e. Produce geospatial overlays of data and plans outlined above, as well as supporting priorities, to guide the development of an overall conservation strategy for the planning region that identifies conservation priorities and opportunities, and evaluates stressors and opportunities

Step 2: Characterize Resource Status. Integrate Conservation, Natural Resource, Watershed, and Species Recovery and State Wildlife Action Plans

for mitigation and restoration.

2f. Convene a team of stakeholders to review the geospatial overlay and associate goals/priorities, and identify actions to support them.

2g. Record methods, concurrence and rationales of this step based on stakeholder input (e.g., how the identified areas address the conservation/preservation, or restoration needs and goals identified for the area).

2h. Distribute the combined map of conservation and restoration priorities to stakeholders for review and adoption

Technical Considerations:

- What are the quantitative retention goals for each resource to ensure preservation of an agreed upon portion of the priority resources?
- What is the conservation status of identified priority species and habitats (including wetlands)? How accurately do we know where priority species and habitats (including wetlands) occur or could occur? Do we understand the viability needs of priority species and habitats (i.e., minimum habitat size required for particular species)?
- What is the condition of the existing data (e.g.,. completeness, age, resolution)?
- What expertise and resources are needed to fill any identified data gaps?
- Are conservation priorities and actions represented accurately in the REF, including ones that are not spatially explicit?
- Is there disagreement in the conservation priority areas and goals identified by different conservation plans developed in the planning region? How will this be resolved?
- What regulated resources are most common in the area, and are most likely to be impacted or are the most sensitive to disturbance?
- What ecosystem services of interest are most likely to be affected by transportation projects?
- Do mitigation banks, habitat conservation banks or other markets exist for ecosystem services likely to be affected?
- What landscape scale measurements exist, if any, for quantifying ecosystem services and impacts?
- What are the limiting factors associated with TMDLs and 403d limited streams?

3.2.2.1 Technical Implementation of Step 2:

Step 2b. Prioritize the specific list of ecological resources and issues that should be further addressed in the REF or other assessment and planning.

First, one must establish the resource list; this can be done through a variety of methods, but we recommend a systematic approach:

1. Begin with federal and state legally-protected resources.
2. Add resources that are determined at risk by the resource collaboration group/scientists.
3. Use ranking systems such as NatureServe’s Global Rank of Imperilment (G1-3 status) and the State Natural Heritage Program S-ranks (S1-S3).
4. Apply the coarse/fine filter approach for biodiversity conservation planning (which seeks to conserve the full range of biodiversity).
5. Add “trust” species (those in addition to legally protected species which agencies are required to manage).

6. Add other resources of interest/value to stakeholders.

Next, it is highly useful to set quantitative retention goals for each resource (e.g., 90% of the distribution of habitat A or 100 occurrences of species B within the planning region) and document the source(s) of information used. Goals are typically set in the systematic conservation planning process using experts in those resources to apply their judgment relative to historic vs. current distribution and viability/sustainability requirements such as species population structure and natural disturbance regimes. While it may be required or desirable to estimate actual historic distribution and loss this is difficult and expensive for most resources. Some states have created historic vegetation distribution maps and approaches exist for mapping historic wetland distribution. Individual plant and animal species historic distribution maps are rare and would have high uncertainty. Another approach is to apply NatureServe global ranks of imperilment. These "g-ranks" already incorporate expert judgment on historic loss and can be found at (http://www.natureserve.org/explorer/). For non-legally protected resources, goal setting can be difficult and controversial but forms the basis for assessing significance of impacts in later stages and facilitating mitigation and tradeoff planning. It is critical to clearly characterize the objectives for legally protected resources, including all goals identified in recovery plans, adopted watershed plans, and programmatic agreements.

The typical alternative to goal setting is weighting the relative importance/priority of resources/features on some categorical scale (e.g., 1-5, low to high, etc.). Weighting resource importance can be used as an initial step to help inform the magnitude of potential impacts while quantitative goal setting is being conducted (which can often times be a lengthier process) and weighting is often an easier value to extract from stakeholders than quantitative goals. However, the use of weights alone limits the usefulness of information generated from the impact assessment conducted later in this process because weights do not result in conclusions about resource viability impacts or the amount of mitigation that may be needed other than for resources where any impact must be mitigated. Weighting values provided by stakeholders can inform the expert judgment process in terms of gauging the amount of representation of a resource relative to science-based judgment about sustainability (e.g., it may not require much area to continue representing a particular resource in sustainable numbers in a planning area but stakeholder values may suggest they'd like to see it widespread). See the introduction to Appendix A for further goal setting guidance.

If choosing to use quantitative goals, decide if a single goal or a goal-range is desired. For legally-protected resources, a single goal is likely needed (often 100%). Goals can also be set as a range rather than a single value such as minimum and preferred levels (e.g., 50% and 75%, respectively) or high-medium-low as an expression of risk of future loss (e.g., 10%, 30%, 50%, respectively). Set resource goals and document the source(s) of information used.

A considerable amount of spatial and non-spatial information will be collected and generated through application of this framework. Creating a database for resource information is critical to document name (and taxonomy if applicable), reason for selection, "champion" meaning which partner(s) hold the resource in trust or otherwise advocate for it and can provide key information about it, and sources of spatial and expert information. This database will also be used to record the retention goals and other key information necessary for effects assessment and retention planning/mitigation describe in Step 4a. The process of populating this database can take some time and can proceed in parallel with other tasks but the sooner it is started the more likely the information will be in place when needed (in particular for Steps 3 and later).

Populating the database essentially involves having subject matter experts (SMEs) for each resource use extant data, their knowledge and judgment and that of other colleagues to develop the required attributes. Resource expertise is distributed among many institutions and individuals and guidance exists for obtaining such information in useful and effective ways e.g., use of workshops (Groves 2003). Oftentimes experts are located outside the planning region or otherwise are not available to attend workshops or funds for such workshops are not available. In those cases, a data collection form can be sent via email. An example of an expert knowledge gathering process and forms is at http://www.natureserve.org/prodServices/vista/docs/expertInputGuide.pdf.

Step 2d. Identify data gaps and how they will be addressed in the combined conservation/restoration plan. Reach consensus on an efficient process for filling any remaining gaps.

Begin this substep by reviewing plans/plan documents to determine fit of scale, precision, purpose, source, etc., and which resources are included. Determine the value of plans for target resources and gaps in resource coverage by plans. If gaps appear to exist, conduct further investigation of resource coverage and decide how the team will address. Creators of the plans will be the most knowledgeable about informing whether their plans can suit the REF purpose and with what limitations. It will also be useful to have resource SMEs review the plans to determine if they can adequately represent individual resources.

Next, determine which plans and or resource maps to include in the Regional Ecosystem Framework (REF) and which resources each plan can represent. Each resource should be represented primarily by only one plan but important conservation areas that include multiple resources may represent an acceptable overlap. For example, a particular conservation priority plan may be deemed acceptable for representing bird conservation generally but an individual bird species priority map may be added to the REF that better represents that individual resource. Though there is some overlap, both input maps will be useful for the REF.

To understand how well existing plans represent specific resources, we suggest creating a matrix that cross-references resources to named plan products. If specific resource content is not documented in existing plans (e.g., locations identified only as habitat conservation areas), interview plan developers to determine resource content. If no further information can be obtained and the plan is to be included in the REF, then conduct the following steps.

1. Identify and obtain existing resource distribution maps that the resource SMEs believe appropriately represent the resource.
2. Intersect plan priority/management areas with individual resource maps to determine resource content.
3. Identify those resources not covered or not adequately covered by any existing plan and decide how or whether they should be represented in the REF.
4. Document how well existing priority maps include each resource. Consider coding the relationship according to the strength of resource treatment in the plan (e.g., on a 1-3 scale from low to high) and document the strength of the treatment. Strength of treatment may refer to the quality of the data used (e.g., recorded observations or range maps vs. accuracy assessed predictive distribution models) and the robustness of analyses (e.g., simple distribution area vs. population dynamics).
5. Determine if enough information exists to include the resources in the process and if so whether they will have separate treatment as individual element layers in the REF or be integrated into an update of an existing plan product by the owner of that plan (e.g., add to State Wildlife Action Plan).
6. Document how each resource will be treated and by whom.

7. Fill gaps in conservation plans as feasible and otherwise note deficiencies and how those should be addressed during later phases of long range planning and or project planning.
8. Document priority areas and individual resource distribution maps with the amount of resource area and occurrences as well as confidence in resource presence in each occurrence. These data will be important for quantifying and evaluating impacts and mitigation needs and opportunities. Confidence information will also be useful for determining re-opening clauses (see Step 7).
9. Document priority maps and or specific priority areas for any of this information that could not be determined, and plans for filling information gaps.
10. Identify any individual resources for which adequate distribution information was not available and plans for filling information gaps.

Step 2e. Produce geospatial overlays of data and plans outlined above, as well as supporting priorities, to guide the development of an overall conservation strategy for the planning region that identifies conservation priorities and opportunities, and evaluates stressors and opportunities for mitigation and restoration

When overlaying the various accepted plans (including individual resource maps) be sure to follow procedures for retaining all relevant attributes as available in those plans. The intent of this step is to create a robust spatial database, not a presentation map because it will be infeasible to visually represent all of the inherent information in one map. It will however provide the attributes needed to create such visual presentations of particular themes of interest. Suggested attributes include:

1. Source/owner of the input map
2. Type/purpose of individual areas
3. Resource content of individual areas
4. Metadata for methods used to map areas

Areas within these plans need to be distinguished by their conservation status as either secured or unsecured (i.e., areas are or are not under some ownership/agreement to manage them in perpetuity for the resources to be sustained). Alternatively, all secured areas can be moved to a protected area database (PAD) and remaining areas from this step are all unsecured priority areas that should be mitigated or may provide offsite mitigation. Secured areas also inform avoidance in planning and as priority areas become secured their availability to offer mitigation is removed. It may be especially useful to attribute areas that contain legally regulated resources.

Prioritizing areas requires a rating system that can highlight areas based on attributes of content (e.g., legally protected or especially rare/imperiled resources or those values integrated in weightings described earlier) and threat from conversion. The REF partnership should come to agreement on the creation of an acceptable rating system. A more rigorous approach uses a key concept from systematic conservation planning called “irreplaceability” which informs how many options exist in the assessment/planning region to meet resource retention goals. For example, an area that contains a rare resource with a 100% retention goal (retention of existing distribution) would be 100% irreplaceable. Applying irreplaceability requires the setting of quantitative goals.

<u>Ecosystem Crediting Aspects:</u> The first step in employing ecosystem crediting is to analyze the need and roles of crediting. This may include a scan of regulatory, conservation and

market needs. The regulatory scan starts with a review of the permitting and compliance requirements in the study area. This can include a historic review of agency permitting obligations and costs, or reviewing the agency records for permitting. Conservation scans require examining bother regulation based and voluntary based conservation efforts that may identify species, habitats, or systems that require attention. Market scans include reviewing the regional mitigation need and banking if used.

Ecosystem crediting decision making begins with agreements on objectives for crediting and the basic rules for their use in transportation planning. The key questions are what existing measurement systems are in use, such as ones associated with ESA recovery efforts, pollutant measures for TMDL management, and wetland measures. Coordination with other planning efforts early identifies both opportunities and challenges that need to be resolved early. Steps 6 A and B coordinate with this step to include context information.

3.2.3 **Step 3: Create Regional Ecosystem Framework**

Step 3: Create Regional Ecosystem Framework (Conservation Strategy + Transportation Plan)
Purpose: Integrate the conservation and restoration strategy (data and plans) prepared in Step 2 with transportation and land use data and plans (LRTP, STIP, and TIP) to create the Regional Ecosystem Framework (REF). *Outcomes:* ▪ Producing the REF-- an integrated map of resource conservation and restoration priorities, transportation long range plans and other land use, infrastructure information, and socio-economic information). ▪ Reviewing and verifying REF and data sources used with all participating agencies and stakeholders ▪ Identifying areas in which planned transportation projects intersect with management/ conservation priorities, including existing conservation areas. *Implementation Steps:* **3a. Overlay the geospatially mapped Long Range Transportation Plan** (or TIP/STIP) with conservation priorities and other land uses. **3b. Identify and show 1) areas and resources potentially impacted by transportation projects and 2) potential opportunities for joint action on conservation or restoration priorities** that could count for 404 and Section 7 regulatory requirements. **3c Identify the high level conservation goals and priorities, and opportunities for achieving them**, relative to the transportation plan and other land uses/plans. **3d. Review and verify REF with stakeholders.** *Technical Considerations:* ▪ What areas will be directly impacted by transportation development? ▪ How severe are the likely impacts in combination with other land uses and/or cumulative impacts? ▪ What and where are the affected natural resources? ▪ How many of these natural resources are statutorily regulated and how many are imperiled but not legally protected? ▪ What areas could be targeted for mitigation? Would these areas contribute to meeting REF objectives? What areas should we target to avoid impacts due to the presence of irreplaceable resources (i.e., endemic species or habitats)?

3.2.3.1 Technical Implementation of Step 3

Step 3a. Overlay the geospatially mapped Long Range Transportation Plan (or TIP/STIP) with conservation priorities and other land uses.

In this substep, we wish to understand how development plans are likely to affect resource conservation priorities. First, you must obtain and integrate transportation and other development plans. Land use data is an important component of these plans but we want to distinguish existing development from future development. We suggest segregating land use data into actual current land use, allowable or planned land use (e.g., from local government comprehensive plans/zoning or public land management plans), predicted/forecast land use (e.g., from urban growth models), and proposed land use that falls outside of existing plans (e.g., a large planned unit development). Include existing conservation lands as a land use to assess the achievement of resource goals under current conditions.

The various developments plans will undoubtedly use different names and identifiers for the different development types represented in those plans. It will be highly useful to create a single classification of all of the development types acceptable to the partners. You can then assign/crosswalk the land uses into this common classification that resource SMEs can then efficiently use to assign response of resources to land uses/disturbances (in Step 4). It is important that the classification be stratified enough for SMEs to distinguish differences in how resources respond to land uses but not so detailed that it unnecessarily increases the burden on the SMEs to attribute the responses. For example, local governments may have dozens of different named land uses but the vast majority of those will be urban uses that have the same effect on resources. On the other hand, "agriculture" can mean many different types of practices that have very different resource implications. The use of a hierarchical classification can lump uses together to reduce the classification complexity when warranted. A good example is the classification of direct threats and conservation actions adopted by the Conservation Measures Partnership and IUCN found at http://www.iucn.org/about/work/programmes/species/red_list/resources/technical_documents/new_classification_schemes/. IUCN standards have also been adopted by USFWS for use in their IPaC online assessment tool.

Once a common classification is established, you can then incorporate the spatial data. The data base can depict the distribution of regulated resources to assure the analysis can identify impacts to individual regulated resources along with overall conservation objectives and tradeoffs. In particular, these would include species distribution maps for listed species showing areas where listed species are likely to occur, and an updated NWI map for the area.

Finally, you can intersect the REF and the LRTP to support Step 3b.

Step 3b. Identify and show 1) areas and resources potentially impacted by transportation projects and 2) potential opportunities for joint action on conservation or restoration priorities that could count for 404 and Section 7 regulatory requirements.

In this substep, we generate output maps and quantitative reports from the intersection in 3a above to identify which priority areas/resources would be impacted, the amount of area/resource distribution impacted, and the location of impacts. Note that if Step 4 is not yet accomplished, this simple intersection assumes conflict between all development and all resources/priority conservation areas. This is a reasonable assumption at this stage to understand potential conflicts and needs. Step 4 will add information for more precise results suitable for more detailed planning. It is still important at this initial stage, however, to apply a consistent format to these results will facilitate ready comparison between alternative transportation scenarios. Note that to get a truly cumulative effects assessment it is important to combine with the LRTP the existing land uses and other proposed/planned/forecast land use and other infrastructure (as described above).

We use the quantitative results from this substep to evaluate impacts. At this state, the objective is to identify the resources/areas being impacted and the projects/uses causing the impacts. This can lead to identification of opportunities for focused joint action on creation of better alternatives through avoidance or design mitigation and early scoping of compensation opportunities should they be necessary.

Step 3c. Identify the high level conservation goals and priorities, and opportunities for achieving them, relative to the transportation plan and other land uses/plans.

The outputs of 3b allows one to develop the list and map of affected resources and areas that will be the focus of further assessment and mitigation under the analyzed scenarios. From there we can list and map the opportunity areas for mitigation and identify the key players that need to be engaged in the process.

Ecosystem Crediting Aspects: A key consideration for ecosystem credits at this step is the ability for landscape level measures to connect to site level ones. Landscape level conservation or transportation decisions must translate to a project level through metrics that aggregate appropriately to track progress or support monitoring. The success of Steps 6 F and G depend on this connection. Landscape goals can often be too general to provide the basis for site level decisions. Detailed landscape measures help to remove ambiguity once the site level is being considered. For example, a conservation level goal may identify the protection of habitat associated with a particular species life stage, but if this is left in general terms, it is impossible to implement at a site level.

3.2.4 Step 4: Assess Land Use and Transportation Effects

Step 4: Assess Land Use and Transportation Effects on resource conservation objectives identified in the REF

Purpose:

Identify preferred alternatives that meet both transportation and conservation goals by analyzing transportation and/or other land use scenarios in relation to resource conservation objectives and priorities utilizing the REF and models of priority resources.

Outcomes:

- Developing program level cumulative effects scenarios associated with transportation development and other future land uses.
- Identifying preferences regarding avoidance, minimization, potential conservation, and restoration investments to support selection of the best transportation plan alternatives.
- Identifying and quantifying mitigation needs.

Implementation Steps:

4a. Work collaboratively with stakeholders to weight the relative importance of resource types (including consideration of resource retention) where needed to help establish the significance of impacts and importance for mitigating action.

4b. Identify/rate how priority conservation areas and individual resources respond to different land uses and types of transportation improvements.

4c. Develop programmatic cumulative effects assessment scenarios that combine transportation plan scenarios with existing development and disturbances, other impacting features and disturbances, and existing secured conservation areas. Include climate change threats to better understand what resources/areas may no longer be viable or what new resources may become conservation priorities in the planning region during the planning horizon.

4d. Intersect the REF with one or more cumulative effects assessment scenarios to identify which

Step 4: Assess Land Use and Transportation Effects on resource conservation objectives identified in the REF

priority areas and or resources would be affected, to identify the nature of the effect (e.g., negative, neutral, beneficial) **and to quantify the effect** noting the level of precision based on the precision of the map inputs.

4e. Compare plan alternatives, and select the one that optimizes transportation objectives AND minimizes adverse environmental impacts (the least environmentally damaging practicable alternative).

4f. Identify mitigation needs for impacts that are unavoidable and that may require minimization through project design/implementation/maintenance, and that may require offsite mitigation. For impacts that do not appear practicable to mitigate in kind, review with appropriate resource agency partners the desirability of mitigating out of kind (e.g., by helping secure a very high priority conservation area supporting other resource objectives).

4g. Establish the preferred transportation plan, and quantify mitigation needs including the amount and quality of area by resource type for which impacts could not be avoided and require further mitigation attention**.**

Technical Considerations:

- What areas have the highest degree of potential impacts? What impacts should be avoided?
- What areas have opportunities for mitigation, or restoration that best benefit target resources (imperiled species, watershed/aquatic resource needs)?
- In assessing mitigation:
    - Which impacts should be mitigated on-site or off-site? Including consideration of off-site conservation priority areas?
    - What are the specific criteria for determining when off-site conservation actions are appropriate or inappropriate?
    - What unprotected conservation priorities can be protected through project mitigation?
    - What markets for ecosystem services are available in the area that could be used to meet mitigation requirements?
    - Are there opportunities for conservation bank development?
- What rules or methods will be used for weighing resources and transportation objectives when tradeoffs are required?
- In assessing climate change:
    - What are the predicted climate change threats to identified resources?
    - Which of the priority species and habitats in the planning region are most vulnerable to climate change? How do we assess this vulnerability?
    - What resources might not continue to be viable and what resources might become priorities in the planning area?
    - How does climate change influence the selection of mitigation sites?
- For species in the planning area, what are their needs related to movement and habitat connectivity? What obstacles exist to habitat connectivity? How will species movement needs and possible transportation and land use impacts influence scenario evaluations?

What are the opportunities for using performance measures to develop standardized conservation outcomes that can be easily incorporated in §7 or programmatic §7 consultations? For example, for species in the planning area, identify opportunities to conserve or restore their habitats using recovery or habitat conservation plans, and determine if these opportunities can be tied into conservation objectives for other listed species occurring in the area.

3.2.4.1 Technical Implementation of Step 4:

Step 4a. Work collaboratively with stakeholders to weight the relative importance of resource types (including consideration of resource retention) where needed to help establish the significance of impacts and importance for mitigating action.

A first step is to set individual resource/priority area importance weights. Weights in this sense do not replace quantitative goal setting but instead inform a tradeoff process when not all resource retention goals can be addressed in an iteration of the scenario assessment/mitigation process. The partnership should establish how the weighting system will be used and how the weights will be set (e.g., SMEs, committees, stakeholder involvement, etc.). Next, establish the weighting system and criteria (e.g., 1-5 highest to lowest, etc.) and set the weights and document source of information/process.

Step 4b. Establish individual resource conservation requirements such as their response to different land uses and types of transportation improvements (and other stressors), minimum viable occurrence sizes, connectivity requirements, etc.

In this substep, we add information to increase the precision of our cumulative effects assessment. In addition to the quantitative retention goal established earlier, expert knowledge is obtained to specify other recommended and optional parameters and input to the resource database such as:

1. The minimum required area for a patch or occurrence of the area/resource (recommended).
2. Ecological condition thresholds. Ecological condition is a function of the criteria used to assess the quality of the resource compared to viable reference conditions and usually takes into account (besides the minimum required area above) the presence of pollutants, exotic species, age class and vegetation structure, offsite effects, etc (optional).
3. Responses of REF priority areas and individual resources (if used) to the plan components of the transportation plan (and any other plans or disturbances to cumulatively assess). This component recognizes that not all resources respond equally to different land use and infrastructure types. Responses can be put on a numerical or categorical scale such as negative, neutral, or beneficial (recommended). Our CEAA process does not explicitly call for calculating multiplicative effects of disturbances (i.e., that the sum level of disturbance to a resource from multiple resources is greater than the sum of their individual disturbances) as there is little science to support quantitative assessment of this effect and it would likely add considerable complexity. However, if such assessment is desired it could be conducted as part of this step.
4. Landscape ecological parameters or characteristics such as patch interior area, edge-interior ratios, connectivity, etc. Use parameters that are meaningful for the resource and tractable using available data and tools (optional).
5. Viable species population size and characteristics when these can be reasonably established. Assessment of these characteristics can be difficult and expensive and more likely gathered during field assessment but recording them during the expert knowledge gathering phase will be most efficient. Because this information is expensive and difficult to determine, it is most often addressed for legally-protected

species where very high certainty of cumulative effects assessment is required (optional).

This information provides assessment that is much more precise by taking into account some important considerations such as:

1. Not every resource responds negatively to every land use/development activity. Some species will have a neutral response and some will benefit though most intensive development will negatively affect most resources.
2. Size and configuration matter: the area of a habitat patch, its shape, context, and connectivity to other habitats are very important in determining its suitability and viability for many species.
3. Condition of habitats is not only very important to suitability for species but also important from a policy perspective for suitability to receive compensatory mitigation.

Step 4c. Develop programmatic cumulative effects assessment scenarios that combine transportation plan scenarios with existing development and disturbances, other impacting features and disturbances, and existing secured conservation areas. Include climate change threats to better understand what resources/areas may no longer be viable or what new resources may become conservation priorities in the planning region during the planning horizon.

First, the partnership should decide what scenarios will be defined and evaluated. This substep builds on those in Step 3 by conducting a more complete mapping of stressors in the scenarios (existing land use, management, and infrastructure combined with planned future land use and other infrastructure, and climate change effects is possible). Typically, the scenarios to be evaluated include:

1. Current baseline of actual land use and management
2. A "policy" baseline of allowable land use/management not yet realized. This is also often know as a "build out" map for urbanization based on current local government plans and zoning.
3. A trend scenario that predicts likely urbanization for example based on demand, suitability, and market conditions but may also include trends such a climate-change effects.
4. Alternative futures scenarios. There are often several of these which represent alternatives to preferred future scenarios which may be based on models, proposals, civic engagement, etc. Examples might include traditional long range plans assuming automotive travel vs. a transit oriented development scenario.

Once the desired scenarios are described, conduct an inventory of data sources that can represent the scenario content (uses, infrastructure, management practices, disturbances) for evaluation such as:

1. Current scenario:
   a. actual land use mapped with aerial photography and or satellite imagery
   b. actual land use or management records that specify existing or ongoing activities —this is especially useful for land uses and management that are not easily distinguished through remote sensing such as working landscape uses/management

   c. infrastructure
   d. protected conservation areas
   e. known hazard areas that can threaten both development and resources

2. Policy and trend scenario:
   a. land use or management based on existing plans such as zoning or public land management plans. Note that in cases where multiple uses are allowed in an area it may be appropriate to attribute the most intensive allowable use under the precautionary principle.
   b. Urban growth model output for the transportation planning horizon. These are often developed by local and regional governments and other entities. They are not just population projections but often predict types of urban uses for areas expected to be developed. Projections stated as housing unit or human population density can be converted to land use types.
   c. pest and disease spread. For example, pine bark beetle infestation in the Rocky Mountain region poses a significant cumulative threat to ecosystems and individual resources.

3. Alternative future scenario
   a. proposed transportation plans and projects (and their alternatives)
   b. proposed land use and management plans and (and their alternatives)

Resource partners may additionally collaborate on inclusion of predicted climate change threats to better understand what resources may not be viable or what new resources may become conservation priorities in the planning region during the planning horizon. Direct threats modeled from climate change such as sea level rise maps can be incorporated in trend scenarios. In more sophisticated climate change analyses, other indirect resource threats can be modeled such as species range shifts and regional condition impacts on resources such as temperature, soil moisture, etc.

You can then integrate the data into a single map containing the different scenario components. You may encounter instances where one map input trumps others that overlap with it. For example, many counties will zone public lands in case land is swapped that puts that land into private hands (thus it will be appropriately "pre-zoned"). However, what we want to evaluate is the public land management, not the theoretical private land zoned use so we must use rules for combining the data to recognize when multiple uses actually are or can co-occur and when one should trump others.

Step 4d. Intersect the REF with one or more cumulative effects assessment scenarios to identify which priority areas and or resources would be affected, to identify the nature of the effect (e.g., negative, neutral, beneficial) and to quantify the effect noting the level of precision based on the precision of the map inputs

Once the scenarios are constructed in the GIS database per Substep 4c., the spatial analyses can be conducted. The intersection of the REF and scenarios will first determine the location and amount of each area/resource in each land use type in a scenario by intersecting the spatial data.

Next the process will compare the responses of the areas/resources (e.g., negative, neutral, beneficial) to the land use types. Areas/resource distributions with acceptable responses (e.g., neutral or positive) will be compared to other spatial requirements (e.g., minimum viable patch/occurrence size, etc.). Areas meeting response and viability requirements will be considered "retained" under the scenario. Remaining acceptable areas will then be summed and compared to the regional retention goals to determine first if a scenario can meet area/resource retention goals.

For assessing impacts on priority areas from the REF, it is most useful to have quantities of individual resources found within those areas to determine the type and amount of impact though without precise resource location information the results have considerable uncertainty if a portion of the priority area is impacted versus all of it being impacted. When such information is not available, it may be necessary to work with the owner of the plan that area came from to determine the nature of the impacts.

For all areas/resources, a report should be generated that quantifies the current distribution and the expected future distribution to quantify impacts. Maps of locations of expected area/resource loss can identify where impacts would occur and what scenario areas (land use, infrastructure, management, etc.) are responsible for the impacts.

Step 4e. Compare plan alternatives, and select the one that optimizes transportation objectives AND minimizes adverse environmental impacts (the least environmentally damaging practicable alternative assuring regulated resources are sufficiently addressed).

Having generated spatial and quantitative results in Substep 4d, one can readily compare the ecosystem performance of the plan alternatives. Performance is based on meeting area/resource retention goals. The likely rare and easiest case will compare equally acceptable transportation scenarios and readily identify the one with the least impact. In cases that are more common there will be tradeoffs between transportation scenarios and resource impacts. An initial evaluation will likely reveal opportunities to further minimize impacts by creating new transportation plan alternatives e.g., via hybrids of plan alternatives or mitigating conflicts in a preferred plan through avoidance on a site-by-site basis where impacts would occur.

If opportunities for plan improvement are identified, then you can conduct iterations of transportation/land use plan adjustments that lead to identification of a preferred scenario in terms of meeting transportation and land use objectives and least impact on resource goals. The map and quantitative outputs of the assessment will prove highly valuable for guiding these adjustments by identifying locations, resources, and development activities that are in conflict. The database of resource responses to the classification of development activities will also be highly useful for determining compatible uses at priority sites.

Step 4f. Identify mitigation needs for impacts that are unavoidable and that may require minimization through project design/implementation/maintenance, and that may require offsite mitigation. For impacts that do not appear practicable to mitigate in kind, review with appropriate resource agency partners the desirability of mitigating out of kind (e.g., by helping secure a very high priority conservation area supporting other resource objectives).

The outputs from Substep 4d will provide the quantitative information required to understand what resources are impacted and the quantity of the impact (e.g., acres or populations impacted). Combined with policy information (such as mitigation multipliers required) you can then describe the mitigation strategy for each resource that will meet the retention goals. This step does not identify the specifics for implementation but describes if the mitigation will be met through minimization or restoration (e.g., through project design stipulations), or through offsite and / or out-of-kind mitigation where options exist.

For impacts that do not appear practical to mitigate onsite/in-kind or when onsite options are not ecologically viable, review with appropriate resource partners the desirability and permissibility for mitigating offsite/out-of-kind e.g., by helping secure a very high priority conservation area supporting other resource objectives of equal or higher priority. For legally protected resources (wetlands and endangered/threatened species) it may not be permissible to mitigate out-of-kind but for other resources, it should be explored whether mitigation can and should be directed to high priority conservation sites of the REF to support higher conservation values (see Step 6 for more information about value trade-offs). NOTE: This will support implementation of Step 6 and may require partially completing that step in advance.

Ecosystem Crediting Aspects: Step 6 A, E, and F connect to this step. Step A includes a diagnosis of the environmental, regulatory and stakeholder issues. This also includes creating linkages between these various values to assess tradeoffs. This is captured in Step 4 here as well. The market assessment and implementation decision in Step 6 E and F also connect here. These portions of Step 6 define a set of possible options for resolving environmental measurement problems and for finding more effective conservation and mitigation. These two steps connect in Step 4 through the analysis of alternatives and minimization decisions.

3.2.5 **Step 5: Establish and Prioritize Ecological Actions**

Step 5: Establish and Prioritize Ecological Actions

Purpose:

Establish mitigation and conservation priorities and rank action opportunities using assessment results from Steps 3 and 4.

Outcomes:

Developing and agreeing on::

- A regional mitigation (conservation, recovery, restoration) strategy, conservation and restoration priorities with quantitative and qualitative valuation of mitigation sites. The strategy and priorities should be iterative, and it is important for the stakeholders to identify a process that supports updates to be incorporated.
- The preferred conservation/ mitigation actions to achieve the priorities.
- Strategies and actions that consider regulatory requirements and programmatic implementation opportunities, including seeking regulatory buy-in for mitigation solutions and/or establishing a mechanism by which resource agencies can convey their acceptance/approval of investments in vetted conservation or restoration priority areas.
- Crediting opportunities (see Step 6 for details).
- Identify lead agency or agencies for each strategy and method for achieving each strategy.

Implementation Steps:

5a. Identify areas in the REF planning region that can provide the quantities and quality of mitigation needed to address the effects assessment and develop protocols for ranking mitigation opportunities. Ranking should be based on the sites ability to meet mitigation targets, along with: a) anticipated contributions to cumulative effects; b) the presence in priority conservation/ restoration areas of the REF; c) ability to contribute to long term ecological goals;, d) the likelihood of viability in the landscape context; e) cost; and f) other criteria determined by the stakeholders.

5b. Select potential mitigation areas according to the ranking protocols described above.

5c. To increase confidence in the mitigation component of the plan, **field validate the presence and condition of target resources for attention at mitigation sites and reassess the ability of sites to provide necessary mitigation**. Revise the mitigation assessment as needed to **identify a validated set of locations to provide mitigation**. Compare feasibility/cost of conservation and restoration opportunities with ranking score and context of conservation actions of other federal, state, local and NGO programs to determine overall benefit/effectiveness. Predictive species modeling can target field validation process.

Step 5: Establish and Prioritize Ecological Actions
5d. Develop/refine a regional conservation and mitigation strategy to achieve eco-regional conservation/restoration goals and advance infrastructure projects.
5e. Decide on and create a map of areas to conserve, manage, protect, or restore, including documentation of the resources and their quantities to be retained/restored in each area, and the agency and mechanisms for conducting the mitigation.
5f. Obtain agreement on ecological actions from stakeholders.
Technical Considerations:
▪ What areas within REF priority areas meet the mitigation criteria?
▪ If required mitigation cannot be found within an REF priority area, what other mitigation opportunities exist that will further the agreed upon regional restoration plans goals and objectives?
▪ What other conservation actions are occurring in the area?
▪ Who owns or manages the identified priority areas?
▪ What site level measures are needed to verify progress at mitigation sites?
▪ What are the protocols for ranking mitigation opportunities?
▪ What is the most effective way to direct and conduct field validation of identified mitigation areas? How can field data be captured and provided to natural resource data maintainers/providers so that is can be used in future assessments?

3.2.5.1 Technical Implementation of Step 5:

Step 5a. Identify areas in the REF planning region that can provide the quantities and quality of mitigation needed to address the effects assessment and develop protocols for ranking mitigation opportunities. Ranking should be based on the sites ability to meet mitigation targets, along with: a) anticipated contributions to cumulative effects; b) the presence in priority conservation/ restoration areas of the REF; c) ability to contribute to long term ecological goals;, d) the likelihood of viability in the landscape context; e) cost; and f) other criteria determined by the stakeholders.

For mitigation of impacts to individual resources, it will be necessary to have either high confidence distribution maps of the individual resources or attributes of quantities of resources in potential offsite receiving areas. Quantities will need to be verified prior to putting agreements in place but the initial information can be used for planning purposes.

For mitigation of priority areas from the REF, it is most useful to have quantities of individual resources found within those areas to determine mitigation needs. When unavailable, the owner of the source map for the area should be consulted to determine appropriate in-kind or out-of-kind mitigation. Securing approval and funding for such mitigation however may likely require additional investigation and verification of the resources that would be impacted and the value of the proposed mitigation (see Substep 5c below).

For out-of-kind mitigation, Step 6 must be addressed to determine equivalency of values that can be provided by other areas or resources than those directly impacted.

Step 5b. Select potential mitigation areas according to the ranking protocols described above.

When searching for mitigation areas, spatial queries can be conducted against REF attributes to identify those areas meeting mitigation criteria AND occurring in REF priority areas. When required mitigation cannot be found within an REF priority area, then other areas can be identified and investigated. Failure to find any in-kind mitigation opportunities may then trigger discussions for out-of-kind mitigation opportunities.

For wetlands, endangered species, and other regulated resources, identify, adopt or if there is sufficient development likely to occur in the area potentially develop programmatic approaches to mitigation catalogs or portfolios. Developing these is especially useful if mitigation banking occurs in the area, since this can both improve the ease of project implementation and the environmental outcomes for mitigation. Steps for developing a wetlands mitigation catalog are identified below.

Proposed Process for Creating the Priority Wetlands Map

Mapping current and historic wetlands.

A comprehensive digital map of wetlands needs to be available. The goal is to ensure that all wetlands greater than 5 acres in size are represented. If possible, having comprehensive maps of wetland soils and historical wetlands, can greatly improve the quality of the map. The NatureServe national ecological systems map includes the current distribution of wetlands, linked to National Wetlands Inventory, NatureServe, and National Vegetation classifications. Biophysical settings maps from the inter-agency LANDFIRE effort depict historical wetland distributions. Both of these maps are at 30m pixel resolutions (approx. 1:100K scale). These may be compared and combined with NWI, wetland soils maps, terrain models, and/or augmented with additional image interpretation.

There are important benefits to developing wetland maps that are linked to these several standard ecological classification schemes. For example, NatureServe ecological classification units are categorized by conservation status. Using knowledge of relative rarity, trends in extent, and remaining habitat quality, each type is categorized along a scale from “critically imperiled” to “secure.” These conservation status measures feed directly into prioritizing sites for wetland conservation. Additionally, most wetland types in the NatureServe ecological systems classification - typically, 10-20 types per state - have been reviewed and attributed as habitat for at-risk and focal species, so this information becomes accessible to users for project scoring and selection.

In the Willamette Valley, the state Institute for Natural Resources/NHP started with a good wetlands soil and historical wetlands map, and existing NWI data. INR obtained EPA funds to enhance the NWI wetlands cover with data from local wetland inventories, wetlands mapped by the Oregon DOT, and existing wetland restoration sites and mitigation banks. At a minimum, all available wetlands data (national, state, regional, county, and local site information where it is available needs to be integrated. In addition, states must assure that all the digital NWI data for significant wetlands is brought up to date using the most recent imagery and air photography that exists for each state. Virginia incorporated additional spatial data to assure that farmed and partially developed wetlands were included (see Appendix D 8).

Develop a synthesis of spatially explicit representations of conservation and restoration priority sites.

A synthesis would include any conservation opportunity areas developed in the context of state wildlife action plans, conservation portfolio’s created in the context of ecoregional plans, or watershed plans. The Eco-Logical guidance signed by eight federal agencies calls this a Regional Ecosystem Framework (REF). There are a number of methods for developing a regional ecosystem framework or other spatially explicit representation of conservation and restoration priorities for a region. To work in this process, the REF or portfolio needs to: 1) have a set of clearly defined objectives, and 2) be acceptable, adopted, or recognized as the guiding framework or best available data in the region covered. The more comprehensive and detailed the regional ecosystem conservation and restoration framework, and the more widely accepted it is, the more useful it will be. Fortunately, in every state, the SWAP is an adopted and recognized framework that can be used as a starting point. Many already incorporate the ecoregional conservation strategies developed by The Nature Conservancy with the involvement of university staff, other NGOs, and agencies with natural resource scientists

The first step involved in the proposed process is to identify existing watershed and conservation plans for a state, which at minimum will include the above plans. In a few cases, a state may have only one such conservation framework (since The Nature Conservancy has completed conservation strategies for the entire United States), or two (since nearly two thirds have mapped conservation priorities or opportunity areas in their state wildlife action plans, to some degree). Army Corps and EPA staff should become familiar with these and a state project coordinator may want to facilitate and formalize their endorsement and additions to have an approved/adopted working framework that can be improved and modified from there.

If there are conservation or watershed plans and identifications of conservation and restoration priorities, then the process is to integrate these plans, rather than redo them. For a single ecoregion in Oregon, the Willamette Valley, five comprehensive biodiversity or conservation strategies had been developed independently. One was completed by The Nature Conservancy (an ecoregional assessment and resulting portfolio of conservation sites), one by the Oregon Department of Fish and Wildlife (a statewide wildlife conservation plan that identified conservation opportunity areas), one by The Wetlands Conservancy (a statewide cover of important wetlands), one by a consortium of universities with the Environmental Protection Agency (an alternative futures scenarios project), and one by the USFWS identifying recovery areas for a series of listed Threatened and Endangered plants and animals. For this process, The Nature Conservancy synthesized these four strategies to create a combined coverage/map of priority areas. The synthesis was adopted for use by all parties, although this is not a critical step.

In any case, obtaining recognition by the Corps, EPA, the state and other agencies that the final conservation and restoration priority map, the regional ecosystem framework, is the best “currently available” representation of conservation priorities is essential. This synthesis portfolio, REF, or combined conservation and restoration priority map is the input to the next step. If a state or a watershed in a state has developed a watershed approach to define wetland restoration and mitigation priorities, such as the EPA – Army Corps of Engineers approach developed in Maryland, this approach and the catalog developed should be used, and the remaining steps can be skipped.

Extract existing and historic wetlands from the synthesis portfolio.

To do this right, a fairly comprehensive digital map of wetlands needs to be available for the state. Access to a fairly comprehensive map of either wetland soils or historical wetlands (or if possible, both), can greatly improve the quality of the map.

Modify the extracted wetlands coverage into a set of priority wetland polygons.

This is a straightforward GIS exercise in which new, wetland portfolio sites are created. The use of high resolution digital imagery (NAIP) to refine the boundaries is an important step for large or poorly mapped areas. The goal of this is not to develop a conservation plan for a site. It is just refining the boundaries of the areas, so that they make sense to wetland regulators as well as to those working on conservation and watershed restoration.

It is important to make sure that wetland mitigation priority areas make sense. In some of our test areas, we were forced to eliminate portions of some areas because of criteria associated with wetland conservation; e.g., proximity to transportation infrastructure. For instance, an airport was included in the TNC Synthesis portfolio because of the presence of some rare plants on wetland soils. These showed up on our first draft of the priority map, in an area with a number of high priority sites. Wetlands regulators had us remove this area because they did not want to promote wetland mitigation so close to an airport. If it had been a critically important site, or the only priority wetland in the watershed, we might have left it in. This is not very time consuming, but an important task.

An alternative method, especially useful in areas where there are extensive wetlands, would be the approach used in Virginia, in which all wetlands, historic and existing, were analyzed to determine their conservation significance, and ranked accordingly. The highest ranked areas become the wetland priority areas. This is a bit more expensive, but could be useful in areas in which an overall synthesis of conservation priorities cannot be developed.

Assure that at least one to five priority wetland conservation sites exists in every watershed.

Work with regulators to determine that mitigation occur in the same 8 digit HUC (4th field watersheds) could be considered to be in place (assuming the types present are similar enough to be considered in kind). Where desired, a 10 digit HUC (fifth field watershed) can be used, since these are smaller and provide regulators more assurances of mitigation being in kind and in place; but sites need to be identified within each 10 digit watershed across the country. In almost every major basin in the country, one or more watersheds will contain no synthesis, portfolio, catalog, or other priority areas. In these watersheds, catalog sites need to be identified using any of the original assessments that had wetland components or by looking for concentrations of natural wetlands. The team made sure that there was at least one potential site in each of these areas.

Across the nation, conditions will vary considerably across 8 digit HUCs. In those where no potential mitigation sites are already identified, we will use local plans, known locations of at-risk biodiversity, NatureServe conservation status of wetlands (i.e., imperiled-to-secure), and the documented quality and condition of wetlands (using the NatureServe Landscape Condition map and other sources) to identify priority sites for review by local regulators and practitioners.

Create priorities for the wetlands catalog

Developing priorities can make decision making easier for transportation planners, and a simple method is to prioritize or rank the set of priority wetlands within each fourth field watershed. The basic concept is that ANY restoration, mitigation, or conservation within a priority wetland area is good enough, and if being included in a priority area is a criteria for increased wetlands function (as it hopefully will be), there should be no difference in function crediting between any priority wetland, regardless of its rank. It may help DOT to be able to demonstrate that all decisions they made were based on regulators’ or priority criteria, not theirs, which is why ranking the priority wetlands within each watershed can be useful. Specific criteria for ranking the catalog are not recommended here, although clearly the overall significance to conservation in the REF for each site should be considered.

Vet the priority map with regulators and wetland program staff.

The priority map must be vetted with regulators and wetland program staff. A good first step is to vet the priority map with conservation partners, if they are available in the area. Then leads should set up a meeting with regulators, making sure to include the Army Corps of

Engineers, EPA, NRCS, USFWS, any state agencies that regulate wetlands, the state DOT, state fish and wildlife agency, and state DEQ if they are not the primary wetland regulator.

Promote the Wetlands Priority products and facilitate its use by federal, state, and local planners.

Once the wetland priority maps and resources have been developed, it is imperative to identify further steps that are needed nationally and in respective states, Corps Districts, and EPA or USFWS regions and field offices to facilitate its use in decision making for 404 permitting, and as appropriate in ESA §7 consultations and in other regulatory matters. Clearly, the best methods for doing this will be different in each state and jurisdiction.

It is essential that the information be made available to the public as soon as it has been vetted, since otherwise wetland bankers who do not have access to the data will have a persuasive argument for protection of non-priority areas. This should be made available ASAP to local governments and all who develop and/or approve development applications on the local level, as considerable avoidance is anticipated, on a voluntary or pre-regulatory level.

Step 5c. To increase confidence in the mitigation component of the plan, field validate the presence and condition of target resources for attention at mitigation sites and reassess the ability of sites to provide necessary mitigation. Revise the mitigation assessment as needed to identify a validated set of locations to provide mitigation. Compare feasibility/cost of conservation and restoration opportunities with ranking score and context of conservation actions of other federal, state, local and NGO programs to determine overall benefit/effectiveness. Predictive species modeling can target field validation process.

It is critical to integrate any field validation information into the REF. This can include adjustments to resource distributions or priority area configurations and resource (e.g., species) condition/viability information. By instituting an agreed, standardized approach to input any field work done by or on behalf of the REF partners (and others) into the REF database, the database will gradually improve in its precision and utility. The state natural heritage program (see www.natureserve.org) has the job of conducting surveys for rare and imperiled species and communities as well as integrating others' survey work (if it meets heritage standards) and thus can serve as a critical partner for both contributing and maintaining such data. Data security/privacy issues may preclude integrating the most spatially precise data directly into the REF database so data use agreements must be established.

Step 5d. Develop/refine a regional conservation and mitigation strategy to achieve eco-regional conservation/restoration goals and advance infrastructure projects

The outcome of the previous substeps is development of the conservation/mitigation component of the REF that identifies, in a particular analytical cycle, what areas will be conserved and restored to meet partner objectives. This must include documentation of which resources and their quantities are to be retained/restored in each mitigation area, and the implementation agency and mechanism for conducting the mitigation. This could be incorporated in or used to update the REF.

Assure the mitigation catalog and mitigation actions are updated based on restoration activities, lost opportunities and areas conserved.

Ecosystem Crediting Aspects: This step will specify many of the necessary parameters for an ecosystem credit. Step 6b connects to this step to inform decision makers on the various measurement systems available to meet the goals and outcomes of this step. The subsequent step in this process, Step 6 will provide the tools for implementing these priorities. Similar to earlier goal setting concerns in Step 3, the definition of resources and priorities must provide a level of detail to be used at the implementation steps. Priorities must consider the spatial, functional, habitat and population issues defined in Step 6b.

Step 6: Develop Crediting Strategy

Step 6: Develop Crediting Strategy

Purpose:

Develop a consistent strategy and metrics to measure ecological impacts, restoration benefits, and long term performance – with the goal of having the analyses throughout the life of the project be in the same language.

Outcomes:

- Improving and integrating the mitigation sequence at a site level through: Avoidance – using a metric that provides a systematized and structured scenario analysis that leads into, Minimization – which is aided by the same metric providing the basis for outcome based performance standards, which sets the stage for Compensation – which is defined by the same metric calculating the debit/credit totals associated with the project impacts and mitigation outcomes, respectively.
- Accelerating implementation and improving mitigation results.
- Supporting implementation tools such as advance mitigation, banks, programmatic permitting, and ESA Section 7 consultation.
- Supporting use of offsite mitigation and out-of-kind mitigation where appropriate, since equivalency of value can be determined across locations and resources.
- Informing adaptive management and updates of the cumulative effects analyses.
- Balancing gains and losses of ecological functions, benefits and values associated with categories of transportation improvements or specific project related impacts
- Providing the means of tracking progress towards regional ecosystem goals and objectives (assumes site level ecological metrics are correlated to the landscape level tools used to define the REF).

Implementation Steps:

6a. Diagnose the measurement need. Examine the ecological setting (including regulated resources and frameworks, non-regulated resources, and ecosystem services); examine the regulatory and social setting, and identify additional opportunities.

6b. Evaluate ecosystem and landscape needs and context to identify measurement options.

6c. Select or develop units and rules for crediting (e.g., rules for field measurement of ecological functions, approved mitigation/conservation banking, outcome-based performance standards using credit system)**.**

6d. Test applicability of units and rules in local conditions.

6e. Evaluate local market opportunities for ecosystem services.

6f. Negotiate regulatory assurance for credit.

6g. Program implementation.

Technical Considerations:

- How will debits/credits be calculated? Is credit stacking allowed?
- What is the permissible service area for a bank, off-site mitigation?
- Who may participate in the crediting system?
- How will credits be registered and tracked?
- How long will regulatory decisions on a given project be binding?
- How will values be calculated across locations and resources?
- What long-term monitoring is needed?

The ecosystem service accounting methodology follows a seven step process for a Department of Transportation to self-diagnose the need for a system, identify existing crediting options, and if needed select a method for developing a custom crediting system. These measurements may be used to provide the basis for credits or debits in a compensatory mitigation context, or to evaluate design alternatives that best avoid or minimize impacts.

Step 6a: Diagnosis of the Measurement Need

Diagnosing the resource measurement needs with a DOT requires examining the resources, constraints, and opportunities that affect the choice of a methodology. The first components are the natural environment and resources in the area, either in the entire jurisdiction, or within the areas of anticipated highway improvements. The second component is the evaluation of regulatory requirements and non-regulatory expectations for the agency in managing the environment. The final component is to examine the opportunities for meeting the environmental management needs through existing markets, conservation initiatives or other innovative solutions. Through this diagnosis, an agency can assess the ecological, social, and economic needs for tracking their environmental impacts in both the regulated and non-regulated arenas.

Examining the Ecological Setting

A key challenge in any environmental planning effort is to understand the scope of what may be impacted. Impacts range across types, scales and time based on a variety of factors, and they occur in a context of other impacts from existing and new actions, as well as other recovery or conservation actions and priorities in a region. Understanding this ecological setting is key to identifying the correct strategy for measuring the environment. Traditionally, the need to make measurements on transportation projects has been based on a regulatory framework that relies on consultation with appropriate natural resource agencies. This consultation typically occurs late in planning stages and often only at the project level as specific details are developed. As the *Eco-Logical* approach has advocated, earlier and more comprehensive coordination is needed for successful environmental planning.

This step overlaps with the process for developing a regional ecosystem framework (REF) as described in *Eco-Logical*. An REF is simply a planning-level document and set of data that allow for early transportation decision-making to have a reference in conservation and recovery planning (Brown, 2006). The REF, and the resources it is based on, ultimately become the basis for setting regional ecological goals. Accordingly, to be able to track how projects affect progress towards those goals, the same scan for resources and identification of data needs for the REF will also inform the decision on the type of credit or debit tool used.

Different resource types and habitats each lend themselves to different measurement needs. Highly diverse ecosystems with complex biophysical processes require more detailed measurement systems. Simpler or more homogenous ecosystems can allow for more basic measurement systems. The interaction of ecosystem functions also informs the measurement system selection. In ecosystems with competing processes, the analysis is complicated with a need to either mimic the tension in the natural system or develop a series of tools to weigh tradeoffs in implementation that may favor one resource. An example of this can be found when habitat enhancements for an anadromous species may occur at the expense of a native warm water fish species. In this case, a policy decision is made to favor one over the other in a system that may have increasing pressures for both.

Resources to examine can be roughly categorized into three categories based on the resource connection to the DOT business model. Recognizing that not all DOTs have the same levels of authority or support for addressing some resources, these categories can be different from state to state. However, they are based primarily on the existence of drivers to force an issue into consideration in the planning process (Manderet al., 2005).

Regulated Resources and Frameworks: Working through resource agencies, identify species and habitats covered by the ESA or state or local protections. Data may include species distribution data such as probabilistic data or recorded occurrence data. Water quality regulations will identify aquatic resources to consider in measurement, along with other datasets such as local or national wetland inventories.

Non-regulated Resources: In addition to species or resources with specific protections, resources or habitats may exist that require consideration for community or regional interests. These resources may include species of local or state concern that are not afforded protections, but which are recognized by the public or NGOs as important. Examples are recreational, fishing and hunting, or subsistence resources. Native foods or resources may also need to be included.

Ecosystem Services: Ecosystem services must be selected for inclusion in analysis or in a measurement system. Depending on the classification system used, ecosystem services can be divided into many categories, often too numerous for implementation in a transportation context. The Millennium Ecosystem Assessment provides a broad set of definitions for ecosystem services that can help identify ecosystem services to include in analysis (Millennium Ecosystem Assessment, 2003). The MEA system divides services into four categories:

- Provisioning Services: These services and goods are most directly consumed by society. They include the production of fuels, foods, fiber, and other tangible goods that may already have an established market or economic definition.
- Regulating includes the natural systems that moderate floods, maintain healthy fire, disease, or pest regimes, or provide protection for catastrophic events naturally.
- Cultural services are the social, spiritual, and recreational services from the landscape.
- Supporting services, which provide the underpinning for all other services. These include biodiversity, nutrient cycling, and other key ecological processes.

Examining the Regulatory and Social Setting

The regulatory and social conditions can be evaluated through both a historical review of DOT experiences and a forward looking one that evaluates new potential regulations or social expectations from projects. A review of the historical experiences should include compiling permitting documents from previous projects over the past five years. This creates a baseline level of impacts that provide important planning information. First, this baseline helps understand the trends in resource impacts. Ideally, it includes cost assessments for compliance to understand the organizational costs. This baseline must be understood in the context of the statewide transportation improvement program (STIP) priorities over the past planning period and compared to current priorities. Statewide planning and project delivery often come in cycles of periods of greater and lesser construction intensity. Looking at the decisions made by policy makers about what is included on the Long Range Transportation Plan or the STIP can forecast the regulatory needs for existing regulations. Additional forecasting is needed to assess future new potential regulation. In interviews with transportation planners, our team uncovered a concern about the expansion of listings under the ESA, the growing applicability of the Safe Drinking Water Act, and the role of climate change regulation in transportation planning. These are examples of a need to analyze the potential challenges for transportation permitting and delivery assumptions in the early stages of planning.

The social setting captures the concerns, usually outside the formal regulatory system, that the public expects the DOT to address. These concerns are often identified via scoping or the development of environmental documents. These concerns can also be captured in a review of ongoing press and stakeholder communications, in a more passive approach to assessing public concern (Costanza and Folke, 1997). Often the public has not had the opportunity to fully study environmental issues, so clear and consistent preferences are not established. We experience these first hand in environmental processes where stakeholder positions shift greatly over the life of a project as they learn more about the issues. This has called for a more active approach to developing public input where the public becomes not just an input in the process, but is allowed to develop public judgment (Yankelovich, 1991).

In this process, stakeholders are engaged to become experts of their own in the issues. Integration of transportation planning with conservation planning furthers this effort as conservation, transportation and other stakeholders can build better understanding of issues through the crafting of the REF. This process is critical as preferences and values for natural resources are often difficult to capture at a personal or site level. To assure fairness and equity in environmental planning, transportation and conservation planning need to share information with the public about the functions and role of natural systems and allow preferences to be expressed or formed (Costanza and Folke, 1997).

Identifying Additional Opportunities

An additional component to assess are ongoing compliance efforts or conservation programs that can be opportunities for off-site mitigation actions that may provide improved environmental performance (Bean et al., 2008). These same programs have provided better transportation cost efficiencies as well as costs are controlled and specific in project delivery (Oregon Department of Transportation, 2008).

Traditionally, these opportunities focus on examining existing banking or mitigation programs the DOT can take part in (Environmental Law Institute, 2007). As mitigation banking has evolved more innovative solutions are also emerging from other biodiversity based drivers based on state or local laws (Carroll et al., 2008). However, new policy research has called for opening up innovative DOT sponsored environmental mitigation and conservation programs to private entities to increase private environmental compliance and to support DOT environmental programs (BenDor and Doyle, 2010). BenDor and Doyle examined the North Carolina Ecosystem Enhancement Program (NCEEP) and identified the difference in compliance efforts by public versus private permittees. They suggest that the public based system can be a smart extension to support local land use compliance requirements in private developments.

Non-mitigation based opportunities can include examining the greenspace, open space or other public lands needs of neighboring jurisdictions including state or county parks, or local parks districts. These approaches can align with regional open space or green infrastructure programs including “Greenprint” or green infrastructure programs (Benedict and McMahon, 2006). While these programs may not legally be available for compensatory mitigation under federal law, they may provide an opportunity to comply with state, local, or non-regulatory expectations for projects, especially urban capacity projects.

Step 6b: Evaluate ecosystem and landscape needs and context to identify measurement options

The initial step of diagnosing the needs for a measurement system identified the important boundaries for managing the resources. The subsequent step is to evaluate the necessary scale and units for management and to identify linkages to landscape tools such as the REF or other selected tools.

The starting point for evaluating the need for an environmental measure is to define the service area boundary that the measure will be used within and the relevant resources and actors present. A service area is defined by the spatial limits that include resources with ecological connections and also provide a definition for where off-site actions might be undertaken. For aquatic resources, service areas are often hydrologic. For faunal species, the service area may be a particular range or habitat. Air resources, especially carbon, can have large service areas. If an REF is being developed for the area this is the proper starting point to identifying the appropriate boundary. However, additional refinement may be needed to assess the measurement options available if multiple resources are being combined. In addition to the ecological boundaries, it is important to be aware of traditional regulatory or political boundaries such as ones created by federal or state law and local conservation regulations or land use requirements. It may be necessary to identify multiple boundaries initially, and once crediting is decided upon, the boundaries can be reevaluated for integrity.

Crediting Definitions and Considerations

Environmental measures can be divided into three classes of systems. First are condition based measurements. Measurements in this category focus on quantifying changes in the status of the regulated resource. For instance, species of concern would be measured through population surveys. These systems also include pollutant load measurements, which are normally defined by quantifying specific amounts of criteria pollutants added or removed from the system – e.g., pounds of nitrogen or percent increase in turbidity. Condition based examples include fish return counts, water quality measurements, and indices of biological integrity.

The second form are model-based measures rely on data to estimate species or ecosystem response. Often these measures rely on similar concepts to condition-based ones, or try to replicate a condition-based measure with models.

The third form of environmental measures is function-based. These measures focus on habitats, structures and processes as the basis for measuring the environment. Function based systems are not species specific, and are used when rare or unique resources need measures, but that are not easily measured with one species. Model based measurements can start to combine elements of a function based measure and a conditions-based systems where the model relies on habitat or field data to estimate habitat use and densities.

To truly get at a measurement for use in transportation projects the results need to tie the natural impacts back to specific actions at a site. This is needed for the full suite of mitigation decisions: avoidance, minimization, and compensation. These concerns need to guide the selection or development of a measure. In the following sections, the various existing measures used in environmental management settings are presented. This is followed by a guide for the development of custom measurements.

Condition-Based

Condition-based measures are structured to collect data on the physical, chemical, and biological attributes of a system. These measures can be as simple as a plant and animal survey to measure occurrence of set of species. More complex measures provide the basis for long term monitoring and management of a region.

Condition-based measures can be applicable in certain cases for transportation projects, though they present important challenges that must be considered before agreeing to use in permitting or in restoration. For transportation projects in remote and undeveloped areas with no other anthropocentric inputs to affect environmental quality, condition measures may be able to evaluate an action's level of impact. They may also be important in regulatory settings where they are a common tool for management such as under the Clean Water Act or Safe Drinking Water Act. An example of such a use is a river crossing with potential impact on surface drinking water sources. Disturbances to surrounding upland areas may potentially create erosion and sediment inputs that place the waterbody over limits for turbidity in a municipal water system.

Two primary forms of condition based measures are indices of environmental quality or integrity and observation-based systems:

Indices-Based

Indices for environmental measures are based on identifying a set of field-based measures that can provide a comprehensive index for health. The use of indices expanded with the passage of the Clean Water Act which requires a comprehensive measure for a water body's health. Early implementation of the Act was supported with the development of indices of biotic integrity (Karr, 1981). These methods reflect an understanding that biological organisms better capture the health of a system compared to strictly chemical and physical measures. This places a focus on a selection of species that are understood to represent the health of a system, such as macroinvertebrates or fish species. These measures provide a relative measure of health based on the comparison of reference sites and other randomly selected sites that are considered comparable for analysis. This process develops measures of deviation and allows for long term monitoring. Data collected in this process are based on sampling surveys. Data can include species abundance, diversity, size classes, species composition, observations of health, and other biological measures. Data can be in absolute terms such as abundance or in qualitative terms such as health (Hughes et al., 1982).

Observation-Based

Observation-based measures are rarely used in accounting applications because of challenges in attributing causation to the observed data. A reasonable use is for relatively closed systems where the DOT actions are clearly the only source of undesired impacts. Observation-based systems also apply in situations with species or resources that are relatively static, such as with floristic species. Observed measures may also be a component of monitoring sites after restoration or disturbance. Permit conditions can also be based on observed data. Examples of this include water quality monitoring in systems where the contributors to turbidity are easily understood and any observed increase of the expected levels can be assigned to the construction activities in the watershed. This method has been used in limited cases, and depends heavily on well understood watershed processes that the permittee and regulator both agree on and trust.

Probability-based distribution mapping tools are introduced as a part of the SHRP2 program as a replacement for traditional inventories of observed points as described in Chapter 2. These probability-based tools are best suited for project planning to incorporate in avoidance and minimization measures, and to support the identification of sites for compensation. In general, observed data is not recommended for use unless a trusted and continuous base of data is available to provide reference conditions to compare against.

Model-Based

Model-based systems rely on an agreed upon set of rules and conditions that are expected to result in an environmental outcome. Model-based systems are similar to condition-based measurements systems, but are usually employed for planning purposes. Unlike condition-based systems that focus on sample-based data, models focus on the elements of the ecosystem that can be affected by human action.

Examples of this are found in biological and chemical applications. Salmonid modeling, such as with the Ecosystem Diagnosis Tool, identify the restoration actions or ecosystem components that contribute to species health (Mobrand et al., 1995; Lestelle et al., 1996). Similarly the emerging carbon protocols for climate change accounting are agreed upon models that represent the carbon benefits or detriments of specific actions (Voluntary Carbon Standard, 2007). Models are best applied in complex environments where complete baseline data is not easily available and where individual actions or impacts need to be understood in a context of many human actions that are difficult to attribute.

Function-Based

Function-based systems combine elements of condition-based systems and model-based systems. A function-based measurement identifies attributes that capture the habitat structures, elements, and other biophysical features. A function can be both abiotic and biotic. Abiotic measures tend to be more common as they are relatively static and easily observed. Biotic measures are also used but are more complex, relying often on multiple sub-functions to assemble to a properly functioning measure.

Functional measures are often performed with field-based observation and investigation. Attributes are empirical, observed data that include such measures as percent cover of vegetation, substrate types, slopes, species mixes, and so on. The attributes are then evaluated based on scoring protocols built on existing literature, models, or peer review processes. These attributes then combine to provide a measure of performance for that function. The final unit of measure is then a combined multi-function level of performance by area. This provides a functional areal measure that can be compared to other sites. While reference sites are not necessary for functional measures, they can be used to test outcomes and calibrate scoring of credits. In this manner, they are based on site level evaluations with values based on best available science.

This approach provides a common unit of measurement for biological, chemical and physical processes that can readily be linked to economic decision making (Groot, 1987). Functions also provide a robust common unit for analyzing multiple resources or ecosystem services because functions provide a bridge between the biophysical and the final outcomes that we manage resources for (Boyd and Banzhaf, 2007; Brown et al., 2007). Environmental economists have recommended making a shift towards function-based measures as they also allow for analysis of the services before clear pricing or valuation is developed. The structures and functions of a natural system must be understood before any value system can be placed on top of it (Limburg et al., 2002).

Several implementation benefits are available with the use of function-based systems. First, because the natural environment and ecosystem services are measured through constituent functions, multiple resources can be captured in a single measure. Second, the empirical basis of observed attributes of functions allows for easier inclusion of functional measures in contracts or permit terms and conditions. They are objective and enforceable elements that can be requested of an agency or contractor. Alternatives analysis and scenario based planning can also be implemented with function-based measures. The future scenarios specify the assumed attributes to be found on a site and can then be scored and credits or debits estimated. Scenarios in this context can include alternative vegetation management programs, stream restoration, forest management, as well as impact scenarios based on highway development. The alternatives can then each be evaluated based on the number and type of credits generated or diminished by the proposed actions.

Another benefit for functional measurement systems is that they provide a basis for ecosystem service measurements (Farber et al., 2002; Limburg et al., 2002). Adding the opportunity to also provide a field based measurement provides the best approach to an empirical measurement for ecosystem services. Currently, functionally based approaches are developed regionally, with different but similar methods used based on the local scientists. Developing standards may be difficult, but could improve the adoption of these methods.

Summary of Challenges

These three forms of measure can be understood based on the type and nature of data required and the temporal frame these measures work within. Data included in these systems can be primary or secondary. In general, condition- and function-based systems focus on primary data collected specifically for the measure, though secondary data can be used. Modeled data processes existing data and does not rely on field-based datasets necessarily. The temporal frame is the usability of the measurement system to *track* changes versus the ability to *forecast* change. Functional and model systems are able to forecast change based on proposed actions or change in the environment. Condition-based systems rely on historic data and are challenged when they attempt to forecast future changes in condition. This temporal frame is critical in a regulatory or crediting scenario as proposed impacts and proposed restoration actions need some certainty in measurement before they are implemented. A common application of credits are in the terms and conditions of permits, these credits must be easily defined based on proposed restoration actions that may be written into a construction contract or similar agreement.

Condition- and model-based systems center on species and their responses to impacts on the environment. These measurements are most commonly used in monitoring species health and for responding to impaired landscapes such as in restoring water quality. These measurement systems are suited for comprehensive management for a given resource. The challenge they present for impact and conservation actions is they do not provide a methodology to attribute the benefits or impacts of a given action. For example, a protocol for condition-based measure may include random sampling for macroinvertebrates. Ideally longitudinal data collection has occurred to provide the baseline and level of variation. Following construction of a project, the monitoring can continue and document a change. In practice, this is problematic. The baseline and variation analysis present the main barriers to implementation, which does not rule out the use of condition-based systems: they can provide information in design about resources that are considered vulnerable and therefore required to avoid. However, the need to compare actual impacted conditions to a reference site makes these measures best applied after construction of a project. This makes estimating credits in the planning stages challenging. The measures do not lend themselves to reliable forecasting of change because of the level of assumptions required. Condition-based systems can also provide a support for long-term monitoring after construction of a highway project or a restoration project.

Recognizing that each region, agency, and regulatory setting requires a unique response, these general classes of measurement are presented to help decide on the best system to use. In areas with lower levels of biodiversity, or with only one or two resources of concern, condition-based measures can assist transportation project delivery. In this context, the condition measure is tiered off of the REF, conservation plan, or recovery documents to provide priorities. For more complex environmental settings or where forecasting impacts are more critical due to the sensitivity of resources, models and functional measures excel. Finally, if multiple resources need to be tracked, forecasted, and credited then functional measures excel. Appendix A lists a comprehensive and representative set of measures available for use in transportation projects.

Selecting the Right Measure

The SHRP2 C06(B) project has identified a number of tools at the landscape and planning level that address the need for integrated resource management with transportation development. These integrated programs provide guidance in planning to the project level. The crediting system documented here addresses the connection needed between planning level analysis and site level analysis. To fully implement the planning tools developed in C06, a functional measurement system is necessary to reconcile multiple resources at a site level.

One of the key challenges in site measures for multiple resources is *stacking* of various credit types. Because many of the crediting programs will need to connect back to both regulatory and non-regulatory processes it is necessary to document that no single credit is satisfying multiple regulations. In other words, credits must be shown not to “double dip” or count twice for a liability. One strength of functional measures is that credits are created with constituent functions that can be assigned to specific regulations or goals and mathematically isolated to prevent double dipping. It is important to note that this challenge is not an environmental one. Stacking in the environment is common as multiple resources can benefit from a single feature. For example, a riparian forest provides shading to cool adjacent waters, carbon sequestration through growth, and song bird habitat. These resources evolved to maximize the use of these benefits. However, our regulatory system requires that mitigation benefits only be counted for the debit they are assigned to. This is technically accomplished with functions – but we note this distinction to remember that while the environmental benefits of stacking are clearly beneficial, they are seen as undesirable in the regulatory system. The technical details of stacking are discussed in the next step.

The following step introduces the method for adopting or developing a functional measure to integrate into the Eco-Logical approach and the larger planning tools included in C06(B). The step provides a process for a DOT to develop, negotiate, and adopt a crediting system that can include ecosystem services and regulated resources while at the same time managing multiple stacked credit types.

Step 6c: Select or develop units and rules for crediting

This step provides the basis for developing a custom measurement system based on functions for multi-resource crediting. If an appropriate existing measurement system was identified in the previous step then this step may not be necessary. The following sections detail the considerations and issues that must be addressed for a robust measurement that is also balanced with the level of effort needed to implement it. An excellent introduction into regional scale measurement requirements for ecosystem services can be found in Ruhl, Kraft and Lant’s 2007 text *The Law of Ecosystem Services.*

Development of a measurement system must first consider the resources of concern and the size of the areas to be included. Much of this will have been identified in Step A, with the assessment of the various ecological, regulatory and social contexts. However, in this step the details of the resources are further developed.

Identify Resource and Ecosystem Services

The first question to ask is what services or resources are of concern. An important starting point is to review the highway or agency specific concerns and then identify services from there. For example, stormwater treatment may be identified as a concern. From an ecosystem services perspective then the site level need is for more naturally occurring water quality regulation. Water quality regulation as a service is provided by functions performed based on the existing vegetation, soil types, site topography etc.

Similarly, a regulatory agency or other stakeholder may identify a resource concern such as listed species or species of concern. These are biodiversity services. Functions are then identified that support these specific biotic concerns. For example, concern over aquatic species will then require functions that support various life stages of the species such as foraging and rearing, spawning and connectivity for migration. These functions can then be defined through specific attributes such as pool or riffle types, substrate, and adjacent bank characteristics.

As the services or resources are compiled and the necessary functions are identified to support them, overlap of functions will occur. Using the example of the water quality and aquatic species above, both will rely on functions performed by stream side vegetation that shade waterbodies or reduce sediment and pollutant transport into waterbodies. This overlap is a critical feature of the multi-resource functional measurement system. It allows for the multiple resources to have a relationship that can inform site and design choices.

Develop Functions and Attributes to Measure Services

The basic spatial unit of a functional system is the map unit, a relatively homogenous and contiguous land cover type. Within these map units, attributes are collected that indicate the level of functional performance. Functions must be developed understanding this structure. Functions can be divided into the abiotic and biotic ones – or functions that address biophysical processes versus species-specific processes. The measurements are based on attributes that can be easily collected by a field crew without extensive field instrumentation or long-term monitoring.

An overall functional performance score for the map unit is derived equally from the contributions of the abiotic and biotic functions. The respective biotic and abiotic functional performance scores are combined to provide a total biotic and a total abiotic functional performance score for the map unit. The abiotic functional performance score and the biotic functional performance score are then combined and multiplied by area and habitat type to obtain the overall measure of functional performance for the particular map unit. These scores are summed to provide the functional performance score for the entire site.

To develop a biotic or abiotic function, a conceptual diagram is the first step. This aids in all aspects of the development of the function, but most importantly in terms of the application of the measurement system. The conceptual diagram considers pre-existing conditions or current conditions to describe what the function requires at a site level. In general terms, this creates the logic of how and when to score a map unit for a particular function. The system itself turns functions on and off within the equations based on the triggering conditions identified in the conceptual diagram.

With the functional diagram completed, the attributes and scoring must be generated. Through a survey of literature, available science, outreach to experts and other tools, the list of field-based data needed is developed for the function. In addition to identifying these attributes, their role in contributing to the performance of the function is evaluated. For all functions, there is a 100% level where the natural system is performing the function at its highest possible level. It is helpful to consider this in evaluating the type and amount of attributes needed. Similarly, at 0% function, it is useful to think of what attributes that, if missing, would limit the function fully. It is important to remember that at this level, other functions may be affected. For example, a function that is highly dependent on canopy cover will not co-exist with a function that is dependent on exposed ground or grasslands.

As attributes are identified, their relative contribution to the function will start to emerge, but the next step is to score all attributes for the function. For example, in a function that is evaluating a map unit's ability to infiltrate stormwater the amount of pervious surface needs to be scored. In this case, it may be a logarithmic curve that indicates slight loss of functional performance as the initial increments of impervious surface are added to the map unit. However, each additional increment of change to impervious surface will have an increasing rapid impact to the functional score. The scoring curves are drawn for all attributes that contribute to the functional performance.

As the functions are developed, the attributes must be checked across all the functions to assure that the data collection protocols remain constant. This is frequently a challenge where different measurement standards are combined across disciplines. The compilation of the attributes will provide the basis for the creation of a functional measurement datasheet that combines all the data requirements for the system into a single instrument for field use. Another benefit of this functional approach is that as new functions are identified, they can be built from existing attributes, or with just a few additional attributes needing to be programmed into the system.

The final consideration for functional measure development is temporal factors. In order to ease implementation, the goal should be for measures to work at any point in time. Water cycles, seasonal fluctuations and other natural system dynamics can complicate this. For example, substrate observations for stream systems may be influenced by turbidity that limits visual assessment. These considerations need to be addressed as attribute data collection is defined in the field protocols. Other measurement methods may need to be developed or other assumptions may need to be in place to address the limitations.

As functions are developed, they are combined based on agreed-upon rules. Depending on the selection of functions to combine, there are often policy considerations that inform the relative importance of functions. For example, stormwater management functions may be prioritized over other functions in a transportation context. In these situations, formal weighting factors must be applied to capture these priorities. While other services may still be important, they must be combined at a lower level with the higher priority stormwater management functions.

Step 6d: Test applicability of units and rules in local conditions

The application of a functional measure is recommended as a three-step process. Initially the current pre-implementation (baseline) condition of the site is determined using data collected on-site. The system generates a baseline functional performance score for the site. The second step of the process is to generate one or more design alternative scenarios. For each of these design alternatives, a set of map units and data for each is generated based on the information in the design plan. This should reflect conditions on the site at some pre-determined future date. In general, a 20-year post implementation time period is used. Using this set of map units and data, a future conditions functional performance score is generated for each alternative considered. To determine the uplift or impact of a given design, the baseline conditions site score is subtracted from the future conditions site score. If the resultant number is negative, a debit has been generated; if positive, the project results in uplift. The degree of impact or uplift is the number generated.

Step 6e: Evaluate local market opportunities for ecosystem services

Market opportunities can include existing wetland or conservation banking systems or more advanced payment for ecosystem service (PES) systems. PES programs are negotiated contracts with landowners to maintain a certain level of environmental performance to maintain or enhance ecosystem services (Forest Trends and Ecosystem Marketplace, 2008). Criticisms of these systems come from a concern that there is no clear way to track the performance. However, this is a technical measurement problem and does not undermine the potential power of PES systems (Redford and Adams, 2009).

Developing ecosystem metrics and tracking project impacts using those measures can make it easier to access any operating regional ecosystem markets. Step A includes consideration of the existence of ecosystem markets as part of the regulatory compliance considerations associated with selecting or developing an ecosystem metric. If these criteria have been properly considered, then the DOTs ecosystem measurement system should be well-suited to ecosystem market use.

There are number of reasons why ecosystem markets provide a better solution for DOTs, including the following:

- **Certainty.** Purchasing credits from a mitigation bank removes the schedule risk and uncertainty associated with getting approval of mitigation siting and design. Further, there is greater budget certainty since the cost per credit is generally a known quantity, whereas mitigation design and construction is not (particularly for sites that have difficulty with plant establishment). Further, the costs of mitigation and the liability associated with those costs can extend out five to ten years or more.
- **Transfer of Liability.** Many ecosystem markets include a transfer of liability for mitigation success. Wetland mitigation banks pursuant to §404 of the Clean Water Act, and conservation banks pursuant to the Endangered Species Act place the liability for restoration/conservation success on the banker. Note that this is not universally the case. Liability under the Clean Water Act's NPDES program remains with the permittee, even when the permittee is meeting permit conditions through a market transaction.
- **Better Alignment of Missions.** Although many DOTs employ highly qualified and experienced biologists and ecologists, the mission of the DOT is focused on providing and maintaining transportation systems. This means the DOT project delivery focus is on the road, bridge or other aspect of transportation infrastructure - not the wetland or native habitat being restored as part of the project's impact compensation. In this circumstance, it is not uncommon to have the mitigation lumped into the same contract as the road or bridge construction. This can lead to situations where the grading and earth work for the mitigation site is done by contractors with experience and expertise in road construction. Restoring a wetland and building a road require different skill sets. It is best when restoration professionals build mitigation sites and road construction contractors build our highway infrastructure.
- **Improved Ecosystem Outcomes.** Ecosystem markets provide the opportunity to focus larger more meaningful restoration projects towards addressing regional ecosystem priorities. In making this shift, the "postage stamp" mitigation that is the frequent outcome of DOT projects is eliminated. These small mitigation sites are inefficient, and too often not ecologically viable or useful.

Mitigation bankers on the other hand, have an incentive to focus on ecologically desirable outcomes (since regulators are less likely to approve use of the bank if it is not providing good ecological benefits). Further, they have an incentive to focus on the site and make it successful, since in most banking contexts, credit release is incumbent upon reaching pre-established success criteria. This means that not only is society more likely to realize the ecological benefits, those benefits are in place before the impact occurs. In traditional mitigation, the restoration activities at best are concurrent to the impact activities, but there is inevitably some temporal lag before the mitigation starts to provide ecological benefits.

To add to all these benefits, mitigation banks provide in perpetuity protection for the site. Often this means turning the site over to a third party (e.g., land trust or conservation organization) with an endowment to pay for long-term site management. In contrast, a typical mitigation site receives five to ten years of monitoring and then the site is on its own.

Step 6f: Negotiate regulatory assurance for credits

Stacking Credits and Double Dipping

Ecosystem functions and services have interconnected relationships that can be complementary, conflicting, or magnified based on their interactions. The ability to measure multiple resources and services at once is a critical feature in functional measures, particularly when used to generate credits that will be bought or sold in a mitigation or ecosystem marketplace context. By working at the most basic level of environmental measurements, functional measures provide a system that can “stack” or combine multiple credit types or resources and, at the same time, assures that credits are used only as approved and allowed. This stacking function allows for the interactions of the natural elements to be more fully measured.

Incentives for investing in conservation and restoration actions that generate a wide variety of ecosystem benefits are currently missing in regulation-driven, acreage-based credit systems. Generally, once a site meets the minimum regulatory requirements for mitigation of a given resource, all potential additional benefits provided by the site are ignored or forgotten. But with a “stacking” credit system, the proper incentives for conservation can be introduced, as the benefits of an action to all resources become clear. Similarly, in an impact context, stacking allows the effects on resources to be better understood.

Stacking requires strict accounting to prevent the use of credits to offset impacts of multiple projects. In a regulatory context, this is critically important. Through the function-based nature of credits, individual functions are assigned to the credit type that must be audited. This ties the constituent components of the credit together, ensuring that credits are not used repeatedly in different transactions (double-dipping). The diagram at right shows several overlapping circles, each of which represents an amount of restoration benefit (uplift) expected to result from restoration actions on a hypothetical mitigation site.

Step 6g: Program implementation

There are a number of ways in which good metrics can inform transportation planning processes and be incorporated into project compliance documentation and regulatory processes. For instance, good metrics can provide a much better means of conducting NEPA alternative analysis. A good metric can also provide the basis for terms and conditions, conservation measures and performance standards. In addition, when combined with an appropriate landscape measurement system, it can be the basis for justifying off-site and/or out-of-kind mitigation. It is important that project delivery staff be aware of these opportunities.

There are a few basic thing DOTs can do to encourage these improvements. For instance, it is important to provide on-going training and support for staff to help them understand the potential opportunities for process improvements. An easy way to affect this type of support is to use a community of practice approach, so that relevant staff have a mechanism to share concepts and ideas and impart lessons learned about what worked and what did not work. Another useful step for program implementation is to develop a data sheet that standardizes the metric application. Ideally, the data sheet can become an integrated part of project data collection and can be used to make that process more efficient and effective. See Appendix E for an example of Natural Flow Regulation.

3.2.6 Step 7: Develop Programmatic Consultation, Biological Opinion or Permit

Step 7: Develop Programmatic Consultation, Biological Opinion or Permit

Purpose:

Develop MOUs, agreements, programmatic 404 permits or ESA Section 7 consultations for transportation projects in a way that documents the goals and priorities identified in Step 6 and the parameters for achieving these goals.

Outcomes:

- Agreeing on resource management roles and methods.
- Incorporation of outcome based performance standards into programmatic agreements to improve project avoidance, minimization, as well as aiding effective monitoring and adaptive management actions.
- Establishing Programmatic ESA Section 7 consultation, SAMP, RGP, or agreements enabling agencies to proceed with conservation action in line with CWA Section 404 and ESA program objectives/requirements and with maximum assurance that investments count and will be sufficient.

Implementation Steps:

7a. Ensure agreements are documented relating to CWA Section 404 permitting, avoidance and minimization, ESA Section 7 consultation, roles and responsibilities, land ownership and management, conservation measures, etc.

7b. Plan for long-term management/make arrangements with land management agencies/organizations (e.g. land trusts or bankers) for permanent protection of conservation and restoration parcels. Notify and coordinate with local governments for supportive action.

7c. Design performance measures for transportation projects that will be practical for long-term adaptive management and include in 404 permit and/or Section 7 BA/BO.

7d. Choose a monitoring strategy for mitigation sites, based on practical measures above, ideally using the same metrics as those used for impact assessment, site selection, and credit development.

7e. Develop Programmatic ESA Section 7 consultation, Special Area Management Plan (SAMP), Section 404 Regional General Permits (RGPs), or other programmatic agreements to advance conservation action in line with CWA Section 404 and ESA program objectives/requirements and with maximum assurance that conservation/restoration investments by DOTs count or will count.

7f. Set up periodic meetings to identify what is working well, what could be improved.

Technical Considerations:

- Who will lead in development of needed agreements?
- Under what conditions would the agreement be re-visited?

Set up periodic (at least annual) meetings to identify what is working well, what could be improved.

The use of the integrated planning method described in this report provides the ideal basis for programmatic agreement implementation. Programmatic agreements can include agreements for compliance under a number of regulations or statutes. Common programmatic agreements include biological opinions, Section 404 permits, and local permits. In general, programmatic agreements require more time and effort to develop initially as the details and terms are developed. Due to this, the usual application of programmatic agreements is in settings where a project, or series of projects will require numerous permits or consultations and each will be very similar to each other. In this case, a traditional review process would drain staff and agency resources through repetitive reviews that do not add value by repeating.

The level of resource and transportation information developed in the REF and transportation plan documents provide a strong foundation for identifying programmatic implementation opportunities. Through an analysis of the common impact types, a set of programmatic permits can be developed to help speed project delivery. Programmatic agreements within the REF must describe the resources covered, the types of impacts or activities covered, and clear instructions on avoidance, minimization, and mitigation in program delivery. The programmatic must also include tools to assist in monitoring and management of the programmatic to assure the sum of the actions included is meeting the expectations of the signatories and participants.

Advantages for using programmatic rest primarily on the streamlining allowed once the agreement is in place. Using a programmatic can be as simple as a one or two page letter that outlines the information and certifies the impacts are included in the programmatic. Programmatic agreements allow for resource agency time to be more efficiently used and allow them to focus on monitoring or tracking of projects. These agreements can also cover multiple regulations or resources, and in the REF setting should in fact do this. This multi-resource programmatic approach can allow for more integrated permitting decisions to avoid conflicts between regulated resources, such as listed species and Section 404 requirements. This multi-resource approach may also rely on on-the-ground ecosystem credits as identified in Step 6. These multi-resource credits can allow for more comprehensive mitigation with conservation priorities included.

Challenges for a programmatic tend to rest on how complex the resources are, and the diversity of impacts included. Another important component of programmatic agreements is the level of trust and history of collaboration among all involved agencies. These agreements may require high level support and an ongoing collaborative staff relationship. If these two components are not in place, programmatic agreements are difficult to create and maintain. This may also include stakeholder buy-in as well. Conservation groups or other advocacy groups can play a key role in challenging these agreements, or supporting their implementation. This makes the efforts of Step 1 important in getting to successful implementation.

The SHRP2 C06(A) Phase 2 report documents the benefits and challenges in implementing programmatic agreements. The report also includes guides for developing agreements and sample documents based on agency and resource.

Even in cases where the diversity of resources, impact or stakeholders makes programmatic agreements difficult or impossible, the data and values from the REF can provide a key path to individual permit decisions. The REF and ecological priorities allow for analysis of alternatives, permit performance standards, and other important decisions to be reached without having to perform the analysis for each permit. This savings alone can speed project delivery greatly and reduce costs from delays.

3.2.7 **Step 8: Implement Agreements and Adaptive Management**

Step 8: Implement Agreements and Adaptive Management. Deliver Conservation and Transportation Projects

Purpose:

Design transportation projects in accordance with ecological objectives and goals identified in previous steps (i.e., keeping planning decisions linked to project decisions), incorporating as appropriate the programmatic agreements, performance measures and ecological metric tools to improve project.

Outcomes:

- Maintaining continuity from early planning processes into project implementation phase, including:
  - Use of regional ecological goals and objectives in project planning and decision-making
  - Use of REF map to guide project avoidance and mitigation decisions
  - Incorporation of performance standards and programmatic agreements as appropriate into permitting and consultation documents
  - Integration of programmatic cumulative effects analysis into project NEPA, §404 and §7 analysis
- Incorporating tools and approaches into a monitoring and adaptive management strategy to ensure positive project outcomes.
- Accurate recordkeeping and tracking of all commitments by transportation agency in project delivery
- Updating information from construction and operation into REF.
- Measuring performance success in project delivery.

Implementation Steps:

8a. Design/implement methods to complete transportation project(s) consistent with REF, conservation/restoration strategy, and agreements.

8b. Identify how advance mitigation/conservation will be funded, if this has not been done already.

8c. As needed, develop additional project specific, outcome-based performance standards related to impact avoidance and minimization.

8d. Design transportation projects and integrate performance measures to minimize impacts to resources.

8e. Use adaptive management to ensure compliance with requirements and intent of performance measures.

i. **Develop and track ecoregional biodiversity, indicators of viability and integrity**.

ii. Develop and track conservation status, protected and managed area status, and management effectiveness.

iii. Identify remedial actions and needed plan adjustments

iv. Adjust the planning process and management processes and/or management of individual conservation areas.

v. Incorporate outputs into future cumulative effects analyses for the region.

Technical Considerations:

- What tools are available that could help document goals and priorities identified in the REF that need to be considered in project delivery?
- What tools/methods can be used to track how projects contributed to and/or improved the REF priorities and goals?

No additional guidance was developed as the step and substeps are suitably described. Step 8 interaction with REF (described in other step guidance of the CEAA) is primarily iterative with other substeps described earlier such as updating the resource status and condition.

<u>Ecosystem Crediting Aspects:</u> An important aspect of any crediting system is to include an adaptive management or policy feedback loop that allows for new discoveries to inform better crediting. IEF Step 6g works to capture these lessons and redefine credits or

measurements in subsequent revisions. Credits should be monitored and measured against other measurement systems. Step 6g includes a discussion of how indices or other long-term monitoring measures can accompany a crediting system and provide a useful tracking mechanism for system performance.

This is an important step, and one that may change standards from one version of the crediting to the next. This is an acceptable change if justified by new science or policy priorities. However, it is important to set these changes in the context of previous decisions so as to not create new barriers for crediting in future projects. Adaptive management relies less on the idea of precedents, and more on the notion of new discoveries and decisions – the process cannot become overly tied to past decisions if new information is available.

3.2.8 Step 9: Update Regional Integrated Plan/Ecosystem Framework

Step 9: Update Regional Integrated Plan/Ecosystem Framework

Purpose:

Update the effects assessment to determine if resource goal achievement is still on track. If goal achievement gaps are found, reassess priorities for mitigation, conservation and restoration in light of new disturbances that may impact the practicality/utility of proceeding with previous priorities. Identify new priorities if warranted.

Outcomes:

- Updating REF and cumulative effects analysis
- Updating conservation and restoration priorities.

Implementation Steps:

9a. Integrate any revised conservation plans into the regional integrated plan/ecosystem framework and, where appropriate, individual resource spatial information.

9b. Update the area/resource conservation requirements, responses, and indicators in collaboration with stakeholders (e.g., assess regional goals, update to minimum required area for species and/or habitat, review confidence threshold for achieving goals, review weighting values of resources in REF, evaluate responses to land use and infrastructure).

9c. Update the implementation status of areas in the REF to review those areas that are contributing to REF goals and priorities, and determine if additional conservation/protection action is required.

9d. Update the cumulative effects analysis with new developments, new disturbances, proposals and trends (e.g., ecosystem-altering wildfire, new policies, plans, proposals, and trends such as new sea level rise inundation model).

9e. Conduct regular review of progress, including effectiveness at meeting goals and objectives, current take totals, and likelihood of exceeding programmatic take allowance.

Technical Considerations:

- Has the status of species or habitats changed? How does this affect REF goals?
- Do areas on the landscape critical to meeting goals identified in REF need additional protection or restoration action?
- How often should the REF be revised to incorporate new conservation data or plans?
- How often should the cumulative effects analysis be updated?
- Are indicators used to track conservation progress capturing the correct trends?
- Are transportation project delivery indicators improving (e.g., streamlined decision making and/or better conservation outcomes)?
- How can modifications be moved forward to alter mitigation and restoration priorities previously identified but not yet implemented?

3.2.8.1 **Technical Implementation of Step 9**

Step 9d. Update the cumulative effects analysis with new developments, new disturbances, proposals and trends (e.g., ecosystem-altering wildfire, new policies, plans, proposals, and trends such as new sea level rise inundation model)

The framework implementation as described is explicitly designed to support adaptive planning and management. A key aspect of this process then is to re-analyze the cumulative effects whenever there is a significant change in potential stressors to the ecosystem. Each assessment iteration should entail the following:

1. Update the effects assessment to determine if resource goal achievement is still on track
2. If goal achievement gaps are indicated, reassess priorities for mitigation in light of new disturbances that may impact the practicality/utility of proceeding with previous priorities.
3. Identify new priorities if warranted.

Ecosystem Crediting Aspects: As changes occur in the REF or new information is included in the decision making, the crediting system will also need to adapt. This may be due to new resource concerns, emerging regulations, or public concern that is critical but not yet regulatory. Reevaluating IEF Step 6a periodically will be important to assuring the crediting system is current and in alignment with environmental, social, and regulatory concerns.

4. CHAPTER 4: PILOT PROJECTS

4.1 BACKGROUND OF PILOT TESTS

As discussed above, three major obstacles to doing integrated transportation planning have been identified by researchers: 1) lack of data, information and tools, 2) lack of resources, and 3) resistance to institutional/process change. Other research (e.g., NCHRP Project 8-38, NCHRP Project 25-25-32) cites the lack of environmental data, in particular, to be an obstacle to achieving better environmental results during transportation decision making – planning, project development, and maintenance. We developed the technical components of the overall C06 Framework to address all of these obstacles. The CEAA guidance and supporting strategies provide natural resource and transportation practitioners with a step-by-step, peer-reviewed, and science-based process that guides the implementation of transportation decision making integrating environmental considerations. The guidance includes documentation on commonly used methods, data and tools, as well as supporting case studies on the successful use of these methods, data and tools in integrated planning. Practitioners are provided with: 1) recommendations on the use of data, tools and methods, 2) a corresponding 'roadmap' that can improve and streamline decisions by introducing the appropriate environmental information earlier in the decision making process, and 3) assistance for practitioners to adopt decision making practices that integrate environmental considerations.

The next section provides a summary of the results of testing the CEAA process in three states. Appendix D includes a detailed report of each pilot test addressing the following information.

1. How and why the project was selected.
2. An introduction to the original project and project area.
3. Results of the testing – comparison of 'original' outcomes to outcomes using the CEAA process.
4. Conclusions and/or lessons learned.

4.2 SUMMARY OF PILOT TEST RESULTS

In our pilot tests, we compared the approach and outcomes of the original project and planning efforts in each state with the approach and outcomes using the CEAA process. Our comparison focused on decisions and outcomes related to: 1) direct impacts, 2) cumulative impacts, and 3) mitigation effectiveness.

Overall, in the three pilot areas, we found that transportation agency staff accurately understood and accounted for ***direct impacts*** to natural resources. The transportation agencies used existing data in combination with environmental studies to support the evaluation and selection of the transportation alternatives that typically looked at direct and cumulative impacts. Using the CEAA process our pilot assessments achieved very similar results to the original project assessment, thus in the realm of direct impacts our approach produced similar results to traditional methods used by transportation agencies. But it is important to note that the CEAA testing process did not include any field studies, and so very similar potential impacts were found at a much lower cost, and likely with much less time. That said, it is understood by the team that limitations of data accuracy and resolution will not eliminate the need for on-the-ground evaluation of a project site, but the CEAA process could target field studies and thereby reduce overall assessment costs.

For ***cumulative impacts***, the traditional approach is to look at the impacts to a species based on the existing condition of the landscape or habitats, but our pilots included information that indicated how the habitats looked historically in order to show how much of the habitats has been impacted over time, and therefore provide a truer picture of the cumulative effect that additional impacts would cause. Data that shows how the landscape looked historically is often not used because it is not readily available, but in most cases there are other sources of data often available through state or federal agencies that can be used as a proxy for historic data (such as hydric soil data). The CEAA documents a recommended list of data sources including the types of data that can provide a true assessment of the cumulative impact of transportation infrastructure and associated land use on species and habitats over time. Our guidance also provides recommendations on other high priority datasets that are generally not available across the country but, if they were available, would streamline the assessment of landscapes for planning and project development (e.g. high quality data on wetlands and endangered species).

When our team looked at the assessment of ***cumulative impacts and the selection of mitigation options***, especially when comparing our results to the results of planning efforts (long range and corridor), our pilot test teams observed more significant differences utilizing the CEAA process. These differences were due mostly to the fact that:

5. Our process recommends that for species within a project area or corridor, cumulative effects and mitigation options should be evaluated within a larger, more ecologically based area than is typically used,
6. Some of the original planning efforts in the pilot states included less comprehensive or no ecological information, and/or
7. Different and/or more comprehensive data (e.g., historical landscape, wetland priorities, predictive species distribution maps) were utilized in the C06(B) assessment of the project area.

Another result of the pilot testing analyses was a more accurate and complete understanding of some of the issues related to the ***use of data*** to help guide a more accurate assessment of impacts to natural resources and evaluation of mitigation options, and recommendations for the development of key datasets that could bring significant improvements to the assessment of ecological resources. For example, the pilot tests illustrated how the accuracy and resolution of data influences what types of data are most useful for planning level decision making versus project level decision making. Therefore, one key component of the CEAA guidance is a recommended list of data sources that support each step of the guidance. The CEAA also provides recommendations on other high priority datasets that are generally not available across the country but, if they were available, would streamline the assessment of landscapes for planning and project development, such as high quality data on wetlands and endangered species. Also, for the datasets that may not be readily available across the country, we document how they could be created. Thus one result of the pilot testing analyses was a more accurate and complete understanding of some of the issues related to the use of data to help guide a more accurate assessment of impacts to natural resources and evaluation of mitigation options, and recommendations for the development of key datasets that could bring significant improvements to the assessment of ecological resources.

We also looked at the ***time and cost*** of planning and project development for the pilot test areas and documented ideas on how the use of the CEAA could have streamlined some of the transportation planning and project development decision making - possibly saving time and money. For example, the Michigan pilot illustrated how the evaluation of corridors using the CEAA process would result in a more accurate assessment of potential impacts, supporting the selection of corridors with the lowest mitigation related costs. Also, as noted above, use of our CEAA process (which includes use of more comprehensive data and decision support tools) for conducting direct and cumulative impact assessments could target and reduce field studies required.

The ***most significant differences found from each pilot test state*** comparing the outcomes of the original assessment versus the outcomes of the CEAA were as follows:

1. Pioneer Mountain – Eddyville Project (Oregon): CEAA assessment would likely have resulted in mitigation being done in larger priority wetland areas in the watershed that would have provided opportunities for restoration contributing to creation or enhancement of salmon (Coho, Chinook and Steelhead) habitat.
2. South I-25 Corridor (Colorado): CEAA assessment would likely have provided a more accurate assessment of cumulative impacts (therefore effecting ratio of mitigation requirements) due to the fact that we did spatially explicit analyses of the impacts that included some data types not included in the original assessment, and the CEAA pilot team used a larger ecologically based area for the cumulative impacts assessment.
3. US-131 Corridor (Michigan): The CEAA assessment resulted in the selection of a different alternative that had the least number of impacts and therefore would have reduced mitigation requirements. The results differed because the C06 pilot team used more detailed ecological data than was used in the original corridor assessment including historic wetland data and data from a 2005 wetland functional assessment, and utilized a decision support tool allowing a very precise and quantitative impact assessment by resource.

It is worth noting that our team ***utilized two different decision support tools*** to conduct the CEAA pilot tests, NatureServe Vista was used in Colorado and Michigan and EnVision was used in Oregon. Although the focus of these pilots was not to demonstrate the efficacy of decision support tools the detailed pilot test report for Michigan (found in Appendix D), includes information on the advantages of using NatureServe Vista versus a GIS without the Vista ArcGIS extension. The efficacy of decision support tools has been demonstrated in many other publications, this is due to the fact that these tools allow the practitioners to automate the process of running new transportation alternative scenarios as information or priorities change – something that cannot be done as efficiently utilizing only GIS (NCHRP Report 481, NCHRP Project 25-23).

An unexpected finding of the pilot tests included the fact that in all three states, the data that was used for original assessment of the project area was not readily available, and not available in a GIS layer suitable for use with a decision support tool. Thus, even data collected from costly field studies were not captured in a way that it could be used for future assessments. The development of data management standards that support transportation planning and project related assessments would contribute to better application of data collected for future decision making not only by transportation agencies but by natural resource agencies as well. For example, if field studies for a listed species are completed and that information was provided to a database on the status of imperiled species in that state, that information could contribute to range-wide assessments of those species by USFWS and other natural resource practitioners for conservation planning purposes.

4.3 **CONCLUSIONS**

Overall, the pilot tests were essential in demonstrating the practical value of utilizing the CEAA process to streamline and improve decision making in transportation planning and project development. Clearly, the CEAA could be effective at creating more accurate 'sign posts' early on in any transportation decision making process that could alert practitioners to potential impacts and mitigation opportunities.

Some key findings and conclusions from the testing of the CEAA process included:

- ***Better Outcomes***: Most significant changes in outcomes from the original project or planning outcomes were in the areas of mitigation site selection, evaluation of multiple corridors, and/or development of transportation plans. The pilot test results lead to the selection of mitigation sites with more ecological benefits, and more accurate and comprehensive scenario assessments that identified corridors with the least number of direct and cumulative impacts.
- ***Modest Investments in Data:*** Usefulness of the CEAA for planning and project development is dependent on the accuracy and resolution of available data. But a relatively modest investment in process changes and data development upfront would create more accurate 'sign posts' early on in the decision making processes of potential impacts and mitigation opportunities, vastly improving planning, corridor evaluation, and consideration of mitigation opportunities.
- ***Scientific Credibility:*** Decisions have more credibility because the CEAA process ensures the use of a more standardize, scientifically-based, peer-reviewed process that utilizes the best available suite of methods, data and tools.
- ***Saving in Time and Resources:*** The CEAA approach would likely save time and resources by reducing impacts and therefore mitigation requirements, as well as supporting more targeted field studies for assessment of alternatives.
- ***Standard Data Management Practices:*** Better data management practices would contribute to better application of data collected during transportation alternative assessments for future decision making not only by transportation agencies but by natural resource agencies as well.

5. CHAPTER 5: THE WEB TOOL

An interactive database was developed to provide ready access to the CEAA technical guidance and supporting strategies for regulatory assurances and environmental crediting. The database is designed to integrate with and support the website developed by Project C01, Transportation for Communities: Advancing Projects through Partnerships, http://www.transportationforcommunities.com/shrpc01/. It will be presented in full as a "practical application" and linked to key decision points. A permanent repository for the website will be developed in collaboration with TRB and FHWA.

The website is intended to serve as a hub, promoting interdisciplinary collaboration by filtering the vast quantities of information and resources supporting local and regional transportation planning, and ecosystem-based management according to four themes: tools/methods; cases; references; and data. Thematic content will be linked across these four areas, as well as follow the nine steps of the Framework providing multiple access points for practitioners to locate relevant information. The interactive database and website represents a valuable platform to make research and resources readily available to communities and for this information to be in the form of a "living document" that is constantly updated and refined.

Users will be able to access information in the following ways:

- Search by Concept: You want to better understand how off-site mitigation might be done and why it is useful? Or what is predictive species modeling and why it is relevant to transportation planning?
- Search by Case Study: You are wondering what your neighboring states are doing? You can search by location or type of work being done (cumulative effects assessment, spatially explicit long range planning, etc.)?
- Search by Eco-Logical Step: You are familiar with the Eco-Logical framework steps but want to understand one of them in more depth or how others have implemented this step in the framework?
- Search by Data: At a recent conference, you heard about a source of data or a new type of data that might be useful in your state, and you are trying to understand more about it and where you might be able to acquire it in your state?
- Search by Tool: You heard about a tool and want to understand how it can be useful in integrating conservation and transportation planning?

The primary audience for our technical guidance is transportation agency staff, state and federal fish and wildlife agencies and other environmental regulatory agencies. To fully realize the C06(B) vision, a secondary audience is also addressed. This audience includes non-regulatory agencies and organizations that typically create data and other products such as conservation priorities of use in the assessment process.

The database and resulting website is written in an accessible, hierarchical way so that users can begin with the overall Framework and hyperlink to increasing levels of detail based on their role and interests. For example, a manager may want to understand the overall Framework while a resource specialist will want to link to details about specific tools, data, and analytical procedures. The site has interactive search capabilities and the ability to tap into a rich database of sister sites. The site is designed to provide forums for practitioners to communicate informally and highlight innovative programs and activities. The website is designed to be flexible, easily refined and expanded as the process evolves and is implemented. We believe the guidance will ultimately best be updated through volunteer efforts of the transportation community much like open source software.

6. CHAPTER 6: SYMPOSIUM

At the Symposium in September 2010 the C06(A) and C06(B) research was presented to transportation and resource agency participants. This chapter summarizes the discussion that occurred and recommended next steps related to the CEAA technical guidance and supporting strategies. Our work was presented following each step of the Framework for integrated conservation, restoration, and transportation planning. The results of the pilot projects were summarized. This chapter summarizes the feedback received from participants with a focus on the technical and scientific work done by our project.

Feedback and discussion started by asking participants to write down what they see as the greatest opportunities for implementing the integrated planning approach and what they think is needed to make it practical for users. One comment summarized much of the discussion:

> "*There is an emerging paradigm where transportation can be an ally, and not an enemy, in the conservation process that is starting to take hold*."

The written answers to the introductory questions were combined with discussions captured from facilitated breakout groups to summarize the principle themes raised at the Symposium.

6.1 APPROACHES AND FRAMEWORKS

Transportation agencies now are considering what the right project is and factoring in ecosystem approaches and watershed frameworks, rather than doing business as usual. This allows better information sharing and allows information to be used and improved on an on-going basis. New approaches, like ecosystem services markets are aligning interests of development entities, conservation groups, landowners, and investors. Development of these markets could not only provide on-the-ground conservation, but could also drive data collection and information generation to minimize investment risk.

6.2 WORKING TOGETHER

Resource agencies are collaborating and providing a basis for broader regional collaboration. Trust is growing and interagency relationships are starting to build which leads to more consensus on areas of ecological importance, improves conservation outcomes and promotes leveraging funds for enhanced ecological success. As one participant said, "Agencies and organizations are coming together more and sharing initiatives, ideas, and priorities, realizing we are all going in the similar direction and making changes to work together (and not staying in our bubbles)."

Transportation and resource agencies are talking, learning and sharing more at all levels. The conversations are moving beyond technical matters and legal requirements to recognition of the need for trust in order to make progress. Collaboration like this is needed at all levels, including with interest groups and stakeholders.

It is critical to develop a better understanding of terms being used (e.g. mitigation, avoidance, assurances, restoration, conservation) and systems being developed (e.g. Eco-Logical, REF) to avoid confusion and clear communication. This is vital in terms of building on all the work currently underway relationship and avoiding confusion. The discussion itself suggested that transportation and resource agencies, and different resources agencies, may use terms like avoidance, mitigation and restoration differently. There was not time to sort out the differences at the Symposium.

6.2.1 **Awareness and Recognition**

There is increasing recognition that all agencies can integrate conservation within their missions and work together toward shared goals. Recognition of the need protect natural areas (function and services) across jurisdictional and ownership boundaries is also growing. There is widespread recognition that the current process is failing us and failing ecosystems. There is an emerging push to balance mobility needs with the need to preserve and restore ecosystem health.

6.2.2 **Institutional Change**

The participants identified several forces driving the need to shift to an integrated conservation and transportation planning system and several unmet needs if these opportunities are to be realized. The Reauthorization bill and climate change both create a sense of urgency. But it will be vital to build partnerships with other development and land use agencies beyond transportation agencies, particularly land use decision makers, for the value of the approach to be fully realized.

High-level officials now recognize that the comprehensive ecological approach is good for the environment and the economy and new state legislation is being enacted to develop integrated ecosystem market places. New Administration initiatives, like Sustainable Cities, complement the Eco-Logical approach and need to be built on. However, the Administration's National Infrastructure Initiative does not include natural resources or "green infrastructure" and it should. Many organizations now seek to work with EPA and USACE to apply the watershed approach. There are now more mitigation banking systems, landscape level approaches to project mitigation, statewide connectivity plans and other examples of integrated transportation and conservation planning for regulated and non-regulated resources.

These developments represent a major cultural shift for transportation and resource agencies from a single project (tit for tat, project by project) to a landscape approach focused on ecosystem results at a larger scale. The landscape approach allows more flexibility and requires more stakeholders. Ultimately, it is critical that all agencies look at ecosystems in their entirety, not just regulated resources.

Regular face-to-face meetings at the regional level are needed to develop trust and maintain continuity to do integrated planning. This approach also requires staff with specific responsibilities to support it in local government, state transportation, and resource agencies

For the Framework to be implemented, champions need to be built at all levels of transportation and resource agencies. Today, the participants said that resource agency staff do not know what Eco-Logical is, even if their agencies signed the agreement. Even in states or regions where the integrated approach has been embraced, staff changes and continuity pose major problems.

6.3 **FUNDING**

Transportation agencies have perhaps the largest source of dedicated public funding for restoration and conservation and they have been willing to fund projects that do not necessarily benefit the transportation systems directly. Local agencies have also been willing to fund advanced mitigation. Flexible funding is needed for holistic solutions that address pre-existing deficiencies and enhancements.

6.4 REGIONAL ECOSYSTEM FRAMEWORKS

The biggest issue raised regarding REF preparation is the need for some entity to "own" it and assure that it is implemented. Answering this question is critical to selling the approach.

The second issue raised is who pays for it? One participant said that the Framework underplays the amount of time, money and effort needed to do it. We need to be able to explain how much these processes cost and what a DOT needs to do to make this approach happen?

The third issue is the audience. The audience needs to be targeted in write up of the Framework in order to reach them.

An opportunity exists to use REFs for other than transportation projects. For example, the REF could be useful in helping to figure out best way to replace aging infrastructure overall. Energy companies and other utilities should become partners in integrated planning efforts. The REF could support improved stormwater management, asset management and climate change responses. The approach could be sold on the basis of these benefits.

Inevitably, in states where there are more listed species and wetlands, like California and Florida, there is a demand and urgency for innovative solutions that does not exist in states without the species and wetlands. One participant also noted that transportation agencies are doing fewer new capacity projects. The projects are categorically excluded from NEPA so there is little reason for a transportation agency to participate in the REF work because the projects have little cumulative effect.

6.4.1 Data, Tools, Scientific Information, and Decision Support

Advances in remote sensing, species and habitat inventories improve information on population distributions and new decision support tools support the Eco-Logical approach and improve conservation outcomes. Landscape scale and project specific scale data are different but this hierarchy can be flattened now given greater computing power and modeling methods. The new information and tools are more accessible and usable by non-specialists allowing agencies to share data, tools and analysis. A wish was expressed for a database of potential mitigation and restoration projects that could meet multiple federal and state requirements and the goals of non-government entities

Data needs and opportunities were raised in some detail. The participants repeatedly noted the need for improved geo-spatially explicit datasets in digital form that capture historic, as well as current, information. Data set development needs should be prioritized for investment. The data needs to be collected and maintained to provide ready access for multiple users and applications and to incorporate data from all levels and projects. This will require data for multiple functions, not just transportation.

The data needs to be "live" in order to allow users to create their own data mash ups. This data is needed to populate decision support systems like the USFWS IPac program. Tools need to be developed to use the data in implementing the Framework and the tools should have a common interface. There needs to be a primary funding source for gathering and managing these regional, state and nationwide data sets.

Participants confirmed what we found in our research. Most DOTs and MPOs do not have protocols for data collection and management and they do not require consultants to integrate data they collect into an accessible central system. For an integrated planning system to work, consistent protocols are needed describing what type of data is to be collected, how data will be evaluated and what data should be retained and managed. The overall system must be designed to assure that data are updated regularly because natural events (fire, disease, flood, climate change) and development can alter resources of concern. It also requires a long- term commitment to gathering, managing, and sharing data.

6.4.2 **Crediting and Advance Mitigation**

There are challenges with crediting that the Framework cannot address such as market development, double dipping and the sophisticated operations and management and accounting systems needed to assure a market delivers results. Resource agency staffs are often leery of crediting and concerned that mitigation done for one project not count for another. There is a tendency for regulatory agencies and transportation agencies both to focus only on the project site.

In terms of both crediting and advance mitigation, metrics from the planning process need to carry through to project delivery and monitoring. At the planning level, transportation and resource agencies need to think about whether the right project for the context is being proposed. Participants also noted that for all planning and projects, there is a 'sweet spot' when money for the transportation project are available at the same time the mitigation or conservation opportunity exists. Mitigation is likely to be more effective for long-term conservation and advance mitigation is more likely to occur when funds line up with opportunity in this way.

Participants emphasized that buying land and doing a mitigation or conservation project is not enough. Long term land management is essential to assure that the environmental outcomes are both achieved and maintained.

6.5 **IMPLEMENTATION ACTIVITIES**

Specific recommendations were made to the TRB on how to implement the results of the C06 research projects.

- Share the research results with key public officials. Engage ASHTO regarding streamlining project delivery and groups like ECOS (Environmental Council of the States), AFWA, WGA and NGA.
- Document the benefits of the approach—sell it. The documentation should include the business case (return on investment of time and money) and address time savings (especially if they made it possible to reallocate agency resources), cost savings, triple bottom line co-benefits and quality of life benefits, and improved conservation outcomes. Examples of success should be included. Opportunities for streamlining processes or programs should be demonstrated.
- Require it. One participant suggested requiring it in legislation.
- Fund more pilot projects. More pilot projects are needed to illustrate how to implement the approach, including regional forums for engaging local, state and federal agencies.
- Interagency training. Regional seminars and interagency training is needed in order to implement the approach, beyond the Eco-logical grants and customary technology transfer. Interagency training is especially useful if it is related to specific projects or permits so that it can be used as a demonstration.

- Guidebook and website. Prepare a guide like the FHWA Roadside Restoration Guide with chapters for each step and examples and provide an accessible and searchable website.

7. CHAPTER 7: CONCLUSIONS

The Framework developed by the C06 project should help transportation agencies and resource agencies work together during long-range planning to identify strategic transportation program needs, their potential environmental impacts and conservation opportunities. The CEAA process provides technical guidance to transportation and natural resource practitioners—helping them bring the right expertise, data, methods, and tools to the right stage of the transportation planning and project delivery decision making process. The result is better environmental outcomes through reduced impacts, identification of high quality mitigation and enhancement opportunities, and accelerated permitting through proactive inclusion of resource considerations early in the transportation planning process.

The major outputs of the CEAA are:

1. Unified map of transportation, land use, conservation, and restoration priorities.
2. Maps of each potential transportation scenario that shows an assessment of direct and cumulative effects at a landscape level with supporting data.
3. Identification of affected resources and the quantification of the cumulative effects for each transportation scenario being considered.
4. Identification and evaluation of potential mitigation and enhancement areas within a region.

Within the overall Framework and the CEAA process, two strategies are critical. First, transportation planners and project managers must address regulatory requirements, ideally as early in the transportation planning and development process as possible. Based on our research, we believe that, particularly for wetlands and endangered species, regulatory conflicts and delays largely result from transportation planners and regulators having insufficient, incomplete, or poor quality data. There are two critical requirements for improved outcomes: 1) to provide tools planners can use to identify potential impacts to regulated resources very early in the planning process—allowing them to avoid or minimize these impacts as much as possible; and 2) to assure that any mitigation that must occur due to unavoidable impacts provides effective, measurable, and high quality environmental outcomes for the impacted resources.

Second, environmental accounting strategies can be used to reach agreement with regulatory agencies on project impacts and mitigation requirements. In the Framework and CEAA process, we focused on linking and correlating environmental measurements at a landscape scale with measurement of similar resource issues at a site level. This allows transportation planners to broadly understand and plan around a resource at a regional scale— identifying goals and desired outcomes for that resource. It also allows specific outcomes for that resource to be measured at a site level in a manner that meaningfully addressed the increment of change associated with a project's effect on the resource. Linking measurement scales maintains continuity between early transportation planning and project specific planning, improves regional goal setting and tracking of the effect of specific projects on the progress towards those goals, provides a framework for understanding and presenting cumulative effects analyses, and improves understanding of the opportunity/need for using programmatic approaches and an improved ability to develop them.

There are challenges to implementing the Framework. As with most innovations requiring broad partnerships, the key challenges to adoption tend to be institutional, political, and financial rather than technical. One of the biggest of these institutional challenges is getting transportation and resource agencies to agree on who will convene and lead the REF process and on-going maintenance and updating of data. We believe the technical and scientific limitations and challenges of the CEAA can be overcome, as discussed above. Many of the technical challenges and limitations of the past have been overcome with improved computing power and creation of decision support tools to automate a considerable amount of the CEAA process. The remaining technical challenges are: 1) creating robust analyses understandable to decision makers and stakeholders; 2) integrating and maintaining information from distributed sources; 2) integrating dynamic processes and information; and 4) developing methods for low capacity agencies to use the process.

Addressing data distribution infrastructure needs and how the data can best be incorporated into the Framework has yet to be done. One of our goals is to assure internal data sharing of newly developed models within the natural heritage network and the regulatory agencies and to assure that the models provide regulatory certainty. A remaining goal is to assure protocols and software exists to allow programs to provide their data through web services to transportation agencies and other partners. The advantage to providing data through web services is that the primary data manager is electronically and automatically publishing their data for web sites to harvest. Data security can be built in, but applications using web services receive constantly updated data.

The pilot tests were essential in demonstrating the practical value of utilizing the CEAA process to streamline and improve decision making in transportation planning and project development. We found that the most significant changes in outcomes from the original project or planning outcomes were in the areas of mitigation site selection, evaluation of multiple corridors, and/or development of transportation plans. The pilot test results lead to the selection of mitigation sites with more ecological benefits, and more accurate and comprehensive scenario assessments that identified corridors with the least number of direct and cumulative impacts.

The usefulness of the CEAA for planning and project development depends on the accuracy and resolution of available data. But a relatively modest investment in process changes and data development upfront would create more accurate 'sign posts' early on in the decision making processes of potential impacts and mitigation opportunities, vastly improving planning, corridor evaluation, and consideration of mitigation opportunities. Decisions have more credibility because the CEAA process ensures the use of a more standardized, scientifically-based, peer-reviewed process that utilizes the best available suite of methods, data and tools. Better data management practices would contribute to better application of data collected during transportation alternative assessments for future decision making not only by transportation agencies but by natural resource agencies as well

The CEAA approach would likely save time and resources by reducing impacts and therefore mitigation requirements, as well as supporting more targeted field studies for assessment of alternatives, although we were unable to evaluate the extent of these savings in our research.

Implement the results of our research will require additional effort. Integration into the TCAPPs website is underway, which should make the CEAA process accessible to transportation and resource agency staffs. To be successful, however, the research results should be shared with key agency leadership, along with supporting documentation of the business case for adopting the Framework. Additional pilot projects, such as those that will be undertaken under Project C21, are needed to illustrate how the approach can be used in different settings, with different data availability. Regional seminars and interagency training are also needed.

8. REFERENCES

Apogee Research. 1996. Monetary measurement of environmental goods and services: Framework and summary of techniques for Corps planners. In *Evaluation of Environmental Investments Research Program*. U.S. Army Corps of Engineers: Bethesda, Maryland.

Baker, Joan P., David W. Hulse, Stanley V. Gregory, Denis White, John Van Sickle, Patricia A. Berger, David Dole, and Nathan H. Schumaker. 2004. Alternative Futures for the Willamette River Basin, Oregon. Ecological Applications 14:313–324.

Bauer, W.S. 1980. A case analysis of Oregon's Willamette Greenway Program. PhD Dissertation, Oregon State University. Oregon State University Library. 246 pp.

Bean, M., R. Kihslinger, et al. 2008. *Design of U.S. Habitat Banking Systems to Support the Conservation of Wildlife Habitat and At-risk Species*. Environmental Law Institute: Washington, D.C.

Benayas, J. M. R., A. C. Newton, et al. 2009. Enhancement of biodiversity and ecosystem services by ecological restoration: A meta-analysis. *Science*, 325:1121-1124.

BenDor, T. K. and M. W. Doyle. 2010. Planning for ecosystem service markets. *Journal of the American Planning Association*, 76(1):59-72.

Benedict, M. A. and E. T. McMahon. 2006. *Green Infrastructure: Linking Landscapes and Communities*. Island Press: Washington, D.C.

Boyd, J. and S. Banzhaf. 2007. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*, 63: 616-626.

Brown, J. W. 2006. *Eco-logical: An Ecosystem Approach to Developing Infrastructure Projects*. Federal Highway Administration: Washington, D.C. http://www.environment.fhwa.dot.gov/ecological/eco_index.asp.

Brown, T. C., J. C. Bergstrom, et al. 2007. Defining, valuing, and providing ecosystem goods and services. *Natural Resources Journal* 47: 329-376.

Cambridge Systematics, et al. *Linking Environmental Resource and Transportation Planning.* NCHRP Project 25-25, Task 32, National Cooperative Highway Research Program, Transportation Research Board. 2008

Carroll, N., J. Fox, et al. 2008. *Conservation and Biodiversity Banking: A Guide to Setting Up and Running Biodiversity Credit Trading Systems*. Earthscan: Sterling, Virginia.

Chan, K. M. A., M. R. Shaw, et al. 2006. Conservation Planning for Ecosystem Services. *PloS Biology*, 4(11):2138-2152.

Costanza, R., R. d'Arge, et al. 1997. The value of the world's ecosystem services and natural capital. *Nature*, 387:253-260.

Costanza, R. and C. Folke. 1997. Valuing ecosystem services with efficiency, fairness, and sustainability as goals. In *Nature's Services* (Ed.) G. C. Daily. Island Press: Washington, D.C.

Daily, G. C., S. Polasky, et al. 2009. Ecosystem services in decision making: Time to deliver. *Frontiers in Ecology and the Environment*, 7(1):21-28.

Emerson, D, et al. *Improved Linkage between Transportation Systems Planning and the National Environmental Policy Act (NEPA).* NCHRP Project 08-36, Task 48, National Cooperative Highway Research Program, Transportation Research Board. 2006.

Environmental Law Institute (ELI). 2007. *Mitigation of Impacts to Fish and Wildlife Habitat: Estimating Costs and Identifying Opportunities*. Environmental Law Institute: 223. Environmental Law Institute: Washington, D.C.

Environmental Protection Agency (EPA). 2008. Compensatory Mitigation for Losses of Aquatic Resources, Final Rule. Federal Register, 40 CFR Part 230, Vol.73, No. 70, 4/10/2008: 19594-19705.

Environmental Protection Agency (EPA). 2010. National Environmental Policy Act. Web resource: http://www.epa.gov/oecaerth/basics/nepa.html#process, accessed October 21, 2010.

Farber, S. C., R. Costanza, et al. 2002. "Economic and ecological concepts for valuing ecosystem services." *Ecological Economics* 41:375-392.

Fisher, B., K. Turner, et al. 2009. Defining and classifying ecosystem services for decision making. *Ecological Economics* 68(3):643-653.

Floberg, J., M. Goering, G. Wilhere, C. Macdonald, C. Chappell, C. Rumsey, Z. Ferdana, A. Holt, P. Skidmore, T. Horsman, E. Alverson, C. Tanner, M. Bryer, P. Iachetti, A. Harcombe, B. McDonald, T. Cook, M. Summers, D. Rolph. 2004. Willamette Valley-Puget Trough-Georgia Basin Ecoregional Assessment, Volume One: Report. Prepared by The Nature Conservancy with support from the Nature Conservancy of Canada, Washington Department of Fish and Wildlife, Washington Department of Natural Resources (Natural Heritage and Nearshore Habitat programs), Oregon Natural Heritage Information Center and the British Columbia Conservation Data Centre.

Forest Trends and Ecosystem Marketplace. 2008. *Payments for Ecosystem Services: Market Profiles*. PROFOR.

Gardner, R.C., J. Zedler, A. Redmond, R.E. Turner, C.A. Johnston, V.R. Alvarex, C.A. Ximenstad, K. Prestegaard, and W.J. Mitsch. 2009. Compensating for Wetland Losses Under the Clean Water Act: Evaluating the Federal Compensatory Mitigation Regulation. Stetson Law Review, Vol. 30, No. 2, 2009: Stetson University College of Law Research Paper No. 2009-24.

Groot, R. S. D. 1987. Environmental functions as a unifying concept for ecology and economics. *Environmentalist*, 7(2):105-109.

Groves, C.R. 2003. Drafting a conservation blueprint. Island Press.

Hughes, R. M., J. H. Gakstatter, et al. 1982. An approach for determining biological integrity in flowing waters. *Place Resource Inventories: Principles and Practices, A National Workshop*. Society of American Foresters: Bethesda, Maryland.

Karr, J. R. 1981. Assessment of biotic integrity using fish communities. *Fisheries*, 6:21-27.

Kolstad, C. D. 2000. *Environmental Economics*. Oxford: New York, New York.

Kremen, C. and R. S. Ostfeld. 2005. A call to ecologists: measuring, analyzing, and managing ecosystem services. *Frontiers in Ecology and the Environment*, 3(10): 540-548.

Lestelle, L. C., L. E. Mobrand, et al. 1996. *Ecosystem Diagnosis and Treatment (EDT) Applied Ecosystem Analysis: A Primer*. Bonneville Power Administration : Portland, Oregon.

Limburg, K. E., R. V. O'Neill, et al. 2002. Complex systems and valuation. *Ecological Economics*, 41: 409-420.

Mander, U., F. Muller, et al. 2005. Functional and structural landscape indicators: Upscaling and downscaling problems. *Ecological Indicators*, 5:267-272.

Millennium Ecosystem Assessment. 2003. *Ecosystems and Human Well-Being: A Framework for Assessment*. Island Press: Washington, D.C.

Mobrand, L. E., L. C. Lestelle, et al. 1995. *Grande Ronde Model Watershed Ecosystem Diagnosis and Treatment: Template for Planning Status Report for Grande Ronde Model Watershed Project and Progress Report on the Application of an Ecosystem Analysis Method to the Grande Ronde Watershed using Spring Chinook Salmon as a Diagnostic Species*. Bonneville Power Administration: Portland, Oregon

Nelson, E., G. Mendoza, et al. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. *Frontiers in Ecology and the Environment,* 7(1):4-11.

Oregon Department of Fish and Wildlife. 2006. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon.

Oregon Department of Transportation. 2007. Mitigation Operations Manual. E. Section. 1. Oregon Department of Transportation: Salem, Oregon.

Oregon Department of Transportation. 2008. *Environmental Programmatic Permitting: Benefit/Cost Analysis*. Oregon Department of Transportation: Salem, Oregon.

Redford, K. H. and W. M. Adams. 2009. Payment for ecosystem services and the challenge of saving nature. *Conservation Biology*, 23(4):785-787.

Ruhl, J. B., S. E. Kraft, et al. 2007. *The Law and Policy of Ecosystem Services*. Island Press: Washington, D.C.

The Wetlands Conservancy. 2005. Oregon's Greatest Wetlands. Web resource at: http://oregonexplorer.info/wetlands/WetlandConservation/OregonsGreatestWetlands, Oregon Wetlands Explorer. Accessed October 21, 2010.

U.S. Environmental Protection Agency Office of Water, Notice of Availability and Comment Period for Draft Federal Geographic Data Committee Wetland Mapping Standard, Federal Register, Vol. 72, No. 151, August 7, 2007.

U.S. Government Accountability Office. 2004. *Environmental Indicators: Better Coordination is Needed to Develop Environmental Indicator Sets that Inform Decisions*. U.S. GAO: Washington, D.C.

U.S. Government Accountability Office. 2005. *Environmental Information: Status of Federal Data Programs that Support Ecological Indicators*. U.S. GAO: Washington, D.C.

Vira, B. and W. M. Adams. 2009. Ecosystem services and conservation strategy: beware the silver bullet. *Conservation Letters*, 2:158-162.

Voluntary Carbon Standard. 2007. *Guidance for Agriculture, Forestry and Other Land Use Projects*. Voluntary Carbon Standard: Washington, D.C.

Williams, J.N., C. Seo, J. Thorn, J.K. Nelson, S. Ervin, J.M. O'Brien and M.W. Schwartz. 2009. Using species distribution models to predict new occurrences for rare plants. Diversity and Distributions 15: 565-576.

Wilson, M. A. and S. R. Carpenter. 1999. Economic valuation of freshwater ecosystems in the United States: 1971-1997. *Ecological Applications*, 9(3):772-783.

Yankelovich, D. 1991. *Coming to Public Judgment: Making Democracy Work in a Complex World*. Syracuse University Press: Syracuse, New York.

APPENDIX A

Cumulative Effects and Alternative Analysis Template

APPENDIX B

Wetlands Workflow and Data Development

APPENDIX C

Predictive Modeling for At Risk Species

APPENDIX D

Pilot Project Reports

APPENDIX E

Example Function – Natural Flow Regulation

APPENDIX F

Ecosystem-Based Tool Assessment

APPENDIX G

Ecosystem Service Accounting Tools