USDA
Conservation Effects Assessment Project, National Assessment – Wetlands Component Work Plan

Working Draft
October 2008

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Introduction

Wetland ecosystems are components of landscapes valued for an array of services that benefit individuals and society (Mitsch and Gosselink 2000; Taft and Haig 2002; Bedford and Godwin 2003; Haukos and Smith 2003; Jordan et al. 2003; Whigham and Jordan 2003; Sharitz 2003; Ehrenfeld 2004; Leibowitz and Nadeau 2004; Santelman and Larson 2004; Boyer and Polaski 2004; Hansson et al. 2005). Historically, wetland losses and alterations in the United States have been attributed to agricultural activities that eliminated or significantly degraded ecosystem services (Childers and Gosselink 1990; Johnston 1994; Rice et al. 2002; Brinson and Malverez 2002; Hernandez et al. 2006; Venne et al. 2006). The loss or degradation of wetland ecosystems through anthropogenic activities has resulted in decreased fish and wildlife populations, increased flood damage, declines in aquifer recharge, changes in soil chemistry that affect ecosystem processes, and increases in polluted waterbodies (Brinson 1991; Walbridge and Richardson 1991; Baber et al. 2002; Bruland et al. 2003; Gleason et al. 2003; Jenkins et al. 2003; Zedler 2003; Gray et al. 2004; Sigua et al. 2004).

Wetlands in agricultural landscapes in particular have experienced significant alterations or losses that have resulted in multiple-scale effects (Mensing et al. 1998; Tufford et al. 1998; Houlahan and Findlay 2005). National efforts to conserve wetlands have slowed the rate of historical losses, particularly from agricultural conversion (see the USDA National Resources Inventory 2003 gross gains and losses and net changes at: http://www.nrcs.usda.gov/technical/NRI/2003/table4.html). However, the effects and effectiveness of USDA conservation practices and Farm Bill conservation programs on ecosystem services provided by wetlands in agriculturally dominated landscapes are relatively unknown.

Various conservation provisions have been included in Farm Bill legislation to slow wetland loss. The 1986 Farm Bill included a significant wetland conservation provision, “Swampbuster,” that was developed to halt wetland loss in agricultural lands by penalizing producers receiving USDA payments if they manipulated wetlands to grow a commodity crop. The 1990 Farm Bill established the Wetlands Reserve Program, to *. . .protect, restore and enhance the functions and values of wetland ecosystems. . .* (USDA, Natural Resources Conservation Service 2007). Ecosystem services provided by wetlands were initially inadvertently partly or fully re-established where landowners enrolled wetlands and associated uplands in the Conservation Reserve Program (CRP) and practices were implemented to restore native upland cover surrounding wetlands that were never drained or not drained effectively. More recent initiatives under CRP encourage active hydrologic restoration of specific wetlands (e.g., prairie potholes, playas,

bottomland hardwoods. In addition, practices to restore or manage wetlands for specific water quality or fish and wildlife habitat goals are specified through the state-federal cost-share Conservation Reserve Enhancement Program (CREP), intended to target specific practices to remedy identified environmental problems for a selected geographic area. Wetlands also may be managed or re-established as part of the Wildlife Habitat Incentives Program (WHIP), and wetlands constructed for point-source pollution reduction purposes are funded through the Environmental Quality Incentives Program (EQIP).

While Farm Bill and non-Farm Bill conservation programs targeting wetlands have undoubtedly contributed to the return of ecosystem services attributable to wetlands, the cumulative contribution of wetlands and associated upland and aquatic environments in agriculturally-dominated landscapes has not been measured directly at scales that can contribute meaningfully to national conservation policy discussions regarding water pollution, atmospheric pollution, water quantity, or fish and wildlife population sustainability and habitat quality. In addition, the specific treatments associated with the suites of practices undertaken to re-establish and/or manage wetlands may result in unexpected tradeoffs among services. For example, planting nonnative vegetation in the uplands surrounding re-established wetlands to control erosion can impede hydrologic re-establishment in the wetland, further impairing biogeochemical processes that drive wetland functions and production of other wetland services, such as optimal fish and wildlife habitat or reduction of greenhouse gases through carbon sequestration.

The 2002 Farm Bill significantly increased funding levels since the 1996 Farm Bill for conservation programs, including those targeting wetlands (USDA Economic Research Service 2002; Mausbach and Dedrick 2004). The Conservation Effects Assessment Project (CEAP) was initially developed by the Natural Resources Conservation Service (NRCS) and the Agricultural Research Service (ARS) to *quantify the environmental benefits of conservation practices at the national and watershed scales as a measure for how the money being spent is meeting the goals* (Mausbach and Dedrick 2004). The scope of CEAP is defined to address resource concerns for which Farm Bill conservation programs are designed: water quality (e.g., nutrients, sediments, pesticides), water conservation (e.g., drought, flooding), soil quality (e.g., carbon sequestration, soil erosion), air quality (e.g., particulates, odors) and wildlife habitat (both aquatic and terrestrial). Specific *agricultural land use categories* were emphasized for national and watershed level assessments, including cropland, grazing land, and wetlands. Farm Bill Conservation Programs identified for inclusion in the scope of CEAP are EQIP, CRP, WHIP, Grassland Reserve Program (GRP),

National Conservation Technical Assistance Program (CTA), Conservation Security Program (CSP) and Wetlands Reserve Program (WRP) (Mausbach and Dedrick 2004).

A *Blue Ribbon Panel*, facilitated by the Soil and Water Conservation Society, was established *. . .to provide an external policy-level review of CEAP* (Soil and Water Conservation Society 2006). While the panel strongly endorsed the original scope of CEAP, the panel recommended that CEAP revise its direction to *. . .become the coherent science-based assessment and evaluation system that policy-makers, program managers, and the conservation community urgently needs* (Soil and Water Conservation Society 2006). Specifically, the panel recommended that *(1)* CEAP should become part of a larger and *ongoing* collaboration *. . .to inform and adapt strategic resource management* and *(2) CEAP should define and test the science base for adaptive management of conservation programs* (Soil and Water Conservation Society 2006).

The CEAP national assessment is currently comprised of four components, coordinated by the NRCS: Cropland, Wildlife, Grazing Lands and Wetlands. Watershed level activities of CEAP are coordinated by the ARS, Cooperative State Research, Education and Extension Service and the NRCS. Details on CEAP national assessment and watershed activities and products can be viewed at:

http://www.nrcs.usda.gov/technical/NRI/ceap/

Work plans for each of the national components have been or are being developed that identify the scope, methods, timeframe and products for each component. The Work Plan for the wetlands component of CEAP identifies the purpose and current structure of the wetlands component. General products and a timeframe for delivering information from the component activities are also included. However, the document, like the wetlands component itself, is not static but will continue to evolve as a result of new ideas and methods, and refinement of conservation needs.

Overview of the CEAP-Wetlands Component

The Wetlands National Assessment Component (CEAP-Wetlands) was developed to address the initial scope of CEAP, and to the extent possible, incorporate the Blue Ribbon Panel's recommendations to develop a mechanism that provides information for strategic management of resources within an adaptive management approach to conserve wetlands and the landscapes they are embedded within. CEAP-Wetlands has two goals:

1. **Provide science-based data, results and information to routinely inform conservation decisions affecting wetland ecosystems and the services they provide, particularly focusing on the effects and effectiveness of USDA conservation practices and Farm Bill conservation programs on ecosystem services provided by wetlands in agricultural landscapes.**
2. **Develop a broad collaborative foundation that facilitates the production and delivery of scientific data, results and information.**

Five objectives have been developed to achieve the two goals:

OBJECTIVE 1. Conduct collaborative regional investigations. The regional investigations will provide data to:

- quantify wetland ecosystem services across an alteration gradient in agricultural landscapes,
- interpret effects and effectiveness of conservation practices and programs on ecosystem services,
- identify multiple-scale factors that influence the capacity for a wetland to provide an ecosystem service within a predicted range of estimates and
- develop integrated landscape monitoring and simulation modeling capability within NRCS as part of a National Wetlands Monitoring Process.

Wetland ecosystem services are intricately linked to biogeochemical and physical processes operating *in situ* and at landscape scales. As such, the structure and function of wetlands cannot be separated from the provisioning of ecosystem services nor the optimization of those services to benefit people. The following wetland ecosystem services represent a sampling of services that may be affected by implementation of conservation practices on agricultural landscapes and that may be the focus of CEAP-Wetlands regional investigations, depending on the wetland class of interest and the resources available to conduct the investigations:

- Suitable fish and wildlife habitat
- Pollutant regulation
- Storm water runoff and floodwater regulation
- Greenhouse gas emissions regulation
- Water sustainability
- Cultural benefits
- Provisioning of goods

The economic benefits derived from these and other services is also of value to help predict and develop strategic conservation programs.

However, it is key that economic analyses go beyond benefit/cost analyses to better account for and value ecosystem services that may be critical to developing and providing conservation incentives to a range of landowners. It would also be prudent to use the CEAP-Wetlands regional ecosystem service metric data in the economic analyses. This will provide a stronger basis for applying the findings within an agricultural wetlands conservation program and policy environment.

OBJECTIVE 2. Build science collaborations as the foundation of CEAP-Wetlands.

Build upon existing and develop new ***scientific collaborations and partnerships*** (i.e., alliances) to facilitate the science-based foundation of CEAP-Wetlands.

OBJECTIVE 3. Document the scientific knowledge base and gaps in knowledge to understand the effects of conservation practices and programs on wetland ecosystem services.

Conduct a ***literature synthesis*** addressing the effects of conservation practices and programs on ecosystem services provided by wetlands and associated upland and aquatic environments.

OBJECTIVE 4. Analyze NRCS conservation practice and program data to illustrate applications of data to support CEAP-Wetlands research and monitoring activities.

If CEAP is to be effective in scientifically documenting the effects of conservation practices and programs on wetland ecosystem services, and conservation practice and program implementation effectiveness, improvements in these data sources or development of new practice databases need to take into account the application of the data within a CEAP-Wetlands context.

The success of developing a meaningful database of information and fully implementing the monitoring framework for use within the adaptive decision-making process (Objective 5) is critically dependent on having geospatially accurate, easily accessible conservation program and practice data that are linked, regardless of the source of the data.

OBJECTIVE 5. Develop a national wetlands monitoring process to enhance decisions affecting the conservation of wetlands in agricultural landscapes.

Construct a national wetlands *monitoring process* as part of a *national wetlands adaptive decision support process* by developing:

(1) an appropriate subset of the Annual National Resources Inventory

(NRI) sample points as the sampling framework to routinely quantify conservation program and practice effects, and effectiveness of conservation practice design, location and selection on wetland ecosystem services and condition,

(2) remotely sensed and field-based data capture tools and methods,

(3) an integrated spatially-explicit and temporally robust landscape model that can be used for, among other applications, simulation and forecasting, and

(4) mechanisms to transfer results to users.

The following sections of the work plan provide additional details regarding each of the above objectives.

Collaborative Regional Investigations (Objective 1)

CEAP-Wetlands regional investigations produce data for use in the following applications:

1. interpreting onsite and offsite conservation practice and program effects on ecosystem services provided by wetlands and associated upland and aquatic environments,

2. evaluating the effectiveness of conservation practices and land treatments[1] (i.e.,) to achieve specific ecosystem services within an identified spatial scale,

3. developing predictive wetland condition models to identify multiple-scale factors that influence the capacity for a wetland to provide an ecosystem service within a predicted range of estimates, and

4. constructing a temporally-robust and spatially-explicit integrated landscape model and model input variables from remotely-sensed and field-collected data as a component of the National Wetlands Monitoring Process (see Objective 5).

[1] Land treatments are the structural and non-structural applications associated with each conservation practice. Land treatment equates generally with the term practice "component" that is affiliated with practice cost information developed by NRCS.

The ability to routinely interpret effects on and changes in wetland ecosystem services due to land use changes, conservation applications, climate change and other drivers is currently unavailable for wetlands in agricultural landscapes. As a result, the preliminary information produced from the regional investigations, particularly those investigations conducted early in CEAP-Wetlands, will be *point-in-time estimates* (i.e., temporally and spatially constrained) for ecosystem services resulting from implementation of conservation practices and programs to establish or manage wetlands in agricultural landscapes. Research to develop wetland condition models, simulation modeling and forecasting capability, data collection methods and a mechanism to routinely produce information necessary to enhance decisions affecting wetlands conservation is the ultimate goal of the regional investigations. The result of this research will be incorporated in a National Wetlands Monitoring Process, addressed below in Objective5.

Eleven geographic areas of the conterminous United States have been identified (**Figure 1**) to initially focus CEAP-Wetlands investigations to provide data for the four types of applications listed above. The boundaries shown on Figure 1 may be refined, depending on the scope of a particular study. The 11 CEAP-Wetlands regions were identified to capture geographic areas where historic wetland losses have been most pronounced due to agricultural activities and where significant USDA conservation resources have been invested to re-establish, manage or otherwise conserve wetland ecosystems and the services they provide. However, to comprehensively address wetlands conservation on agricultural landscapes, the existing CEAP-Wetlands geographic scope needs to be expanded. Therefore, additional regions will be identified to eventually provide coverage of the conterminous United States, Alaska, the Pacific Basin and the Caribbean.

CEAP-Wetlands regional investigations are collaborations with regional scientists. Studies are designed using accepted scientific methods. Where possible, they build on existing relevant studies, but may also involve new data collection initiatives where data gaps exist that have to be addressed to calculate ecosystem service estimates and interpret effects of conservation practices and programs.

Each CEAP-Wetlands regional investigation, while designed for regional specifics, is structured around a similar ecological conceptual model (**Figure 2**). The CEAP-Wetlands conceptual model is based, in part, on ecological tenets that provide the basis for the “hydrogeomorphic” approach (i.e., HGM) to wetland functional assessment (Smith et al. 1995). Where appropriate, terminology developed for the HGM classification (Brinson 1993) and functional assessment (Smith, et al. 1995) is used to describe the CEAP-Wetlands conceptual model.

CEAP-Wetlands regional investigations incorporate the concept of *reference* (Smith et al. 1995) in the conceptual model regarding the potential differences in ecosystem service estimates that likely exist along an *alteration gradient* (Figure 2). The alteration gradient represents anthropogenic modifications to landscapes or atmospheric conditions that can affect wetland ecosystem structure, function and services. In CEAP-Wetlands regional investigations, *reference* represents the change in ecosystem service estimates where practices to re-establish, manage or conserve wetlands have been applied compared to sites where such practices have not been applied but where wetlands previously existed and/or altered wetlands currently exist (e.g., prior-converted cropland and farmed wetlands, respectively). However, measuring ecosystem services across the alteration gradient to include existing, relatively unaltered wetlands provides more comprehensive information to make conservation decisions affecting wetlands on agricultural landscapes.

Comparisons of ecosystem service estimates between those measured at sites where wetland practices and Farm Bill conservation programs have been implemented and those measured for the native wetland sample sites provides important information affecting policy, program and/or technical applications regarding agricultural wetlands:

1. Whether applying conservation practices and Farm Bill program policies and guidelines affecting wetlands and associated environments result in providing the same services as native wetlands, and whether they are within the expected range of estimates provided by the native systems;
2. Whether different services are provided due to applying conservation practices and Farm Bill programs and the interpretation of that difference; and
3. Whether the conservation practice/Farm Bill program wetlands and associated land are or will evolve to provide landscape-level services similar to what the native population provided historically or currently does.

Sampling along the alteration gradient also allows quantified *predicted* ecosystem service estimates for the wetland population class at a regional scale, not just quantified estimates for the sites sampled.

The dominant hydrogeomorphic class or classes of wetlands, including USDA program wetlands, that lie along the alteration gradient of land cover and hydrology on agricultural landscapes comprise the initial sample population in each region, i.e., the “reference domain” (Smith et al. 1995;

Brinson and Rheinhardt 1996). For example, depressional wetlands, commonly known as prairie potholes, are the focus of the regional assessment in the Prairie Pothole Region of the United States. In the Mississippi Alluvial Valley, the focus of the regional assessment is bottomland hardwood wetlands which falls into riverine, depressional and flats HGM classes. Again, sample sites were selected along a gradient of altered land cover: cropland and native forest cover at the two ends of the gradient, as well as inclusion of sites selected from lands enrolled in WRP where practices to restore wetland ecosystem services have been implemented. Further stratification of the sample population by regional physiographic features, site 'age,' conservation goal (e.g., hydrologic restoration vs. non-hydrologic restoration), level of management on sites with practices applied, and other regional criteria may also be used to further minimize the variability associated with a strictly random sampling approach.

The following sections provide additional information on the applications of the data derived from the regional investigations.

Point-In-Time Estimates for Wetlands Ecosystem Services to Interpret Conservation Practice and Program Effects

CEAP-Wetlands regional investigations conducted from 2005–2010 will focus primarily on interpreting the effects of implemented conservation practices and programs through point-in-time estimates for ecosystem service metrics. Point-in-time estimates will be produced from the following five regional investigations:

- Prairie Pothole Region
- Mississippi Alluvial Valley Region
- The High Plains Region
- California Central Valley/CA-OR Intermountain Region
- Mid-Atlantic Coastal Rolling Plain and Coastal Flats Region

Following is a brief description of the five regional studies.

Prairie Pothole Regional Investigation

The first regional study was initiated in 2004 in the Prairie Pothole Region (PPR) of the United States. NRCS is collaborating with the U.S. Geological Survey and Farm Service Agency to conduct the investigation.

The USGS Northern Prairie Wildlife Research Center, Jamestown, ND, is the science lead. The sample population was selected from drained and non-drained wetland catchments (i.e., the wetland basin plus the upland portion draining into the basin) on croplands, wetlands enrolled in CRP and

WRP where practices have been implemented to restore wetland services (primarily wildlife habitat), and in native prairie where tillage is not known to have occurred although the lands may have been grazed. In addition, the sample population was further stratified to include age of restoration site, wetland catchment type (i.e., temporary, seasonal, and semipermanent) and sub-physiographic province (i.e., Glaciated Plains and Missouri Coteau). The following ecosystem services are being quantified through several metrics: Regulating Pollutants, Regulating Greenhouse Gases, Regulating Storm Water Runoff and Floodwater, and Supporting Suitable Fish and Wildlife Habitat. An extensive survey to collect onsite and several landscape variables was conducted from May through September 2004. Additional sample design details are available from the preliminary findings (http://pubs.usgs.gov/pp/1745/).

A separate but related study focusing on amphibians was initiated in 2005. The purpose of this study was to investigate the effects of land use on amphibian species richness and occupancy in seasonal prairie depressional wetland catchments in the Glaciated Plain sub-physiographic region. The study was also a pilot to identify suitable methods that could be used to conduct a regional amphibian study as part of the integrated landscape model research underway in the Prairie Pothole Region. The amphibian study plan is available at ftp://ftp-fc.sc.egov.usda.gov/NHQ/nri/ceap/amphibian_signatures.pdf. The results of the study are expected by October 2008, and will be published on the NRCS CEAP Web site at that time.

Mississippi Alluvial Valley Regional Investigation

The Mississippi Alluvial Valley Regional Investigation (MAV) was initiated in 2005. The USGS National Wetlands Research Center leads the science team composed of scientists from the Center, the U.S. Fish and Wildlife Service Lower Mississippi Valley Joint Venture Office and Ecological Services Office, and Ducks Unlimited. Similar to the PPR study, sampling occurred in sites selected across a land cover alteration gradient: cropland, lands enrolled primarily in WRP where conservation practices have been applied to restore wetland services on former cropland, and mature bottomland hardwood wetlands (BLH).

Initial sampling occurred in Louisiana and Arkansas. Sample sites were selected across the alteration gradient, eight each from the Lower White/Cache River Basin in Arkansas and from the Tensas River Basin in Louisiana. The sites were selected to represent former hydrogeomorphic landscapes occupied by BLH wetlands while also selecting lands enrolled in WRP that represent common practices and land treatments/techniques associated with restoring BLH wetlands in the two river basins. All WRP

sample sites involved hydrologic restoration. Data collection will also be conducted in the Yazoo Basin, Mississippi, in 2008, to provide point-in-time estimates and validate draft predictive wetland condition indicator models developed from the Louisiana and Arkansas data.

Interim findings are available at http://www.nrcs.usda.gov/technical/NRI/ceap/MAVreport.pdf.

The High Plains Regional Investigation

The regional study in the High Plains was initiated in 2006. The science team is led by the Oklahoma State University, with scientists from Texas Tech University, and U.S. Fish and Wildlife Service Migratory Birds and Habitat and Population Evaluation Team collaborating on the study. Playa wetlands are the focus of the study. Approximately 300 playa catchments have been selected from cropland, lands enrolled in CRP and WRP where practices have been implemented to restore the playa catchment, and native prairie. Physical and ecosystem process variables will be collected for a variety of metrics associated with the following ecosystem services provided by playa catchments: Regulating Water Sustainability, Supporting Suitable Habitat for Fish and Wildlife Species, Supporting Ecosystem Structure and Function to Conserve and Sustain Native Biota, Regulating Pollutants, and Regulating Storm Water Runoff and Floodwater. The study design can be accessed at: ftp://ftp-fc.sc.egov.usda.gov/NHQ/nri/ceap/thp_research_plan.pdf.

California Central Valley/Upper Klamath River Basin Regional Investigation

The fourth regional investigation was initiated in 2006, initially for the California Central Valley (CCV). Comments and data presented at the scoping meeting, and follow-up information requested from the NRCS Oregon state office, indicated that the regional study should be extended to include the California/Oregon Intermountain Region and the Upper Klamath River Basin (UKRB). As a result, the study now includes the CA Central Valley physiographic region and the Upper Klamath River Basin that lies within the Pacific Mountain Region. The USGS Cooperative Fish Research Unit at Humboldt State University leads the study.

The CCV/UKRB study is designed to capture effects of conservation practices commonly used to establish and manage wetlands, in two of the most intensively managed agricultural regions in the United States, the Central Valley and the Upper Klamath River Basin. The study has two objectives. The first objective focuses on quantifying ecosystem services provided by freshwater wetlands and interpreting the effects of implementing a suite of conservation practices used to restore freshwater wetlands and their services on lands enrolled in the WRP. Wetlands selected

for sampling will follow the CEAP-Wetlands conceptual design, including selection of sites located along an alteration gradient of land cover (i.e., cropland, WRP lands, mature hydrologically managed wetlands such as those on U.S. Fish and Wildlife Service refuge lands). The extensive hydrologic alteration in the CCV required application of the CEAP-Wetlands conceptual design within the constructs of existing conditions. In effect, the mature hydrologically-managed wetlands represent the optimal target for wetland restoration on private and public lands in the CCV. The study will be stratified by management intensity and restoration "age," and along precipitation gradients. Approximately 150 seasonal and semipermanent wetlands will be sampled once to quantify metrics for the following ecosystem services: Supporting Suitable Fish and Wildlife Habitat, Regulating Pollutants, Regulating Storm Water Runoff and Floodwater, and Supporting Ecosystem Structure and Function to Support Native Biota.

The second objective involves quantifying metrics for the ecosystem services identified for the first objective in four types of wetlands established and managed by conservation practices. A total of 36 temporary, seasonal, semipermanent and riparian wetlands in the Sacramento River Basin, Upper Klamath River Basin and California Intermountain Region will be sampled. Repeated measures sampling will be used to sample various biota (e.g., fish, amphibians), with edaphic and morphological data collected once. The purpose of this objective is to quantify and compare ecosystem service metrics for different types of wetlands established and managed on lands enrolled in WRP. The CCV/Intermountain Region study plan can be viewed at: ftp://ftp-fc.sc.egov.usda.gov/NHQ/nri/ceap/ccv_proposal.pdf.

Mid-Atlantic Rolling Plain and Coastal Flats Regional Investigation

The two regions that comprise the Mid-Atlantic study area are characterized by a diversity of wetland types, HGM classes and conservation practices and programs, and a rural-urban land mix. A preliminary scoping meeting was held in 2006, followed by a more focused meeting in late 2007 to facilitate development of the study science team led by the USDA Agricultural Research Service. The study design is still undergoing development, with data collection expected to begin in late winter 2008/early spring 2009.

Regional Investigation Scoping Meetings

The scope of the investigations to produce preliminary information on conservation practice and program effects on wetland ecosystem services is determined through meetings with potential collaborators and other stakeholders. The following information is gathered at the scoping meeting to design the study and identify resources necessary to support it:

- the geographic extent of the investigation,

- the regional class of interest,
- the ecosystem services to be quantified,
- the specific ecosystem service metrics to be measured,
- metric variables to be collected,
- identification of conservation practices and land treatments applied in the region that may affect ecosystem services, and
- identification of Farm Bill conservation programs associated with the applied practices

Invitations to participate in the scoping meetings are extended to researchers, conservation practitioners, NRCS state office staff and other conservation stakeholders, and a science lead is identified to lead the study. Preliminary information on conservation practices and programs is extracted from the NRCS National Conservation Planning Database for the CEAP-Wetlands regions for site selection purposes, but coordination with NRCS state office staff is critical to the acquisition of more extensive information for sites identified for field sampling. Similarly, the NRCS national programs geospatial coverage is used to assist in identifying sites for sampling. On average, the studies conducted to produce point-in-time ecosystem service estimates and interpretation of conservation effects are three years in length. A variety of scientific and technical products from the studies will be distributed via the CEAP product line (e.g., CEAP Science Notes, CEAP Conservation Insights), the CEAP-Wetlands Web page (http://www.nrcs.usda.gov/technical/NRI/ceap/wetlands.html), peer-reviewed journals, scientific meetings and other forums.

Conservation Practice Effectiveness

Documenting the *effectiveness* of conservation practices and land treatments is needed within the broader regional study framework to improve applicability of monitoring results to conservation actions on agricultural landscapes affecting wetlands, and to translate those results to improve on-the-ground conservation affecting wetlands. Studies will be undertaken within a CEAP-Wetlands region, may be at a watershed- or regional-scale, and will be designed to evaluate the effectiveness of conservation practices and the associated land treatments to achieve specific ecosystem services. Factors that will be evaluated regarding practice/land treatment effectiveness include-

- the type and number of practices/land treatments needed to address one or more specific ecosystem services,
- location placement,
- practice/land treatment management, and
- ecosystem service metric targeted value(s).

The studies will focus on one or more practices and the associated land treatments that are and should be implemented to address significant drivers and stressors (i.e., factors identified through the predictive wetland condition indicator models whose inclusion in the indicator model decreases ecosystem service metric estimates). Data and results from these studies will also be used to calibrate regional algorithms developed for the integrated landscape model so that simulation modeling and forecasting can be undertaken, particularly to evaluate the potential effects of climate change on conservation practice/land treatment effectiveness. Depending on the scale at which such data are collected, additional data collection regarding practice effectiveness may be required to validate the regional algorithms.

Studies focusing on conservation practice effectiveness will be posted to the CEAP-Wetlands Web page (http://www.nrcs.usda.gov/technical/NRI/ceap/wetlands.html).

Regional Predictive Wetland Condition Indicator Models

The regional investigations also provide data and the range of estimates for each ecosystem service measured to develop the predictive wetland condition indicator models. The predictive models essentially reflect the drivers of wetland ecosystem change and specifically seek to identify the factors that affect the level of services produced (Millennium Ecosystem Assessment 2003). Research and development of the models results in two primary applications:

1. Translating the scientific information into various media (e.g., translating scientific information from CEAP Science Notes for development of Science and Technology Tech Notes) to improve conservation practice and program applications from field to national scales; and,
2. Developing an operational process to apply the models to inform existing NRI wetlands status and trends acreage results or as a contribution to conservation program performance outcomes (e.g., WRP ecological performance; see OBJECTIVE 5 below).

The estimates produced for any one ecosystem service reflects a range of estimates produced along the alteration gradient from which the regional wetland sample population was drawn. Multivariate tools are used to develop the predictive wetland condition indicator models (i.e., regression models) that identify the multiple-scale factors that influence the capacity for a group of wetlands from the regional sample population to provide an ecosystem service within a predicted range of estimates. Production of several models are likely for any given ecosystem service. One aspect of the

model development research will involve investigating relationships between field-collected data that are incorporated in the model and remotely-sensed data to identify potential surrogates for the model factors while maintaining model integrity. The regional models will be validated to ensure that their application is germane to the alteration gradient represented by the regional sample population. The linkage between the ecosystem service estimates and the predictive wetland condition models is presented in **Figure 3**.

Currently, status and trends in wetland acreage extent are produced by NRCS as part of the Annual NRI. However, the condition models provide an operational tool that can be routinely applied to measure site and landscape factors that influence the capacity of the regional wetland class to provide ecosystem services at some predetermined level (i.e., the range of estimates produced from the regional study sample population selected across the alteration gradient). Operationally, model factors (data) would be captured using a GIS overlay composed of remotely sensed data (i.e., aerial photography, satellite imagery) and geospatial conservation program data (e.g., WRP easements, practice data) (**Figure 4**). Changes in one or more factor values at a site result in either application of a different condition model for that site (i.e., indicative of a change in the ability of a wetland to provide the same level of an ecosystem service as previously estimated) or development of an entirely new condition model (i.e., where the ecosystem service estimate varies significantly from that estimate range previously measured). It is envisioned that periodic research will be required to refine existing models; discard obsolete models; and develop, verify and validate new models.

Once the models have been developed for each regional investigation, a similarity analysis will be done to identify those models that are similar in structure (although the variable and ecosystem service estimates may differ) within and among wetland classes. The results may provide an alternative means to reduce the number of models to apply within an Annual NRI context. Models that highlight regionally important wetland ecosystem services, however, also should be used routinely, perhaps as part of the National Wetlands Monitoring Process.

Integrated Landscape Modeling

Efforts to quantify wetland ecosystem services to interpret conservation effects under existing or future conditions as part of the CEAP National Assessment are challenged by the lack of a modeling and data collection mechanism that captures the temporal and spatial variability that directly affects wetland ecosystems (i.e., natural disturbances such as fire, drought, flooding, and anthropogenic decisions that result in activities that modify climate, land use, and land management). Such a mechanism would

provide the means to routinely provide information to improve decisions affecting wetlands conservation and the services they provide.

Building upon the CEAP-Wetlands PPR Investigation, USGS, in collaboration with NRCS, the Farm Service Agency (FSA) and the U.S. Fish and Wildlife Service (FWS), saw the need to explore the feasibility of developing such a mechanism that would allow NRCS, FSA and FWS to improve upon the data and information used to produce performance outcomes, make conservation decisions, and conduct predictive simulations for policy and program applications. This shared vision culminated in the four agencies signing a Memorandum of Understanding that provided the structural platform to collaboratively pursue development of such an approach. Two CEAP-Wetlands regions – the PPR and the MAV– were identified as pilot areas by the USGS as part of a 2007 national USGS initiative to explore the feasibility of developing an Intergraded Landscape Monitoring approach (ILM). Each pilot is tasked with developing an *. . .operational framework to observe, monitor, understand, and predict landscape change and implications on natural resources and ecosystem processes at multiple spatial and temporal scales* (Euliss et al. 2008). The pilots are designed as five-year research investigations. The PPR ILM pilot study plan can be accessed at: ftp://ftp-fc.sc.egov.usda.gov/NHQ/nri/ceap/ILM_PPR_StudyPlan4_TierII_modified.pdf The study plan for the MAV will be available on the CEAP web site in the near future.

Two aspects of the USGS ILM pilots are relevant to developing the mechanism needed to monitor or simulate changes in wetland ecosystem services resulting from conservation practices and programs or other factors. First, the ILM research in both regions will develop modeling capability. A frame-based model structure is being used to develop specific regional algorithms that eventually will allow the model to estimate and simulate changes in wetland ecosystem services and the factors affecting those services (including conservation practices and programs). The model is designed to address all ecosystem services simultaneously, obviating the need to have several models for different ecosystem services. A GIS-based landscape model is ultimately needed to make efficient synergistic use of remote sensing and other spatial data, as well as to enhance the capacity to simulate temporal effects in a way that is visually apparent. The other relevant aspect of the ILM pilot research is also to identify those model input variables that can be captured via remotely sensed data to further enhance the application of the ILM modeling within a national operational monitoring framework.

A complementary research collaboration, led by the ARS Hydrology and Remote Sensing Lab, Beltsville, MD, is also investigating the application of several remote sensing technologies to capture data that ultimately can be used to predict ecosystem services within a GIS framework. The CEAP-Wetlands Choptank River Watershed Landscape study is an extension of the ARS CEAP Benchmark Watershed study underway in the watershed, a tributary to the Chesapeake Bay (ftp://ftp-fc.sc.egov.usda.gov/NHQ/nri/ceap/choptankceapoverviewfinal61407.pdf).

Intensive sampling will be conducted in headwater wetlands across an alteration gradient (prior-converted wetlands on cropland, lands enrolled in Farm Bill conservation programs where practices have been implemented to re-establish or manage wetland services, and native forested wetlands). Sampling will focus on changes in nutrients across the landuse alteration gradient, the effects of hydrogeologic processes on the capacity of wetlands to transform nutrients transported in surface- or groundwater across the alteration gradient, wetland-stream ecosystem process and functional linkages, and the linkages among habitat quality, nutrient reduction and hydrogeologic processes. The field collected data will be used to validate the use of Synthetic Aperture Radar (SAR), high resolution LIDAR (Light Detection and Ranging), multispectral remotely sensed data and GIS technologies to estimate wetland ecosystem services. This GIS-based landscape tool will be merged with the frame-based landscape model developed from the USGS ILM research to produce a prototype for operational testing to eventually provide GIS-based landscape modeling capability.

Data collected from the High Plains, CCV and Mid-Atlantic Coastal Rolling Plain and Coastal Flats regional studies that will produce point-in-time estimates will also be used to calibrate and validate the ILM algorithms specific to their regions and the remote data capture technologies used to capture model input data for the algorithms. Investigations initiated after 2008 will focus on collecting data to calibrate and validate the regional algorithms that run the integrated landscape model. In addition, data and results from the intensive studies conducted within a region that focus on conservation practice/land treatment effectiveness will be incorporated into regional calibration and validation efforts.

Initially, only wetland classes that predominate the regional landscape and form a significant proportion of the types of wetlands affected by conservation practices and programs will have algorithms developed for incorporation into the Integrated Landscape Model. Other wetland classes can be added over time as needed, following the CEAP-Wetlands regional study template for calibration and validation.

As of June 2008, the ILM pilot in the PPR had developed the prototype frame-based model and initiated research to improve early prototype algorithms specific for prairie depressional wetland catchments, as well as conducted preliminary research to investigate remote sensing data collection applications. Further refinement of the model algorithms and remote sensing data collection is underway within a 3 mile x 18 mile core study area near Jamestown, ND, that includes the USGS Cottonwood Lake Study Area as well as other wetlands sampled by USGS investigations, including the 2004 CEAP-Wetlands PPR study (Euliss et al. 2008). Further refinement and validation of the regional algorithms, including applicability of the regional algorithms to prairie depressional wetlands throughout the PPR, is scheduled to begin in FY09 and run through FY10. The phase following the PPR regional algorithm validation will focus on testing the use of NRI data points in the PPR as a sampling framework. Collaboration with the USGS PPR ILM research team will continue during this phase.

Prototype regional algorithms for bottomland hardwood wetlands in the MAV are also under development, but they are less well developed than those in the PPR for several reasons including level of funding support and availability of appropriate long-term and relevant hydrologic data. Bottomland hardwood wetlands in the MAV occupy several hydrogeomorphic positions (e.g., Riverine, Mineral Flats). Similar to the PPR algorithms for prairie depressional wetlands, development of the MAV algorithms for the ILM will provide template algorithms for refinement and validation in other CEAP regions where similar wetland hydrogeomorphic classes on agricultural landscapes exist (e.g., MIAR). However, without appropriate funding, development of the MAV algorithms will be hampered, perhaps truncating use of the ILM for national wetlands monitoring purposes.

Eventually, operational simulation modeling and forecasting capability, using USDA conservation program geospatial data and/or a subset of NRI sample points as the monitoring framework (i.e., the population to monitor), will be produced as a key component of the National Wetlands Monitoring process (see Objective 5 for further details).

Building Science Collaborations (Objective 2)

CEAP-Wetlands is designed as a collaborative effort because its foundation is science-based. Objective data collection, analysis and deliverable production is key to documenting conservation outcomes and identifying conservation needs of wetland ecosystems as well as the services provided by wetlands and associated upland and aquatic environments. The involvement of scientists from Federal and state government agencies,

NGO's, for-profit companies, and academia ensures that objective scientific information is produced by CEAP-Wetlands.

Policy-makers, program managers, conservation practitioners, landowners and other conservation stakeholders are also important collaborators. Without their support, interest and feedback, CEAP-Wetlands ceases to be an effective tool to wetlands conservation in agricultural landscapes. Two specific activities—a Peer-Review Science Panel and regional assessment scoping meetings—were incorporated into CEAP-Wetlands to solicit input and feedback to improve the structure of CEAP-Wetlands as well as improve communication among a variety of conservation stakeholders within and outside of USDA. The collaborations may also result in exploratory research with resultant application of new technologies or methods within the national wetlands monitoring.

The Peer-Review Science Panel was formed to review the current CEAP-Wetlands conceptual model and structure. A cadre of regional scientists and managers was assembled in May 2005, facilitated by the Association of State Wetlands Managers. Overviews of CEAP-Wetlands, as then designed, and the Prairie Pothole and Mississippi Valley Investigations were presented to the Panel. Panel members suggested emphasizing and clarifying that ecosystem services, and not wetland functions, should be the focus of measurement, as well as making more use of the HGM wetland assessment approach terminology where appropriate.

The Peer-Review Science Panel provided a useful model to periodically hold forums to facilitate continued input from scientific and technological research communities so that there is a institutionalized link between these communities and CEAP-Wetlands activities. The CEAP-Wetlands Coordinator will direct funds in FY 2009 to develop the framework for an annual facilitated Wetlands Science and Technology Research forum.

The regional scoping meetings provide the opportunity to bring managers and research scientists together to outline the scope of the investigation. The meetings are designed to facilitate collaborations that can produce significantly improved information over that produced from individually conducted efforts since such collaborations often leverage resources among the collaborators. This forum establishes a mechanism for continued information exchange between the science collaborators and those from USDA involved in the delivery and implementation of conservation practices and Farm Bill programs affecting wetlands throughout the investigation. The meetings broaden the exposure of CEAP-Wetlands activities in general and the investigation in particular to meeting

participants engaged in similar or complementary efforts, which improves the opportunity for new collaborations.

The efforts to build and widen science alliances are intimately linked with appropriate mechanisms to distribute information from CEAP-Wetlands and, just as importantly, mechanisms to receive input in return, particularly with regard to the types of information generated from establishment of the national wetlands monitoring framework and use of that information. The NRCS CEAP web site (http://www.nrcs.usda.gov/technical/NRI/ceap/) and CEAP-Wetlands web page (http://www.nrcs.usda.gov/technical/NRI/ceap/wetlands.html) provides a useful public source of information, and use of those sites to distribute information derived from CEAP-Wetlands will remain a priority. Responsibility for updating the site currently resides with the NRCS CEAP-Wetlands National Science Coordinator. While input from the coordinator is critical, technical support staff devoted specifically to assembling the information and developing the correct information format to update the CEAP-Wetlands Web page is urgently needed.

Internal and external information exchange vehicles need to be developed so that the information generated from CEAP-Wetlands is relevant, and scientifically credible and applicable. The current CEAP product line (e.g., *CEAP Highlights, CEAP Science Notes, CEAP Conservation Insights*) provides a useful way to distribute information within and external to NRCS, but other mechanisms will need to be developed to improve feedback on the use of CEAP-Wetlands activities and information, particularly once the national wetlands monitoring and modeling capabilities become operational. This area will have to be continuously and judiciously addressed if the investment in CEAP-Wetlands is to be realized.

CEAP-Wetlands Literature Synthesis (Objective 3)

Similar to the CEAP-Cropland, CEAP-Wildlife and CEAP-Grazing Lands components, CEAP-Wetlands is supporting development of a literature/data synthesis to serve as the foundation of scientific knowledge addressing the effects of conservation practices and Farm Bill Programs on ecosystem services provided by wetlands in agricultural landscapes. The synthesis will consist of a series of papers that document the state of understanding regarding conservation practice and program effects on wetland ecosystem services by linking the knowledge of wetland ecosystem processes, drivers, and stressors with what is known and not known about effects of conservation implementation. Most importantly, each paper will communicate the application of this knowledge to policy and management issues of relevance to wetlands conservation at the regional scale. The

CEAP-Wetlands papers will serve as a scientific reference, synthesizing relevant information for wetlands in agricultural landscapes, effects of conservation activities intended to establish or manage wetland ecosystem services, and the strengths and weaknesses associated with policy and management issues relevant to agricultural wetlands and their conservation.

The CEAP-Wetlands synthesis is proposed as a two-volume series. The first volume, targeted for publication in 2009, is a collaboration among NRCS, the U.S. Forest Service, the Ecological Society of America and regional scientists with Federal research agencies and academia. The synthesis is being considered for publication as a Special Issue of *Ecological Applications*. The Special Issue will be composed of a series of papers written by scientists with expertise in wetland ecosystem science, management, and policy. Each paper will cover selected geographic regions of the U.S. to complement the regional focus of CEAP-Wetlands, although not all CEAP-Wetlands regions will be covered in this first synthesis. In addition, a short introduction providing the context for the papers will be authored by the USDA CEAP-Wetlands Science Coordinator. The series will culminate with a paper examining issues common to the regional syntheses that have policy and management implications for wetland ecosystems in agricultural landscapes in the United States. Authors/co-authors and manuscript titles are listed below.

Each regional paper will provide a synopsis of the landscape context as an introduction so that readers will understand the focus of the paper, the synthesis addressing conservation practice and program effects on wetland ecosystem services and the application of this knowledge, or lack thereof, to public policy and management decisions. This general template will connect the papers as an integrated body of information, while the majority of each paper will be devoted to synthesizing information that emphasizes regional distinctions relative to the theme of the overall synthesis document. Papers may include a case study to illustrate specific regional issues that address the linkage between effects of conservation practices and programs, wetland ecosystem services and specific policy or management actions.

A second volume will be initiated to address CEAP-Wetlands regions not covered in the first volume or special geographic areas of regions in the first volume that could not be included. It is envisioned that this effort would begin in 2010 or 2011.

Manuscript titles and authors/co-authors in the CEAP-Wetlands Volume 1 Synthesis:

***Linking Scientific Understanding with Conservation Policy and Management: Ecosystem services, conservation effects and wetlands on agricultural landscapes* (introductory paper)**
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Agricultural conservation practices and wetland ecosystem services in a wetland-dominated landscape: The Piedmont-Coastal Plain region
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Effects of Conservation Practices on Wetlands in the Mississippi Alluvial Valley
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Ecosystem services provided by playa wetlands in the High Plains: Potential influences of USDA conservation programs and practices
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U.S. Department of Agriculture conservation program and practice effects on wetland ecosystem services in the Prairie Pothole Region

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Agricultural conservation practices increase wetland ecosystem services in the Glaciated Interior Plains

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Response of freshwater wetland ecosystems to USDA farm conservation practices in California's Central Valley

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Wetland-associated Ecosystem service and socio-economic benefits of agriculture-related conservation practices in the Appalachian region

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***Patterns and principals of ecosystem services emerging from conservation practice effects on wetlands in agricultural landscapes of the USA* (cross-regional issues paper)**

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Integrating estimates of ecosystem services from conservation programs and practices into models for decision makers: the vision for CEAP Wetlands

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Conservation Practice and Program Data Analyses (Objective 4)

Spatially accurate data on the location and extent of USDA conservation practices and their associated components, and the Farm Bill programs supporting implementation of the practices is critically important to CEAP-Wetlands research and assessment efforts underway and those proposed. Currently, the NRCS National Conservation Planning (NCP) database contains the most extensive information concerning planning and application of conservation practices, components and associated programs. Geo-referenced conservation practices by latitude and longitude exist for most, if not all, states (generally for years beginning 2000–2001 to the present). However, the geo-referenced lat/long presently available at a national level only identifies that one or more conservation practices were planned and/or applied on the landscape—specific location and extent (i.e., footprint) of individual practices are not available at this time. The ability to estimate ecosystem services resulting from applying a suite of conservation practices and components is further complicated by the fact that wetland extent as affected by conservation practices is lacking. While wetland extent often changes due to climatic or other factors, including anthropogenic activities, affecting hydrologic processes, a 'zone of influence' or other similar geo-referenced extent reflecting the influence of conservation

practices on wetlands is necessary to quantify ecosystem services and interpret practice effects.

Acquiring the data directly from the NCP is currently time and labor intensive, but once received reflects the most currently available data. Accessing data via PRS at the NRCS national office does not provide lat/long information nor practice component data, and is temporally constrained, hence, the NCP currently provides the best available source of NRCS conservation practice and Farm Bill data. The NCP data is currently being explored systematically for its quality and application to CEAP-Wetlands activities in parts of 33 of the conterminous United States.

Other data sets of use to CEAP-Wetlands, and which have been used and explored for their application to research and assessment activities, are the spatial coverage of Farm Bill programs administered by NRCS and the NRCS conservation easement programs database. Both provide important boundary or other information, but are not linked to the NCP (nor is the NCP linked to these data sources), making their application in a research or assessment scenario difficult at best.

Efforts are underway within NRCS to improve the spatial data and databases mentioned. However, it is important that—if CEAP is to be effective in scientifically documenting the effects of conservation practices and programs on wetland ecosystem services, and conservation practice and program implementation effectiveness—improvements in these data sources need to take into account the application of the data within a CEAP-Wetlands analytical context.

The National Wetlands Monitoring Process (Objective 5)

Application of a national wetlands monitoring process (i.e., operational institution) will improve the ability to capture information across landscapes that are changing due to a variety of drivers, particularly conservation practices and programs and climate change, to estimate changes in wetland ecosystem services and condition. The conceptual design of the monitoring process is shown in **Figure 5**. It is inherently linked to an *adaptive decision support process* that incorporates use of the monitoring data and analytical results into a variety of decisions that affect wetlands and other natural resources on agricultural landscapes, whether the application is for NRCS operational use (**Figure 6a)** or for broader, national applications (**Figure 6b**). Development of landscape simulation modeling and forecasting capability; remote data capture technologies; and predictive wetland condition models discussed previously are key components of the monitoring framework. However, to effectively contribute to decisions influencing wetlands conservation, mechanisms are needed to distribute monitoring

results to external and internal USDA audiences in a timely fashion. Developing those mechanisms will be an iterative process, beginning with distribution of point-in-time estimates and other relevant information from the initial regional studies distributed through the CEAP-Wetlands web page and CEAP product line (e.g., *CEAP Science Notes*), and through collaborator's publications (e.g., peer-reviewed journals, agency publications). Eventually, landscape and predictive wetland condition modeling results should be made available via a database that is accessible in two related forms, one for external users and one for internal users. As the results become available via GIS, links to user-specified maps or graphics from the results should also be made available.

While the Blue Ribbon Panel final report (SWCS 2006) identified the lack of ". . .plans for on-the-ground monitoring. . ." as a "troubling missing piece" within CEAP, CEAP-Wetlands was designed to facilitate development of a monitoring process relative to wetlands and their associated lands and waters. However, investment in routine on-the-ground monitoring can become expensive and lack a cohesive framework that is needed from a national perspective. Development of the Integrated Landscape Model (ILM), supported by regionally specific algorithms, and the Predictive Condition Indicator Models provide the necessary foundation components of a National Wetlands Monitoring process. ILM data collection using a variety of remote sensing technologies has the potential to minimize routine field data collection at a broad scale, which may be more cost-effective in the long-term. ILM research will identify those data that currently cannot be captured using remote sensing technologies. Continued support of specific research to enhance the ILM regional algorithms and remote sensing data collection will ensure that the monitoring process remains scientifically credible and viable.

A subset of data points within the NRI – focusing on the dominant regional wetland class(es) that are incorporated into the ILM – can be used as the operational monitoring framework (i.e., population to be monitored). Once the ILM is validated and calibrated for PPR prairie depressional wetlands, NRCS can proceed to develop protocols to test use of the ILM and remote data collection technologies developed for the ILM using the subset of NRI data points for prairie depressional wetlands distributed across the PPR. Similarly, the ILM and remote sensing data collection technologies can be tested as a mechanism to document ecosystem services and changes to those services resulting from climate change, conservation practices or other drivers as part of the current WRP compliance effort using aerial photography. Incremental testing and operational use of the ILM using the NRI or WRP as the monitoring framework can proceed as the MAV and other

CEAP-Wetlands regional algorithms are developed, calibrated, validated and incorporated into the ILM.

The results from the National Wetlands Monitoring Process can be used for a variety of applications, including identification of landscapes that are at risk due to anthropogenic activities. Adding the ILM to the suite of modeling tools used by CEAP and using the NRI as the common sampling framework for all these models provides a potentially powerful monitoring application to address multiple resource concerns, issues and potential solutions within a landscape context.

General Timeframe of CEAP-Wetlands Objectives

Presented in **Figure 7** is the CEAP-Wetlands timeline to conduct activities and produce products associated with the five objectives. Changes to the timeline are likely, particularly where funding to support the activities and products is uncertain or insufficient. New activities will be added as necessary.

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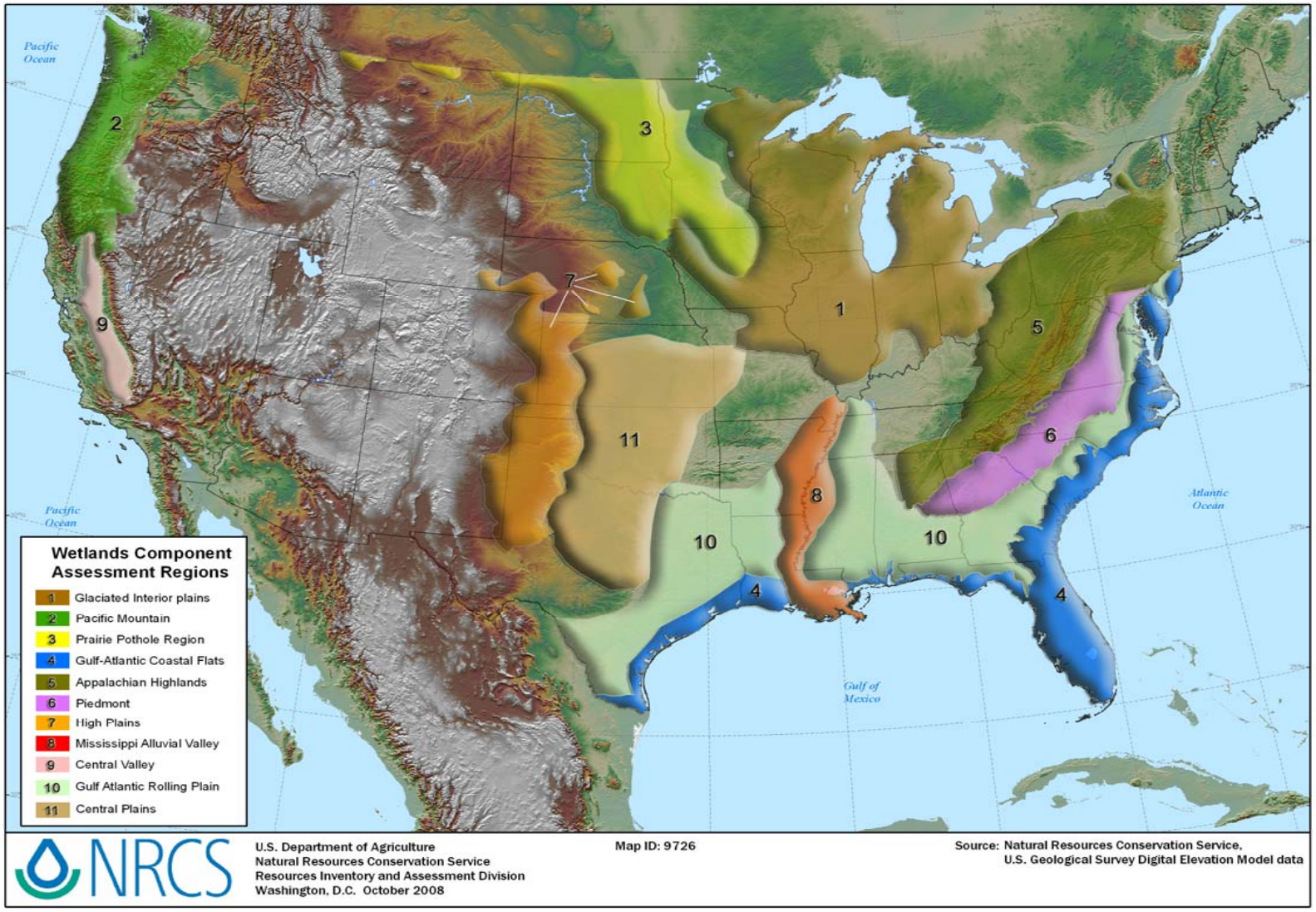

Figure 1. Location of initial CEAP-Wetlands Component regions.

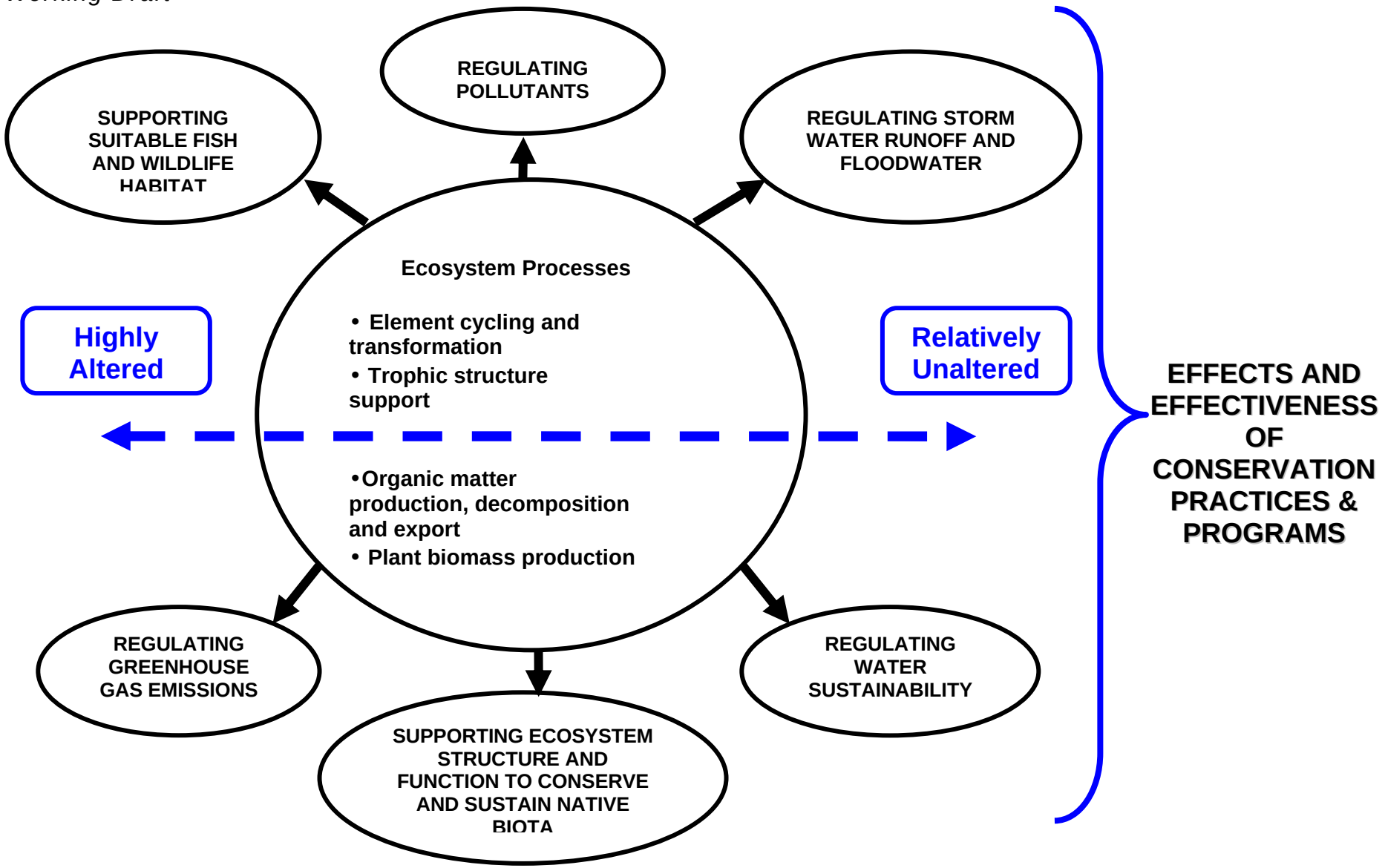

Figure 2. CEAP-Wetlands Conceptual Model illustrating linkages between ecosystem processes, ecosystem services, stressors affecting the provisioning of wetland ecosystem services along an alteration gradient and the effect of implementing conservation practices and programs to ameliorate stressor impacts.

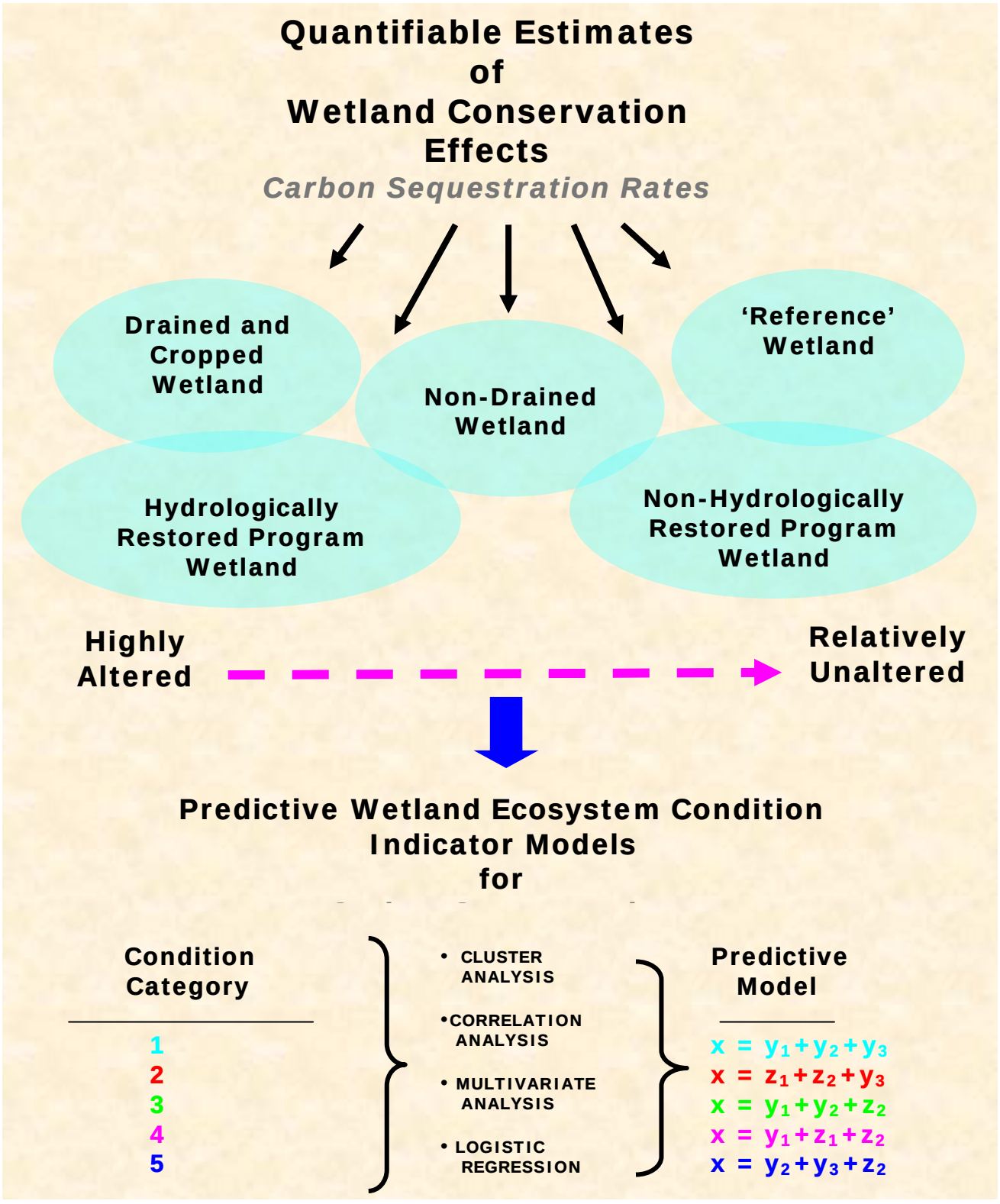

Figure 3. Conceptual framework to develop the CEAP-Wetlands *Predictive Wetland Ecosystem Condition Indicator Models*.

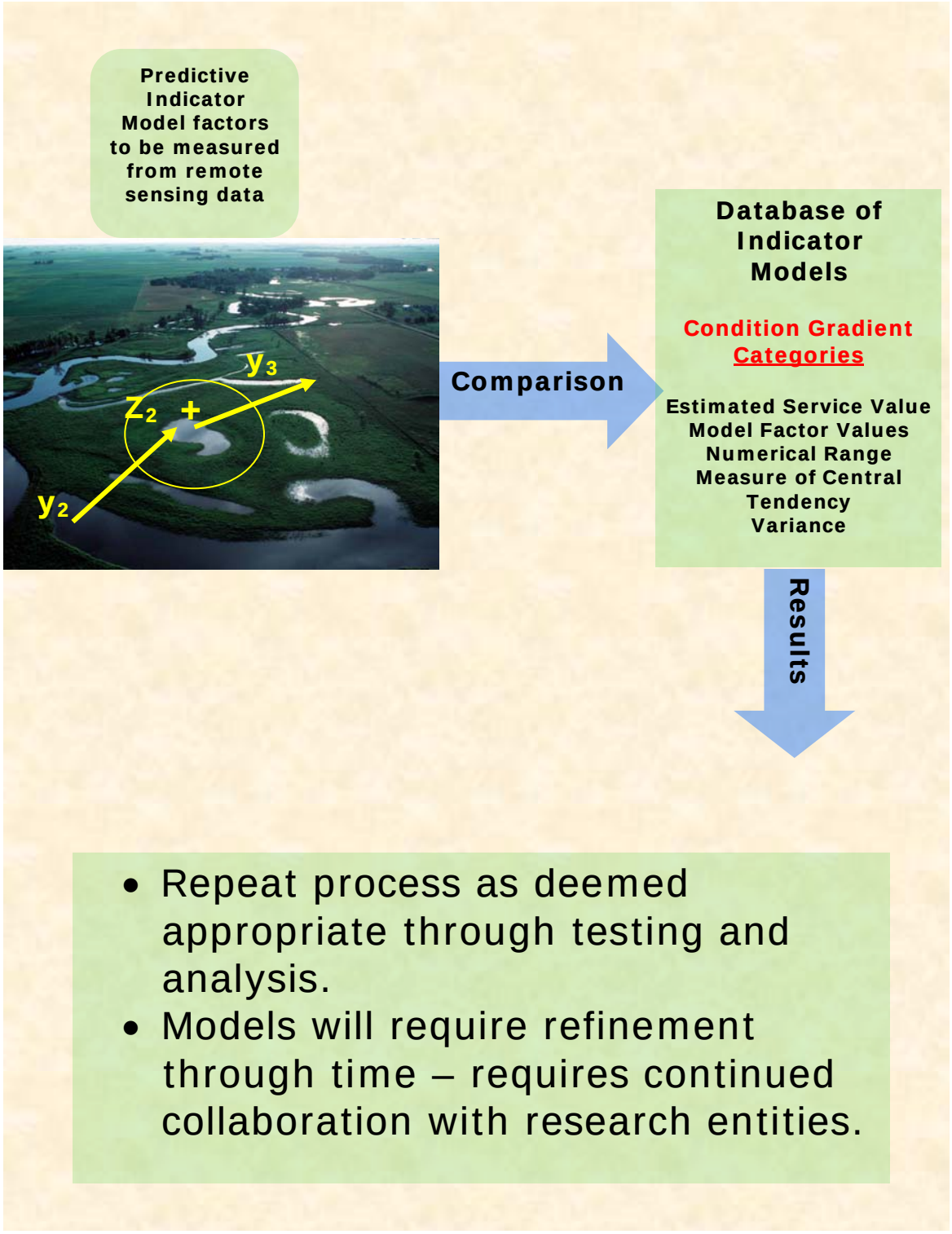

Figure 4. Application of predictive wetland condition indicator models database and remote sensing data to measure changes in wetland condition over time.

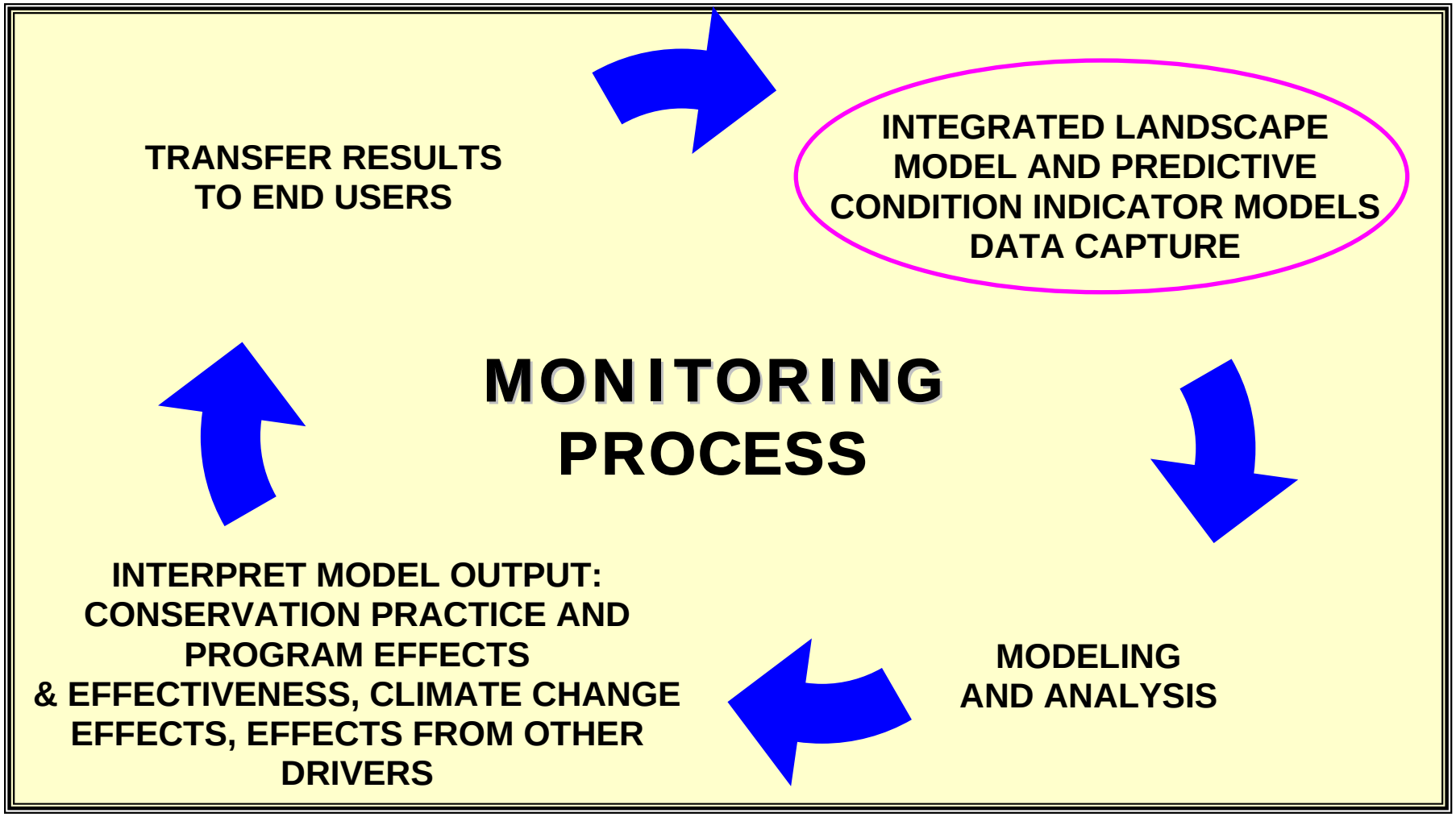

Figure 5. Conceptualized National Wetlands Monitoring process developed from CEAP-Wetlands regional studies.

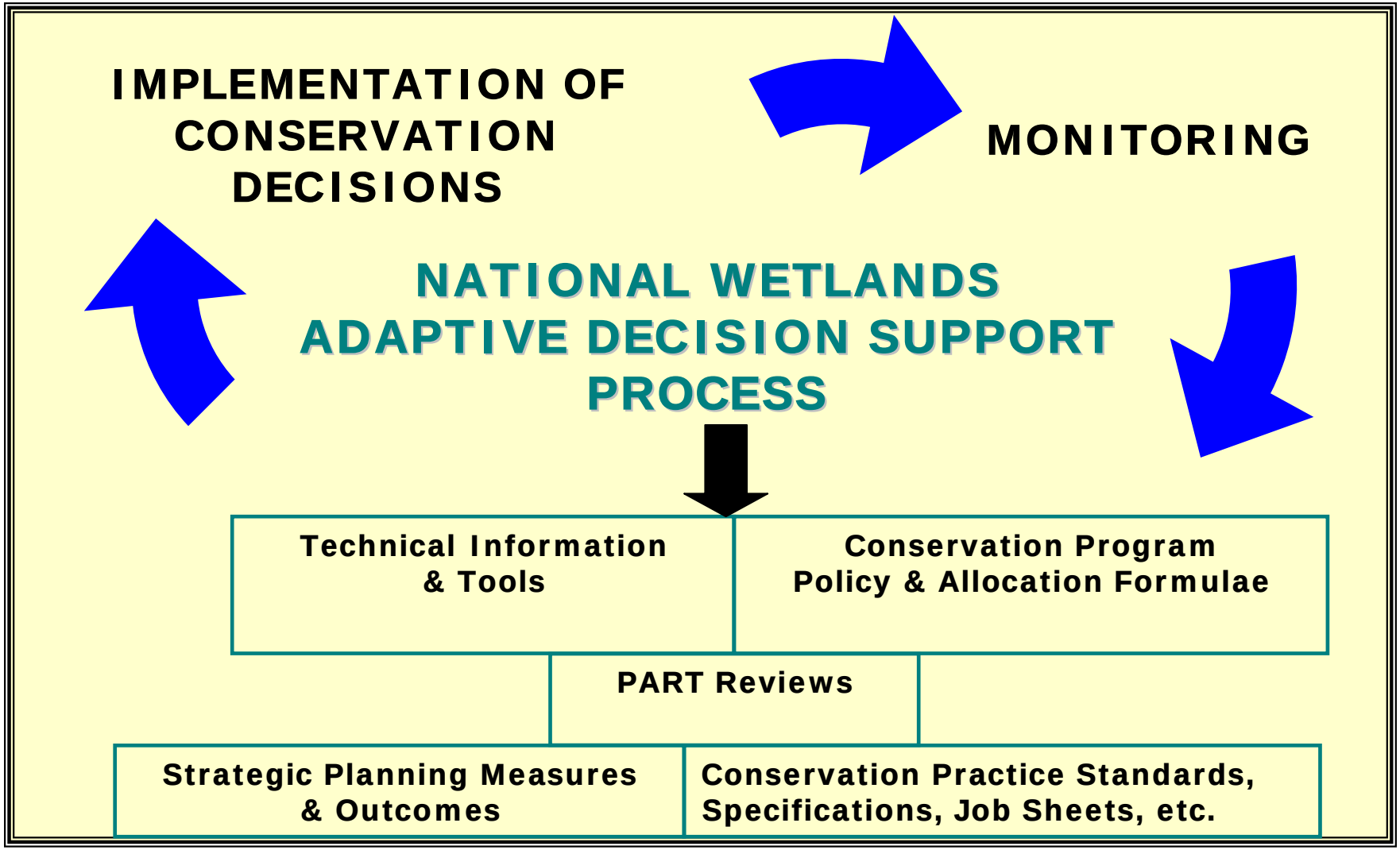

Figure 6a. A conceptual Decision Support Process for application at a national scale that links monitoring, decision-making and implementation of decisions within an adaptive decision-making context. Examples for application of monitoring results is illustrated in green boxes.

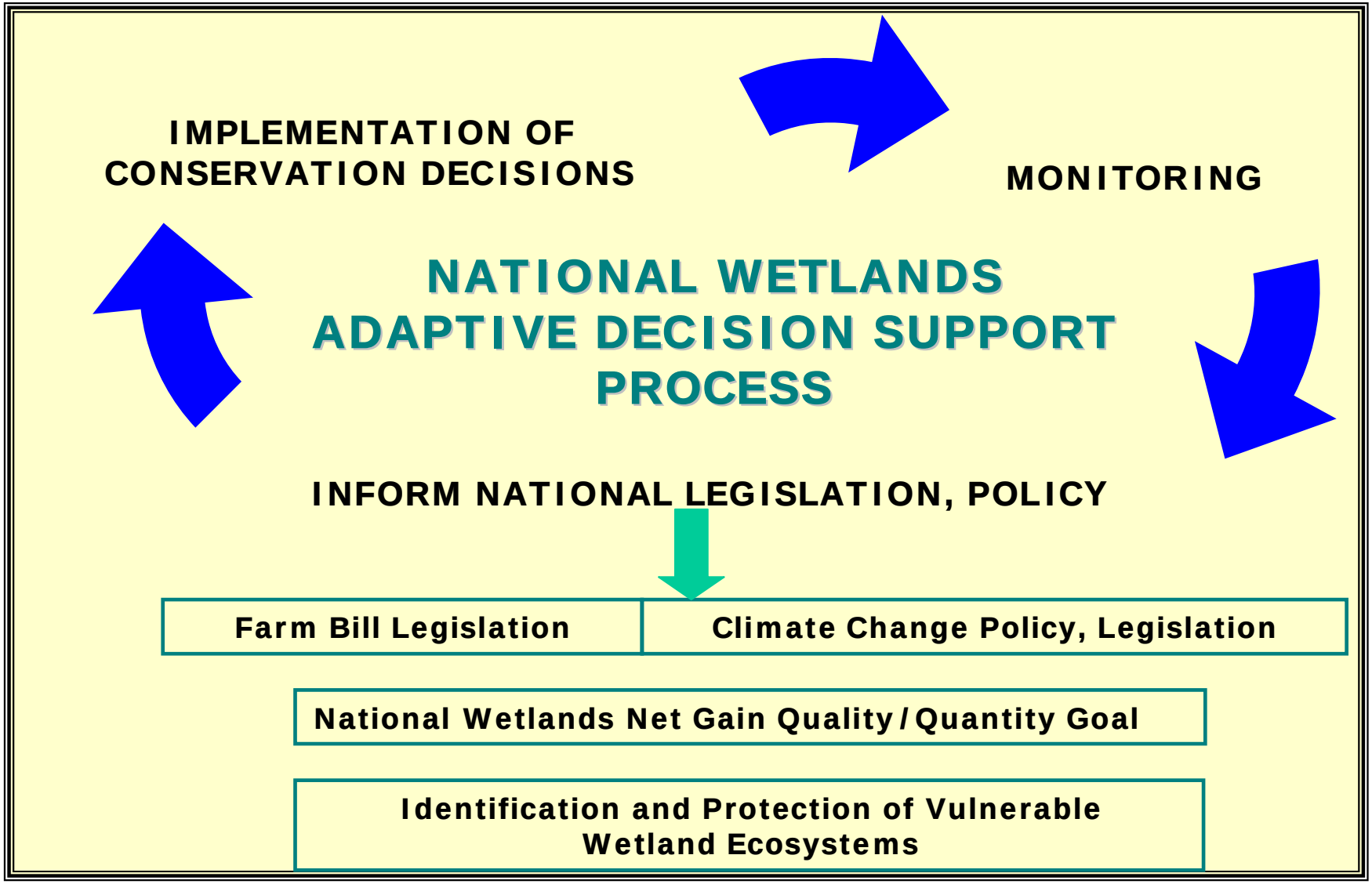

Figure 6b. Application of monitoring data beyond NRCS operational applications.

Calendar Year	Regional Studies: Results for Point-In-Time Estimates and Conservation Practice & Program Effects	Regional Studies: Predictive Wetland Condition Indicator Models	Regional Studies: Integrated Landscape Model Development, Calibration and Validation (PPR and MAV)	Remote Sensing Data Collection Research (PPR, MAV and Choptank River Watershed Landscape Study)	Regional Studies: Calibration and Validation of Integrated Landscape Model Regional Algorithms; Calibration and Validation of Remote Sensing Data	Literature Synthesis	Practice & Land Treatment Studies	Exploratory Analysis - USDA Practice and Program Data	Linkage of USDA Practice and Program Data with Integrated Landscape Model
2004									
2005									
2006									
2007									
2008									
2009									
2010									
2011									
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2013									
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2020									

Figure 7. Timeline showing activities to produce products associated with CEAP-Wetlands Objectives.