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Assessing the Effects of USDA Conservation Programs on Ecosystem Services Provided by Wetlands

The U.S. Department of Agriculture's Conservation Effects Assessment Project (CEAP) began more than seven years ago to document the impact of conservation programs and practices on private lands. The ultimate goal of the project is to fill in the gaps associated with wetland and agricultural conservation so that the most effective practices and programs can be used to maximize wetland ecosystem services in agricultural landscapes.

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The Conservation Effects Assessment Project (CEAP) is led by the U.S. Department of Agriculture (USDA) in an effort to quantify the environmental effects of conservation programs and practices on privately owned agricultural landscapes across the United States. CEAP's approach includes application of both field research and modeling. CEAP has four significant impacts. First, the research contributes to the body of knowledge in agroecology and conservation. Second, the results are used to inform conservation program and practice improvements in order to maximize environmental benefits while promoting sustainable agriculture. Third, the results serve to inform the general public and policymakers about the impacts of current conservation practices and programs. Finally, these findings provide a decision support tool for congressionally mandated reviews and agency-level policymakers to direct future funding and conservation program and practice development toward outstanding conservation needs—increasing conservation benefits in the most effective and economical ways.

There are five thematic national CEAP components—croplands, grazing lands, wetlands, wildlife, and watersheds—all of which necessarily overlap (e.g., wildlife occur in wetlands, wetlands occur in croplands, etc.) to varying extents (USDA-NRCS CEAP 2015). The CEAP teams consist of scientists and engineers from a variety of agencies and universities. CEAP supports research and analysis within each of the components to provide regional and national assessments of the impacts of voluntary conservation on the ecosystem services provided by their component. Here, we discuss the wetlands component of CEAP, henceforth "CEAP-Wetlands."

Planning and Assessment

The CEAP-Wetlands component began in 2004 with the establishment of two collaborative CEAP-Wetlands regional assessments: Mississippi Alluvial Valley Regional Assessment and the Prairie Pothole Regional Assessment. In May 2005, a blue-ribbon panel of wetland scientists was convened as an opportunity for scientists to review the CEAP-Wetlands approach (Adamas et al. 2005). The panel provided feedback to USDA on the validity and design of the approach. Convening the panel also allowed USDA to engage scientists not affiliated with USDA and further dialogue on agricultural issues affecting agricultural landscapes.

The CEAP-Wetlands regions map was based on major wetland types (nontidal), watersheds, ecological regions, locations of USDA wetland conservation activities, and other factors (Figure 1). Scoping meetings for regional assessments were held with regional scientists, USDA Natural Resources Conservation Service (NRCS) state office staff, and other technical conservation professionals to identify the following:

- The hydrogeomorphic class of wetlands to be investigated (Brinson 1993; Smith et al. 1995);
- the conservation practices, programs, and land treatment activities that affect ecosystem services provided by wetlands and the contributing landscape;
- the ecosystem services and measures that will be sampled;
- and the collaborative structure for conducting the investigation (Eckles 2007).

The CEAP-Wetlands plan was formalized in 2008 and identified five iterative objectives (Eckles 2008). The first objective was to conduct regional field investigations targeting wetland ecosystem services across an anthropogenic 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 various ecosystem services, and develop an integrated landscape model for simulation and forecasting capability as part of a National Wetlands Monitoring Process. Ecosystem services are direct or indirect services that wetland systems provide to society. They include, but are not limited to, biodiversity provisioning, contaminant/sediment amelioration, nutrient management, surface water runoff and floodwater management, aquifer recharge, greenhouse gas emissions management, recreation, water sustainability, and cultural benefits.

Regional field research projects to address CEAP-Wetlands' first objective were initiated in the Prairie Pothole region. Complementary research was subsequently initiated in the Mississippi Alluvial Valley, High Plains, California Central Valley, and Mid-Atlantic Rolling Plain and Coastal Flats Region.

The second objective was to build science collaborations as the foundation of CEAP-Wetlands. Since this objective was pivotal to CEAP-Wetlands' success, it was necessary to build these collaborations before the studies in the first objective could begin. The collaborations were initiated across many state and federal agencies, including universities. Although original and continuing base funding was and is provided by NRCS, other federal groups have provided funding and data to support the CEAP effort, including the USDA Farm Services Agency (FSA), U.S. Environmental Protection Agency (EPA), USDA Agricultural Research Service (ARS), USDA U.S. Forest Service (FS), U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), and National Science Foundation (NSF). Many state agencies and universities have also provided funding and expertise. Scientists participating in the field research and modeling efforts come from all of these groups. Of course, the success of research also depended on the crucial relationships developed with landowners, who allowed researchers to study wetlands and their interactions on private lands.

A third objective was to document the scientific knowledge base and gaps in knowledge to understand the effects of conservation practices and programs on wetland ecosystem services. Again, this is an iterative objective, as the knowledge base and gaps are constantly changing. As a result of this objective, several bibliographies were developed. The CEAP-Wetlands literature synthesis "Conservation of Wetlands in Agricultural Landscapes of the United States" was published as the April 2011 supplemental issue of the journal *Ecological Applications* (ESA 2011). The 10 papers in the supplement document the scientific literature summarizing the effects of conservation practices and programs on agricultural wetlands in seven geographic regions of the United States: Piedmont-Coastal Plain, Mississippi Alluvial Valley, the High Plains, Prairie Pothole Region, Glaciated Interior Plains, California's Central Valley, and the Appalachian Highlands. Identification of knowledge gaps for specific regions led to design of further field studies intended to fill those gaps. The number of data gaps was quite large. Therefore, to optimize information-sharing among regions and meet the CEAP-Wetlands goal of providing regional and national assessments of wetland program benefits, research was prioritized across regions by ecosystem services and currently developed data. For example, if one region had extensive information on water storage or amphibian biodiversity, other regions would prioritize quantifying those services in their initial studies.

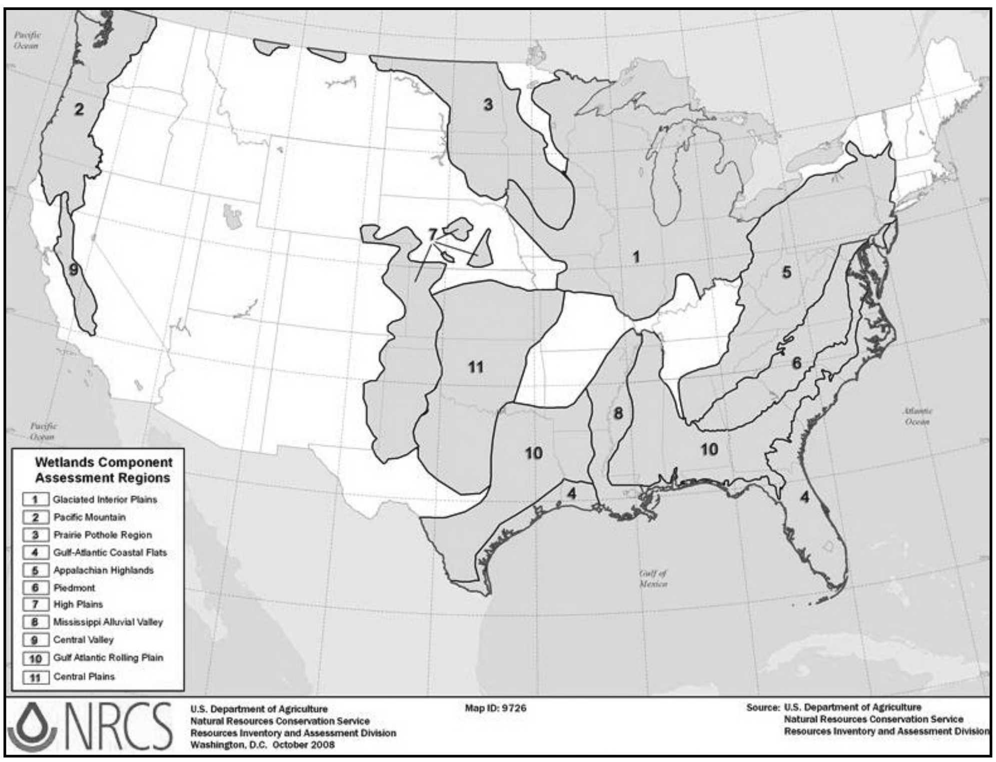

Figure 1. CEAP-Wetlands Component Assessment Regions. Map provided by the NRCS.

The fourth objective of CEAP-Wetlands was to analyze NRCS conservation practice and program enrollment data to illustrate applications of data gained through CEAP-Wetlands research and monitoring activities. Meeting this objective requires use of information gained in objective one in conjunction with other data. In many regions, this objective was achieved at the program level, whereas in others, the practices are so varied that it was addressed at the practice level. The main programs being examined are the FSA Conservation Reserve Program (CRP) and the NRCS Wetlands Reserve Program (WRP), which recently was moved under the NRCS Agricultural Conservation Easement Programs. Within each of these programs, there are specific practices designed to enhance specific ecosystem services. The CRP, initiated in 1985 as part of the new USDA Farm Bill, was aimed at stopping soil erosion on highly erodible cropland. It focused on paying landowners to plant permanent cover on highly erodible lands that had been previously farmed and to maintain that cover for a contract period that generally lasted 10 years. Therefore, CRP mainly influenced wetlands by affecting the practices occurring in adjacent watersheds rather than in the wetland itself. Upon reauthorization of CRP, other environmental benefits besides soil erosion were considered in contract acceptance and extensions with landowners (USDA-NRCS CRP 2015).

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The WRP, on the other hand, specifically targeted wetlands. It offered landowners financial incentives to protect, restore, and enhance wetlands on their property. This program required landowners to establish long-term conservation and wildlife practices. Lands eligible for WRP included: "wetlands farmed under natural conditions; farmed wetlands; prior converted cropland; farmed wetland pasture; lands that had the potential to become a wetland as a result of flooding; rangeland, pasture, or forest production lands where the hydrology had been significantly degraded and could be restored; riparian areas that linked protected wetlands; lands adjacent to protected wetlands that contributed significantly to wetland functions and values; and wetlands that had previously been restored under a local, State, or Federal Program that need long-term protection" (USDA-NRCS WRP 2015). NRCS mainly offered 30-year easements, permanent easements, and restoration cost-share agreements to landowners under WRP. In the High Plains and Prairie Pothole Region, where CRP is the dominant federally supported conservation program adopted on private lands, most evaluations were at the program level. In other areas, such as the Lower Mississippi Alluvial Valley, both wetland conservation practices and programs were evaluated.

CEAP-Wetlands' final objective was to develop a national wetlands monitoring process in collaboration with the USDA National Resources Inventory (NRI) to better inform decisions affecting the conservation of wetlands in agricultural landscapes. The NRI is a statistical survey of land use and natural resource conditions and trends on U.S. nonfederal lands. The NRI selects random quarter sections (160 acres) to survey different variables over time from ground surveys and aerial imagery. Wetlands have traditionally received little consideration except for basic presence/absence and type trends. CEAP-Wetlands continues to work with NRI personnel to provide recommendations on additional field sampling that could be conducted within the NRI framework. Further, CEAP-Wetlands scientists are analyzing NRI data and corresponding aerial imagery to determine which information on ecosystem services can be extracted. This will allow the expansion of trend information across the country especially for wetland services, which will then facilitate the ability to refine conservation practices and programs to optimize ecosystem services for citizens. Plans to actuate NRI activities toward achieving this objective are in development.

Application

To illustrate CEAP-Wetlands' progress in accomplishing these objectives, we examine the High Plains Region, one of the most intensively cultivated regions in North America. The dominant wetlands in the High Plains are playas, shallow depressional recharge wetlands, each occurring with their own watershed. Playas occupy 2-4% of the landscape. Playa wetlands recharge the largest aquifer in North America, the High Plains Aquifer (formerly known as the Ogallala), and exist in the north from Nebraska and Wyoming continuously south to Texas and New Mexico (Figure 2). This is primarily a semi-arid region and therefore the biological ecosystem services provided by playas are principally influenced by the length of time the playa has water, often known as the hydroperiod. Playas only receive water from direct precipitation and watershed runoff, with watershed runoff being the most important water input. They naturally lose water through recharge, evaporation, and transpiration. Because watershed runoff is the primary driver of playa hydroperiod, anything that happens in the watershed influences playa ecosystem function. The most negative anthropogenic influence on playas to date is their being filled with water-eroded sediments from cultivation. This sediment deposition has greatly affected wetland presence on the landscape and has notably altered wetland hydroperiods. Moreover, essentially all the uplands in the High Plains serve as watersheds for playas because riparian features (i.e., streams, rivers) are extremely limited in areal extent.

Because watersheds are so important to playa function, most assessments on conservation program and land use influences on playa ecosystem service provisioning have compared playas embedded in watersheds dominated by different land uses. Playa watersheds vary in size from just a few hectares to over 1,000 hectares. In the western High Plains, the dominant USDA conservation program is CRP. In the Rainwater Basin Region of south-central Nebraska, the dominant program is WRP. Therefore, in these two subregions the conservation programs being compared are different. To examine the improvement these programs provide playas in terms of service delivery, playas in these systems are compared to playas embedded in cropland and to playas in native prairie systems. Because the Rainwater Basin is so intensively cultivated, there is little to no previously unplowed grassland remaining, such that the watersheds representing native prairie reference state systems can also be highly altered.

One of the preliminary aspects of this evaluation was to examine which ecosystem service data sets already existed. A concomitant goal was to develop data sets similar to those developed in the Prairie Pothole Region so that almost the entire Great Plains would be studied and the service data collected would be similar. This allowed prioritization of which ecosystem service data to collect and identification of significant outstanding data gaps. Sediment depth data for playas in the western High Plains existed, but not for playas within CRP or WRP programs. Because of the primary influence of sediment on playa function, this metric was the first abiotic service examined. Conducting field sediment measurements on over 300 playas (100 native sites, 100 USDA program sites, and 100 cropland sites) allowed determination of current sedimentation status and remaining floodwater storage volume. Subsequent

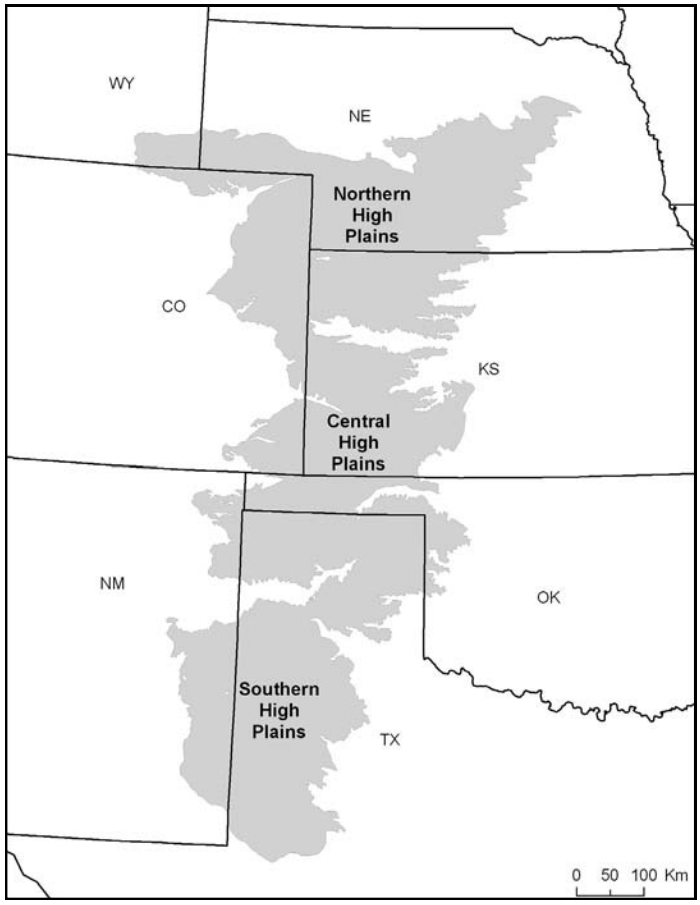

Figure 2. Subregions of the High Plains Map by M. McLachlan, adapted from Smith et al. 2012.

abiotic research projects include assessment of groundwater recharge, soil carbon, contaminant amelioration, and greenhouse gas emissions in different subregions of the High Plains.

From the biotic service perspective, extensive data sets existed for birds in most of the playa region, so initial field studies did not focus on them. The next largest biotic service data sets were on plants and amphibians. These studies had examined the effects of cultivation in the watersheds on plant and amphibian communities by comparing communities within cropland and native grassland. However, USDA sites were not included in these initial High Plains studies. Therefore, biotic studies in the High Plains examining CRP and WRP effects first focused on amphibian and plant communities to build upon the existing information. Recently, native pollinator studies examining CRP and WRP impacts were initiated.

Field research findings contributed to development of algorithms and models to estimate ecosystem services in playas without field measurements. This has been termed the Integrated Landscape Modeling (ILM) effort. The ILM in the High Plains facilitates service estimation for individual wetlands and permits regional estimation of service delivery, which will allow targeted use of conservation programs and practices to provide the best use of taxpayer dollars. All of these field studies have been conducted with numerous collaborators and funding agencies (USDA-NRCS, USDA FSA, USDA ARS, EPA, USGS, USFWS, NSF, and two joint ventures—the Rainwater Basin Joint Venture and the Playa Lakes Joint Venture).

One of the keys to determining conservation project and program effects on ecosystem services is to look at trade offs associated with conservation decisions. If a program or practice affects one service positively, it may have no effect or a negative effect on another. For example, CRP has had positive effects on most abiotic services, such as recharge, water storage, contaminant amelioration, and reduced sediment deposition. However, CRP has not provided as significant benefits to support biotic services. This is primarily due to the impact of exotic grasses planted in CRP sites, such as old world bluestem, which reduces water runoff to less than would be expected in a natural system. Playas embedded in CRP are wet only half as much as playas in native grassland and cropland. This is an area where CRP practices and planning could be improved to provide greater benefits to wetland biodiversity and habitat services. This type of knowledge from field studies allows us to revise recommendations for CRP practices to provide a more optimal set of sustainable services. Future modeling efforts can then provide recommendations to optimize provisioning of all services and to provide regional evaluations to target prudent spending of conservation dollars.

Image 1. Sampling soil carbon in a cropland playa. Photo credit: Loren M. Smith

In the future, CEAP-Wetlands will continue furthering the five objectives stated above. One key component to completing objectives four and five will be achieved through the development and application of process-based models to directly and indirectly estimate the ecosystem services of wetland conservation practices and programs. The Agricultural Policy/Environmental eXtender Model (APEX) is being modified to enable realistic modeling of depressional wetland hydrology, nutrient cycling, and plant growth. The updated APEX model output will provide the necessary inputs to regionally predict ecosystem services using the ILM. The advantage to using a well-established process-based agricultural model is the ability to analyze suites of conservation practices (e.g., wetland restoration with a saturated buffer strip) and agricultural management practices (e.g., no till versus conventional till) within each watershed to assess trade offs between wetland services and agricultural production. Through an iterative approach, CEAP-Wetlands scientists and researchers will continue to identify and address knowledge gaps associated with wetland and agricultural conservation so that the most effective practices and programs can be developed and deployed in comprehensive conservation plans that maximize wetland ecosystem services in agricultural landscapes. ■

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