# THE ECONOMIC VALUE OF NATURE'S SERVICES AND ITS ROLE IN INTEGRATED WATER MANAGEMENT: FOUR CALIFORNIA CASE STUDIES

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## INTRODUCTION

Here we present four case studies of integrated regional water management that include enhancement of biological diversity among their goals. Each pilot-scale project focuses on multiple water-related natural resources in a defined geographic area, usually a watershed. A common element of the projects is to show the economic benefits of protecting and restoring natural resources in a manner that allows their continued use over the long term.

One of the aims of the projects is to recognize the economic value of the goods and services that nature provides and to incorporate that value into natural resource management decisions. Such recognition includes development of ways to measure the economic value of those services. This can be important information for water managers who normally see only the costs of ecosystem protection and restoration, but not the benefits, in their budgets. The goods and services considered in these projects include water supply, water quality, erosion prevention, wildfire prevention, hydropower generation, wood products, flood attenuation, carbon sequestration, land subsidence reversal, and fish and wildlife.

Collectively, the projects constitute on-the-ground efforts to advance several of the objectives in the implementation plan of Water Plan 2009. In particular, they aim to expand integrated regional water management (objective 1), protect surface water and groundwater quality (objective 4), expand environmental stewardship (objective 5), practice integrated flood management (objective 6) and manage a sustainable California Delta (objective 7).

The case studies accomplish and document several key ingredients of integrated resource management--although no single study does all of them. They identify and involve watershed stakeholders, both managers and users of natural resources. In turn, the stakeholders come to agreement about how they want the watershed to look or function, usually in terms of the goods and services that they want the watershed to provide. Then they reach agreement on a set of management practices that can support and enhance those services and move the watershed toward the desired condition. Finally, the case studies seek to estimate the amounts of goods and services derived from specific management practices.

The pilot projects go beyond most watershed management efforts and most ecosystem services work in laying the foundation for establishment of markets for nature's services, that is, mechanisms for beneficiaries to pay producers for goods and services they receive. This requires some sort of assessment of the monetary value of the benefits. One desired end product is to put payments in the hands of producers-- that is, resource managers—as an incentive to keep them producing.

The following pages highlight four pilot projects, discussing their background, work in progress and planned activities. The projects include these: (1) water, fire and flood management in the Santa Ana River watershed in southern California; (2) forest, water and fire management in the Mokelumne watershed in the Sierra Nevada; (3) mountain meadow improvement in the Sierras and Cascades; and (4) carbon-capture farming on islands in the Delta.

## WATER, FIRE AND FLOODS IN THE SANTA ANA RIVER BASIN

The Santa Ana River watershed contains 2650 square miles, with headwaters in the San Gabriel and San Bernardino mountains. The river basin is the largest coastal stream system in southern California. It contains more than five million people and many of the major cities of Orange, Riverside and San Bernardino counties. Seventy percent of the water supply of the region is from wells, and the basin is replete with constructed aquifer recharge facilities and small dams for flood-water detention.

All aspects of water supply and water quality planning and implementation in the basin are coordinated by the Santa Ana Watershed Project Authority (SAWPA), a regional joint powers authority consisting of five public water agencies. SAWPA has developed an integrated regional water resources plan called the One Water One Watershed Plan. It is overseen by a steering committee whose members are drawn from the water agencies, along with three County supervisors, three mayors, representatives from the development and environmental communities and a Regional Water Quality Control Board member. Thus, SAWPA takes a collaborative, multi-jurisdictional, multi-objective approach to water management.

A major concern is protection of water sources in the mountainous parts of the watershed, especially from the devastating effects of fire. Huge wildfires are more common than previously in the mountains, mainly because a hundred years of suppression of small forest fires has given rise to uncharacteristically large fuel loads.

Serious water supply and water quality problems begin during the winter rainy season following a fire. Runoff from burned areas can contain high levels of contaminants and sediment and fills downstream recharge basins with silt and debris. Increased nutrients in runoff promote the growth of algae and other vegetation that clogs recharge basins. The recharge basins play a major role in refilling the groundwater basins in the region, where seventy percent of the water supply is ground water.

Runoff from burned areas also affects water quality in several ways. Orange County Water District operates 2150 acres of wetlands for natural nitrate removal. Silt severely clogs the ponds and reduces the effectiveness of nitrate removal. In addition, salt levels in runoff water may be five times higher after a fire, and this salt infiltrates groundwater basins and degrades their quality for up to ten years. Fires also change the soil chemistry of burned areas in ways that magnify levels of numerous toxic chemicals in runoff.

Wildfires also increase the degree of flooding downslope and downstream. Heavy rain falling on bare slopes can lead to mudslides, as thirty to fifty times the average amount of sediment

washes downhill. This sediment clogs stream channels and overwhelms floodwater detention basins, thereby exacerbating flooding.

SAWPA estimated the cost of large wildfires to water and flood management, based on expected work to mitigate the effects of three fires in 2003. The $450 million total was driven mainly by the expense of salt removal from the water supply ($182 million), sediment removal from groundwater percolation basins ($125 million), improvements to and enlargement of flood control basins ($56 million) and provision of an emergency water supply to compensate for contamination of the regular supply ($35 million). The high cost of mitigation suggested that preventive measures in the upper watershed, where most fires occur, could be worthwhile.

Thirty percent of the land area of the Santa Ana basin is in the upper watershed on National Forests, while ninety percent of the rain falls there. Thus, management of those lands inevitably and disproportionately affects water resources. SAWPA and the US Forest Service have discussed ways to improve forest condition, including restoration of meadow and riparian vegetation, forest thinning and invasive species removal. In 2011 the two agencies signed a Memorandum of Understanding to cooperatively enhance and restore forest health and watershed function on National Forest lands in the Santa Ana watershed in ways that protect water supplies and infrastructure.

Proposed projects that would carry out the intent of the MOU include meadow improvements, restoration of chaparral above recharge basins, fuel load reduction in forested areas and realignment of roads and their rights-of-way. Respectively, these actions would increase groundwater recharge and reduce downstream flood peaks; prevent erosion of soil into recharge basins; reduce the risk of large fires; and prevent gulley erosion near roads. They would also substantially restore the variety and health of local native vegetation and its attendant biological diversity.

Meadow improvements reduce flood peaks by acting as storage reservoirs, compared to meadows that have eroded into gullies and have low water tables. Restoration also dissipates the erosive energy of flowing water that makes gullies. Furthermore, meadows capture and retain silt from upstream. All these effects serve to reduce the flow of muddy water downstream.

Restoration of chaparral vegetation reverses the effect of frequent fires, which kill chaparral shrubs and allow non-native annual grasses to replace them. The shallow roots of annual grasses prevent rain-water from percolating deep into the ground and allow soil erosion and slippage on hillsides. The increased erosion sends more sediment into catch basins and can overwhelm them.

Forest fuel management involves mechanical tree thinning and controlled burns in dense stands of small trees. As in the Sierra Nevada, this removes hazardous fuels that lead to uncontrollable and massive fires. It also makes way for a greater variety of tree species and sizes and the corresponding wildlife that use them.

Road retrofits include the strategic removal of trees and shrubs so as to form fire-breaks or fuel-breaks that limit the spread of fire. Road realignment can prevent roads from concentrating rain-water runoff and causing gulley erosion.

Finally, the SAWPA partners also work in the lowland reaches of the Santa Ana basin to integrate habitat restoration with flood control, groundwater recharge, and water quality improvement. Prado Dam is a key component, serving both flood protection and water storage. Upstream of the dam lies a habitat area that has expanded to support both the largest patch of riparian forest and the largest number of the endangered Bell's vireo (a songbird) in Southern California.

The invasive giant reed displaces native vegetation along the river, impedes flow during floods, and is a heavy water user. An aggressive program of giant reed removal, coupled with re-vegetation with native plants, serves to improve habitat for the vireo, reduce flood risk, and recover more water. The river is the main source of recharge for the Orange County groundwater basin and consists mainly of treated wastewater from upstream cities. Constructed wetlands in the floodplain remove nitrogen from river water and more than ninety percent of the total nitrate removal occurs in the wetlands.

## FOREST, WATER AND FIRE MANAGEMENT IN THE MOKELUMNE RIVER WATERSHED

The Mokelumne River provides several environmental and economic benefits typical of watersheds with headwaters in the Sierra Nevada. It supplies water to the East Bay Municipal Utility District and its 1.4 million customers, and to over 800,000 acres of vineyards, orchards and other crops. The river provides recreational uses, such as whitewater rafting and trout fishing, as well as hydropower generation. The watershed supports forestry and biomass energy plants. At the same time, the watershed is habitat for many species of fish and wildlife, including Chinook salmon and steelhead.

The Mokelumne Watershed Environmental Benefits Program is a collaborative effort designed to protect and restore nature and its benefits, including forests, water, fish, wildlife and recreation. It also aims to support local economies and rural communities, from the headwaters of the Mokelumne River in the Sierra Nevada to the Sacramento-San Joaquin Delta. The program intends to measure and track both expenditures in watershed restoration and their environmental results, with the aim of increasing both the amount and effectiveness of restoration activities.

The project recognizes that downstream communities depend upon the watershed services provided by upstream landowners in the region. As of now, upstream land managers generally have little incentive to invest in stewardship practices that explicitly provide public benefits. There is no clear obligation to, or mechanism for, downstream users to contribute financially to the management practices needed to ensure the continued provision of the services.

The vision of the project is to provide private and public land managers in the watershed with resources and incentives to carry out specific conservation practices and thereby insure the

viability of the environmental benefits. The project intends to develop payment mechanisms that allow private utilities and other companies, government agencies, communities, foundations and nonprofits to pay landowners and managers to enhance and manage their lands in ways that benefit people and nature. Central to this goal is the development of better ways to measure the environmental results of restoration actions. Tracking and accounting for environmental outcomes shows investors what their investments have achieved.

For the upper watershed, the conservation goals of the project include prevention of catastrophic wildfire, less soil erosion, reduced sedimentation of streams and reservoirs, an increase in mixed-age stands of forest trees and improved habitat for key species. Proposed watershed restoration treatments include fuel load reduction via thinning of stands of small trees and brush; a halt to the practice of piling and burning woody debris; conversion of wood scraps into valuable products, such as fence posts, stove pellets and other bio-fuels; and re-vegetation of abandoned roads to prevent their erosion, among others.

Fire suppression since the late nineteenth century has allowed the proliferation of unusually dense stands of small trees that are much more susceptible to combustion during wildfires than larger old-growth trees. They allow fire to spread quickly. The result is that when wildfires eventually occur, they are uncharacteristically large and severe. In turn, the bare soil on burned-over hill slopes quickly erodes in rainstorms and sends large pulses of sediment into streams and reservoirs. Landslides also become more frequent, with the same result.

The program is conducting a study to identify the financial costs and benefits of improved forest management. The aim of management is to reduce the incidence of catastrophic wildfires and subsequent soil erosion and water quality impacts. This, in turn, should reduce the cost to public utilities of removing silt and debris from reservoirs and make more space for water supply and hydropower generation capacity and their corresponding economic value. The study also investigates the effects of forest restoration on the shading and consequent cooling of streams and on the diversity of tree species and associated animal life. Thinning of even-aged, single-species stands of trees should allow more species of trees to grow in an area and increase animal diversity.

The lower watershed supports salmon and steelhead, which are at risk from high water temperatures and habitat degradation. The program aims to partner with agricultural landowners to replant riparian vegetation, reduce bank erosion and restore floodplains to periodic flooding. These actions should improve fish habitat by reducing sediment input and cooling the river with shade from trees. A successful effort could provide more flexibility in the timing of releases of cold water from reservoirs and thereby provide more flexibility in water operations.

The program has a collaborative process and structure. Sustainable Conservation, Environmental Defense Fund, Sierra Nevada Conservancy and The Nature Conservancy, with grant funds from NRCS, have convened a working group of local and regional stakeholders to develop and carry out the necessary ecological restoration. The group meets quarterly and includes representatives from watershed groups, the US Forest Service, local government, East

Bay Municipal Utilities District, Pacific Gas and Electric, other private landowners, and the San Joaquin County RCD, among others.

## MEADOW IMPROVEMENTS IN THE SIERRA NEVADA

In a natural condition, mountain meadows have deep soils, dense vegetation and a drainage pattern where water flows across the flat meadow and infiltrates into the soil. Meadows typically remain saturated with water for most of the year and store groundwater in their soils, acting as natural reservoirs. Slow release of water from the sediments to downstream drainages provides flow long after surface runoff has stopped for the season. In addition, the water storage capacity of meadows can reduce the rate of runoff during spring snowmelt and reduce peak flows that cause floods downstream. The net result is higher summer flows and lower winter/spring flood flows—compared to degraded meadows.

In meadows exposed to practices such as over-grazing by livestock, road-building and deliberate draining, the streams typically erode into gullies. Then water entering the meadow drains quickly into stream channels, rather than across the land surface. Rapid drainage extends and deepens stream-bank and stream-bed erosion, further lowering the water table and drying out the meadow. This conversion is permanent; channel incision does not repair or reverse itself.

Drying of meadow soils allows invasion by drought-tolerant shrubs and trees that contribute to fuel loads and add to the risk of large wildfires. Loss of wet meadow vegetation eliminates habitat for numerous riparian animals, several of which are now at risk of extinction in the Sierra Nevada. Channel erosion adds to stream sediment loads. And dry meadows have less forage value for livestock.

Most meadows in the Sierra Nevada had already experienced gully erosion before 1940. Those effects remain on the landscape and will heal only with active intervention. Meadow restoration commonly involves filling or plugging gullies, routing surface flows over the meadow surface, and raising the water table. The Sierras have more than twelve thousand meadows, comprising about 300,000 acres. Since about two-thirds of them are thought to be degraded, to return all of them to well-watered conditions is a huge task.

Mountain meadows are biodiversity hotspots, especially for birds and amphibians. The large variety of plant and animal species in meadows is mostly different from that in nearby forests. Thus, intact meadows add a great deal to the overall biological richness of California’s mountains. Recent initiatives aim to rehabilitate and conserve wet meadows in the Sierra Nevada, both for their great biological value and to better understand the role of restoration in improving water management. Their impetus lies in a better water supply for people and wildlife.

The largest initiative, begun in 2010, is led by the National Fish and Wildlife Foundation. The NFWF program intends to restore and enhance habitat on a large geographic scale, validate the benefits of restoration and build regional capacity to carry out projects. The first five years of

the initiative focus on building the economic and scientific rationale for meadow improvements and carrying out projects to restore at least 20,000 acres. Contingent upon success in the first phase, the second phase will seek to ensure restoration and management of most of the degraded meadows in the Sierras.

The program addresses three outstanding issues: uncertainty about the magnitude of benefits, maintenance of benefits after restoration and the need to engage the people who live and work in the meadows. Resolution of the first issue hinges on a demonstration that water outcomes are real and cost-effective. This requires clarification of the relation between water-table elevations and base flow increases and the reasons for their variability. To do so, the program is studying a range of meadows from north to south and high to low elevation and across soil and vegetation types. The aim is to quantify groundwater storage and stream-flow regulation. Alongside this is an economic analysis of the ecosystem services provided by restoration, including flow regulation, flood attenuation, water supply reliability and water quality.

Maintenance of desired conditions after restoration is an issue because several pervasive land uses in the Sierras can undo the work and reduce the value of restored meadows. Development, infrastructure and road-building threaten many of the largest meadow complexes on private land, while recreational use, fire and mismanaged livestock grazing pose further risks on both public and private land. One solution is written agreements that define the terms of post-project maintenance and site management. Easements to protect the ecosystem services of meadows from future threats are another option.

On the issue of engagement with local residents, one of the first projects was a joint venture between Environmental Defense Fund, Tuolumne County Resource Conservation District, American Rivers and the Cosumnes American Bear Yuba (CABY) Integrated Regional Water Management Group called “Sierra-wide solutions—working meadows on private lands in the Sierra Nevada.” The main goals of the project were to measure and articulate the costs and benefits of meadow improvements and establish a dialogue on meadow enhancements among the various stakeholders.

The project set up a series of focus groups to engage ranchers and other private landowners and identify their concerns and priorities. The focus group revealed considerable support from private landowners and ranchers in the Sierra Nevada for conserving healthy meadow ecosystems and the wide variety of services they provide. Landowners expressed concerns about the effects of enhancement activities on the profitability of their operations and the likelihood that meadow enhancements would result in regulatory interference.

The project followed up with a study of the economics of meadow improvements. It found that the expected increase in forage value for livestock is real, but generally not enough to cover the cost of restoration. Thus, it concluded that ranchers are unlikely to pay for meadow improvements on their own.

The study also reviewed the literature on the hydrology of restored meadows and their effect on dry-season flow downstream. It concluded that current knowledge is inadequate and results vary greatly, from showing increases to decreases in downstream flow levels.

In a related initiative, DWR is funding the US Forest Service to investigate the hydrology of restored wet meadows and their contribution to improved water supply reliability. Prior to the study, the Forest Service estimated that meadow rehabilitation on National Forests in the Sierra Nevada might increase dry-season stream flow by 5000 to 50,000 acre-feet in the Sacramento-San Joaquin watershed. See the forest management strategy in Volume 3 for details.

The current study is sampling one hundred meadows with areas between 10 and 500 acres on National Forests in the Sierra Nevada. It compares water budgets in natural, degraded and restored meadows to evaluate regulation of groundwater discharge. The aim is more accurate estimates of changes in seasonal groundwater storage and stream flow following restoration. Results to date are that, compared to eroded meadows, restored meadows support higher flows in early to mid-summer in most cases and a longer duration of flows in summer. The effect of restoration on stream flow is a contentious issue, because irrigators downstream of some meadow restoration projects assert that they have seen a clear decline in late summer flows.

## CARBON CAPTURE FARMING IN THE DELTA

The Sacramento-San Joaquin Delta is a critical natural resource, an important agricultural region, and a major hub for California's water supply. Over the past century, agricultural practices in the Delta have caused the loss of over one million, and perhaps more than two million, acre-feet of peat soils, causing land subsidence down to 20-25 feet below sea level on many islands. Current agricultural practices continue to remove these soils and, as part of that loss, emit about 5 million tons of carbon dioxide annually—about 1% of California's total emissions. Peat soil can generate unusually large amounts of greenhouse gases because it is a natural storehouse of enormous amounts of carbon.

Land subsidence contributes significantly to the risk of failure of the levees that protect the islands. The levees protect farmland and maintain a supply of water to 25 million people and 3 million acres of irrigated farmland outside the Delta. Land subsidence increases the hydraulic stress on levees, making them leakier and more likely to fail, and increases the volume of water that could be taken up by an island in the event of a levee break. In turn, a levee break could allow a pulse of brackish or salt water to invade the Delta and compromise water quality for most uses.

Subsidence reversal should reduce the cost of maintenance of the 1100 miles of levees on the islands and provide better protection for a vast array of infrastructure, including roads, railroads, bridges, airports, ferries, electricity transmission lines, natural gas pipelines, oil and gas production fields, marinas, aqueducts and towns. Two land management options, referred to as carbon capture wetland farms and low carbon agriculture, could reduce soil loss and greenhouse gas emissions, reduce the many risks associated with land subsidence, and provide habitat benefits to the Delta ecosystem.

Carbon capture wetland farms are constructed wetlands operated to maximize retention of atmospheric carbon, mainly in the soil, and minimize the release of other greenhouse gases.

Native tule wetlands, in particular, can capture and store carbon at very high rates and, in doing so, build soil that significantly and continuously reverses subsidence

Low carbon agriculture refers to farming practices that reduce GHG emissions and rates of ongoing land subsidence. They could be applied to conventional crops, or in combination with tule wetland farms. These practices could include increasing groundwater levels during the growing and fallow seasons, winter flooding, reduced tillage, soil nutrient management that does not rely on nitrogen-based synthetic fertilizer, and conversion to rice production.

Research on tule wetlands in the Delta shows that a combination of increases in carbon sequestration and prevented soil carbon loss could reduce greenhouse gas emissions by 10 to 35 metric tons of CO2 equivalents per year. The reductions could continue to accrue over a period of 50 to 100 years or so, depending on initial subsided land elevations. Soil accretion could average as much as 2.5 to 5.5 inches per year, and would directly improve levee stability through reduced hydrostatic pressure. Restoring wetland habitats could also benefit native wildlife, including waterfowl, the threatened giant garter snake and many other species.

Wetland water management calls for maintaining saturated conditions in more of the soil profile more of the time than in conventional farming. This prolonged soil saturation reduces decomposition rates of plant material and greenhouse gas emissions that result from the decomposition.

A pilot project on Twitchell Island, conducted by US Geological Survey and DWR, provided much of the foundational science about carbon budgets on Delta islands. Originally a study of the potential for subsidence reversal, the project directly measured greenhouse gas fluxes in tule wetlands and adjacent control sites, which were conventionally managed corn fields. Overall effects on greenhouse gas storage and release were driven both by carbon capture in the wetlands and by large greenhouse gas emissions from corn fields. That is, the conversion of annual cropland to wetlands both sequestered a large amount of carbon dioxide and prevented the greenhouse gas emissions caused by plowing, drying, and fertilizing peat soil.

Growers of tule wetlands could earn revenue from the sale of carbon credits. AB 32, the Global Warming Solutions Act, mandates large reductions in greenhouse gas emissions in California. One likely method to reduce emissions is through a market in carbon offset credits. Economic models are under development to project break-even costs for replacing conventional farmland with wetlands. Preliminary findings are that carbon capture wetlands might become financially viable when carbon prices reach about $20 per metric ton. This break- even price excludes unknown or highly variable factors, such as land acquisition and costs of verification of greenhouse gas credits.

The potential for carbon-capture wetlands and other low-carbon farming methods to provide so many benefits-- wildlife habitat, flood protection and public safety, reliable water quality and supply, greenhouse gas mitigation, jobs and income for farmers—has attracted attention from several quarters. A comprehensive study performed jointly by The Nature Conservancy, Environmental Defense Fund, Wetlands and Water Resources, Inc., and Stillwater Sciences (“Greenhouse gas reduction and environmental benefits in the Sacramento-San Joaquin Delta:

advancing carbon-capture wetland farms and exploring potential for low carbon agriculture") in 2011 concluded that the benefits of carbon capture wetland farming are established well enough to prompt the next step, farm-scale demonstration projects. These would involve technical studies to develop protocols to measure carbon offsets, including greenhouse gas fluxes and overall carbon budgets. Studies also would address potential adverse impacts, including contamination from mercury and dissolved organic carbon and the need for mosquito control.

DWR has partnered with TNC and EDF in an effort to locate and fund a larger, 200- to 400-acre site in the Delta for feasibility testing at the farm scale. A demonstration project could examine both the costs and greenhouse gas emissions from a menu of management practices, including winter flooding, low-carbon agriculture, rice production, tule farms, and wetlands designed for waterfowl and waterfowl hunters. Potential partners include Metropolitan Water District, Irvine Ranch Water District, Sacramento Municipal Utility District, Pacific Gas and Electric and the Delta Conservancy.

Meanwhile, DWR has established a 305-acre project to grow tules on Sherman Island to measure carbon budgets and enhance habitat features. Enhancements include provision of open water (without tules) preferred by waterfowl, islands for bird nesting, and introduction of fish for mosquito control. DWR also has constructed a 300-acre rice research project on Twitchell Island to study subsidence reversal, carbon sequestration, effects on methyl mercury and certain agricultural chemicals, and economic feasibility.