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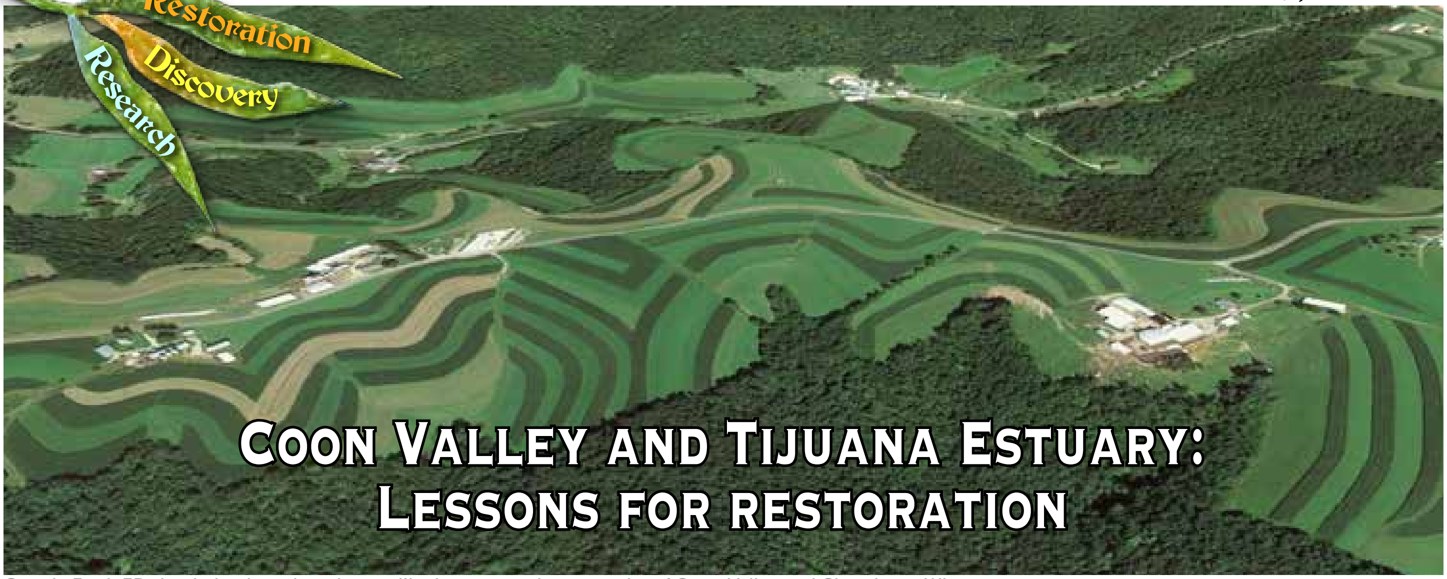

Coon Valley and Tijuana Estuary: Lessons for restoration

Google Earth 3D simulation based on the satellite imagery and topography of Coon Valley and Chaseburg, WI

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Introduction

Aldo Leopold was a central figure in the development of restoration ecology —among several other fields. Long before it emerged as a distinct subset of ecology, Leopold was practicing restoration with a scope, ambition, and holistic understanding that remain impressive decades later. An example of this comes from Leopold's involvement in the Soil Erosion Service's (SES, predecessor of the NRCS) Coon Valley soil conservation project, the first of 175 demonstration projects conducted throughout the country. An agricultural watershed in southwestern Wisconsin's unglaciated Driftless Area, Coon Valley had suffered severe degradation from unsustainable farming practices. The SES, with an admirably broad view of soil conservation, launched a project in 1933 to reverse the damage, and Leopold served as an enthusiastic advisor (Meine, 1988).

Tijuana Estuary has long been home to research that extends the legacy Leopold and others established in Coon Valley. Located in San Diego County, CA, on the U.S.–Mexico border, Tijuana Estuary is one of the few places in the world with a tradition of long-term research in restoration ecology. Work there has spanned decades and provided training and research opportunities for dozens of students and scientists. The long-term monitoring and countless experiments that have been carried out there have contributed greatly to restoration ecology, yielding books, hundreds of scientific papers and presentations, and the beginnings of many careers in wetland and restoration ecology.

Reading a 1935 essay Leopold wrote about the Coon Valley project (Leopold, 1999), we were struck by how relevant the themes he addressed remain to our work in the coastal wetlands of southern California. Separated by 75 years and 2000 miles, common ground may seem scarce for a rural system of the upper Midwest vs. the highly urbanized coast of southern California. Yet the similarities in challenges, promising approaches, and lessons learned speak both to Leopold's prescience and the potentials and constraints underlying many restoration efforts. Here we address some of the persistent themes that unite work done in Coon Valley and Tijuana Estuary.

Google Earth image of Tijuana Estuary

The multidisciplinary nature of conservation

Leopold had little tolerance for lack of cooperation between conservation interests, which he viewed as threats to effective stewardship. Thus, his admiration was great for the broad view taken by the newly formed SES: "…not only soil conservation and agriculture, but also forestry, game, fish, fur, flood control, scenery, songbirds, or any other pertinent interest were to be duly integrated. It will probably take another decade before the public appreciates either the novelty of such an attitude by a bureau, or the courage needed to undertake so complex and difficult a task" (Leopold, 1999).

Events in Tijuana Estuary provide frequent reminders of the futility of trying to view a system's components in isolation. As a consequence, our work there has focused on the interplay between physical and biological processes and resources. For example, development along the US-Mexico border, Homeland Security projects, erosion of steep canyon slopes, and wildfires have all damaged and degraded native vegetation in upstream watersheds (Onuf, 1987; Zedler et al., 1992). The resulting increased sedimentation has reduced the area of intertidal habitat, hurting wetland-dependent and imperiled species such as the light-footed clapper rail, California least tern, tiger beetles, and the hemi-parasitic plant *Cordylanthus maritimus* subsp. *maritimus* (salt marsh bird's-beak) (Wallace et al., 2005; Zedler et al., 1992). In order to respond to such complex problems, our research efforts drew together the expertise of ecologists, engineers, hydrologists, geomorphologists, and others.

In any system, an integrated approach is a prerequisite for effective restoration. This integration is complex politically as well as scientifically. At Tijuana Estuary, it requires international cooperation; coordination of federal, state, county, and city agencies; participation by citizens; the interest of legislators and other decision makers; and the involvement of universities. While sometimes trying, such integrated, multi-disciplinary approaches are essential. As Leopold wrote, "each of the various public interests in land is better off when all cooperate than when all compete with each other" (Leopold, 1999).

A broad perspective: the watershed, the region, and beyond

Leopold and his colleagues were ahead of their time in applying watershed and regional perspectives to restoration, approaches that continue to be recommended (Bell et al., 1997; Boesch, 2002; Vellidis et al., 2003; Zedler, 2003). Leopold described the watershed and regional effects of woodlands being converted to pasture on steep upper slopes: "Every rain pours off the ridges as from a roof… Great gashing gullies are torn out of the hillside. Each gully dumps its load of hillside rocks upon the fields of the creek bottom, and its muddy waters into the already swollen streams. Coon Valley, in short, is one of the thousand farm communities which, through the abuse of its originally rich soil, has not only filled the national dinner pail, but has created the Mississippi flood problem, the navigation problem, and the problem of its own future continuity" (Leopold, 1999).

Tijuana Estuary's salt marshes are strongly impacted by events high in the watershed: winter storms pound steep slopes, bringing tons of sediment into marshes; raw sewage and trash flows into the estuary; illegal fill diverts natural channels. The effects of this watershed degradation extend beyond the confines of the estuary. When there is a flood, sediment plumes dirty coastal waters and reduce tourism value. Waters are often contaminated with fecal coliform bacteria and beaches close as a result (Gersberg et al., 1994). Limitations in sewage treatment facilities mean that any flow above 25 million gallons per day exceeds capacity and raw sewage flows through the estuary onto the beaches.

Aquatic conservation efforts that do not consider upland processes are likely to be ineffective and short-lived. Furthermore, scientists and planners must consider the implications of local processes and conditions on larger-scale systems, and vice-versa. Regional prioritization schemes should be used to position restorations for biodiversity, water quality, or flood control values where they can be most effective (Zedler, 2003). Ambitious interstate planning would enable basin-wide prioritization to address problems such as hypoxia in the Gulf of Mexico, which is exacerbated by fertilizer use on the farms of the upper Midwest (National Science and Technology Council, 2000).

The need to address problems at their source

The Coon Valley project differed from many engineering efforts of its day by addressing problems such as flooding at their source. Leopold described the alternative: "The 'nine-foot channel' and endless building of dykes, levees, dams, and harbors on the lower river are attempts to put a halter on the same bull after he has already gone wild" (Leopold, 1999).

It would be wonderful if such ill-timed "bull haltering" were a relic of the past, but such approaches remain prevalent. Still, there are cases where coordinated efforts have been used to prevent problems before they occur. The City of Tijuana now uses some of its wastewater to irrigate slopes in order to reduce erosion. Perhaps someday, the large basins now used to intercept sediment at the US-Mexico border will no longer be needed; perhaps the new triple border fence will follow the fate of the Berlin wall; perhaps climate change will be curbed and not just accommodated. From a wetland perspective, lower emissions are essential to reduce threats to slow sea level rise (Nicholls, 2002; Nicholls et al., 1999).

Whenever feasible, the underlying causes of degradation should be abated prior to addressing effects through restoration and local management efforts. In many situations, restoration projects are challenged from the start by degraded surroundings that bring in excess water, nutrients, sediments, and invasive species.

Beyond our grasp: mistakes, surprises, and incomplete knowledge

Participants in the Coon Valley project found themselves unable to answer some seemingly elementary questions about creek bank plantings: "What species of willow grow from cuttings?…What shrubs combine thorns, shade tolerance, grazing resistance, capacity to grow from cuttings, and the production of fruits edible by wild life? What are the comparative soil-binding properties of various shrub and tree roots? ...Under what conditions do oak sprouts retain leaves for winter game cover?" (Leopold, 1999). Where scientific ignorance did not block restoration progress, uncontrollable forces could still be impediments: "A December blizzard flattened out most of the food patches and forced recourse to hopper feeders. The willow cuttings planted on stream banks proved to be the wrong species and refused to grow. Some farmers, by wrong plowing, mutilated the new terrace just built in their fields. The 1934 drouth killed a large part of the plantings of forest and game cover" (Leopold, 1999).

We have encountered similar obstacles over the years. Basic questions that we have sought to answer have included: Which species need to be planted and which ones do not? How and where can certain halophytes grow? How tall should cordgrass be to support clapper-rail nesting? How do non-native grasses impair survival of the endangered plant salt marsh bird's-beak? (Fellows and Zedler, 2005).

Beyond the challenges posed by knowledge gaps, restoration and conservation have been hampered by uncontrollable forces. El Niño storms in 1983 filled estuarine channels with sand that mobilized when waves washed over the dunes. In April 1984, a lag effect of this El Niño was the closing of the mouth of the estuary, a surprise to most. Other unexpected events associated with the 1983 El Niño were the demise of cordgrass and the loss of all clapper rails,and an 8-month delay in reopening the mouth (Zedler et al., 1992; Zedler and West, 2008). Sediment accumulated in tidal ponds where it favored marsh vegetation and eliminated prime shorebird-feeding habitat. Residents alongside the estuary planted and irrigated *Melaleuca quinquenervia* in the high marsh—the same invasive tree that plagues The Everglades. When convinced of the threat this posed for the salt marsh, they substituted fan palms (not native, but more benign). Perhaps eventually people will prefer native shrubs, such as *Rhus integrifolia* (lemonade berry) that pose no threat and require no watering.

Take-home messages from Coon Valley, Tijuana Estuary, and many other restoration sites are that good conservation cannot happen in the absence of good basic science, and that we should expect the unexpected (Cottam, 1987), learn from our mistakes, and restore adaptively so that we can distinguish between a mistake and a coincidence.

Ambitious experimentation, innovation, and persistence

The Coon Valley project was an ambitious, whole-watershed trial involving many stakeholders and coordinated planning. It functioned as a large-scale test of the consequences of applying state-of-the-science best practices in reforestation, erosion control, game management, etc. As Leopold paraphrased, "The Soil Erosion Service says to each individual farmer in Coon Valley: 'The government wants to prove that your farm can be brought back. We will furnish you free labor, wire, seed, lime, and planting stock, if you will help us reorganize your cropping system. You are to give the new system a five-year trial'" (Leopold, 1999).

Today, we advocate that restoration efforts apply adaptive management driven by scientific experimentation, an approach that extends Leopold's legacy of ambitious and well-reasoned trials. *Adaptive restoration* is an iterative process by which experimentation allows scientists to make recommendations, these recommendations are incorporated into management practices, and the results are monitored and followed up with further research. Such an approach allows managers to learn from research findings and allows researchers to learn from restoration practice (Zedler, 2001). Ultimately, understanding of cause-effect relationships can emerge, reducing the role of luck (good or bad) in outcomes.

Two other features that characterize Leopold's restoration legacy deserve special mention: innovation and persistence. Leopold was not afraid to apply creative solutions. Faced with a severely degraded watershed, he and his colleagues saw opportunity, and went about applying the best available science to the problem, making the most of a bad situation and rehabilitating a landscape in the process. In our work, we have tried to adopt this legacy of using innovation to transform problems into opportunities. At Tijuana Estuary, we were asked to help route street runoff further into the salt marsh so that it would not erode a slope. We suggested instead a shallow meandering swale near the Visitor Center, to support "riparian habitat." Today the willow-lined habitat is much used by birds and loved by birdwatchers.

In his biography of Leopold, Meine (1988) provides a wonderful example of Leopold's dogged persistence as a restoration practitioner. Deciding that he would like some of his land forested, Leopold ordered two-thousand red and white pines from a nursery. After he and his family had planted them all, dry conditions threatened their survival. They watered them by hand but drought that summer killed nearly every one. So, after two-thousand pines had been purchased, laboriously planted, and laboriously watered, and there was still no forest to show for the efforts, Leopold's conclusion? They would have to try again the following spring. May all who attempt to restore habitat maintain such determination!

Our shared commitment to the land

It would be missing the essence of Leopold's legacy to not consider the role of a deeply ingrained commitment to the land in all his work. He described the nightly "bull sessions" at Coon Valley when technical staff from diverse disciplines gathered and expounded on their areas of expertise: "Underneath the facetious conversation, one detects a vein of thought – an attitude toward the common enterprise – which is strangely reminiscent of the early days of the Forest Service. Then, too, a staff of technicians, all under thirty, was faced by a common task so large and so long as to stir the imagination of all but dullards. I suspect that the Soil Erosion Service, perhaps unwittingly, has recreated a spiritual entity which many older conservationists have thought long since dead" (Leopold, 1999).

The dozens of students, scientists, amateur naturalists, planners, land managers, educators, and others who have committed themselves to restoring and protecting Tijuana Estuary understand the feeling that Leopold described. So too do thousands of others who work in countless habitats throughout the world. While we often lose the big picture when mired in disputes, crises, technical issues, research problems, and the day-to-day minutiae of our work, it is useful to remember that the land ethic lives in its practitioners and underlies all that we do.

Achnowledgment

This essay was inspired by a conference focused on Leopold's land ethic, October 1994, Madison, WI. Kandis Elliot provided the leaflet design and Sarah Friedrich provided the layout. This leaflet can be downloaded from the Arboretum web site: uwarboretum.org/research

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