Innovations in Adaptive Management and Restoration

Satellite Image of UW-Arboretum's Curtis Prairie - Google Earth

Adaptive management and restoration (AM and AR) foster learning while testing and implementing ways to conserve and restore the land (as in Leaflet #4). A forthcoming literature review (Zedler 2017) includes several examples of recent innovations that are relevant to the Arboretum. For example, AM could help decide how to reduce eutrophication caused by nutrient-rich surface-water inflows, and AR field experiments could reduce uncertainties about restoration approaches and explain *why* one approach is more effective than others. How have others de-eutrophied inflowing waters? Can we *lead* by learning how best to control weeds and restore ecosystem services?

1. How can surface water be de-eutrophied? Two examples used watershed approaches to cut nutrient inflows to downstream ecosystems in half. First, Denmark's agriculturalists were mandated to reduce their loading of nutrients in runoff, and over several years, they achieved ~50% for nitrogen (N) and 56% for phosphorus (P). Remarkably, both livestock and crop production increased during the de-eutrophication period, because farmers became increasingly efficient in nutrient use! Second, in Florida, urban residents throughout a ~5700-km^2 watershed de-eutrophied their runoff, first by persistently calling for clear water, then accepting regulatory limitations, and finally, establishing their own voluntary limits on lawn fertilizers and other nutrient-releasing practices. Their collective efforts cut inflows of both N and P and cleaned up the 6600-km^2 Tampa Bay.

Aiming to manage both N and P is a step in the right direction (Wisconsin DNR regulates P, despite pleas to limit discharges of N, which cause weeds to invade wetlands). In Germany, N and P sources and hotspots were used to set limits for loadings to rivers. Eastern states are following suit, and Chesapeake Bay is slowly recovering from algal blooms.

Overall, however, downstream waters need more protection than just reducing the use N and P fertilizers. Rivers and wetlands need to be restored, preferably using green approaches, not concrete structures. In Guam, tree planting reduced erosion from a steep slope based on research that planting 11,000 trees and using other green infrastructure would stabilize sediments.

Elsewhere, the volume of urban runoff is being reduced by "harvesting stormwater" that flows off hardscaped streets and parking lots for use in recharging groundwater or for storage to use later in irrigation. Retaining water upstream has multiple benefits: less flooding, less streambank erosion, and lower loads of contaminants and sediments. These are adaptive approaches, with actions based on monitoring data that indicate what works well in de-eutrophication.

2. How can wetland restoration be improved? AR field experiments are underway in The Netherlands, Spain, California, and Oregon to learn how best to solve site-specific restoration challenges.

Salt marsh in The Netherlands. Ecologists implemented a large field experiment that showed how vegetation recovery was influenced by distance from a tidal opening, distance from a creek, and ± grazing. Their *two-factor experiment* allowed them to identify the *interaction* between two factors as most important in achieving the target vegetation; it developed *near creeks without grazing*.

Ponds in Guadalquivir Estuary. In Spain's Doñana Wetland, 96 ponds were excavated to test effects of pond morphology on waterfowl and invertebrates. Diverse birds revealed their individual habitat preferences among pond sizes, depths and locations. I had suggested this AR approach in 2002 and was pleased to see results in print!

Salt marsh in southern California. Our 1997 salt marsh plantings restored vegetation while showing why the regional dominant plant gradually outcompeted all others. Future "designer assemblages" there and at the Arboretum could be developed from trait-based mathematical models, to restore selected ecosystem functions, e.g., groups of species that best resist weed invasions.

Salt marsh in Oregon. Contouring topography to create three intertidal elevations within a diked, subsided estuary demonstrated that marsh elevation (and hence hydrology) changed every component of the ecosystem, including the abundance and species richness of both the vegetation and fauna.

Coastal prairie in Oregon. Where sandy coastal uplands are eroding, bare areas are being revegetated experimentally. Managers aim to avoid shrub invasions by optimizing disturbance regimes. Their field experiment compares herbicide applications, topsoil inversion, and topsoil removal. To track progress, search for Clatsop Prairie (appliedeco.org).

Field experiment at the Arboretum testing effects of mounds to accelerate restoration of tussock sedge meadows (photo: J. Zedler of plots established by J. Doherty).

3. Conclusions and recommendations.

AM *at its best* when it reduces a wide range of uncertainties and indicates an effective suite of management actions. AR is *at its best* when field experiments are phased, so that early tests can inform later actions, and when hypothesis-based treatments indicate *why* one approach is superior to others.

The Arboretum could consult the manual by Fischenich et al. (2012) for essential steps and benefits and establish an AM/AR Team to characterize uncertainty and management options, design field experiments, obtain robust peer review, and integrate science into decision-making. The Team would adjust actions and set up new tests or augment monitoring to continue reducing uncertainty through sequential feedback loops. Appropriate *evaluation criteria* and *a robust monitoring program* could then lead to a manual of "best approaches for the Arboretum."

Reference cited:

Fischenich, C., et al. 2012. The application of adaptive management to ecosystem restoration projects. EBA Technical Notes Collection. ERDC TN-EMRRP-EBA-10. Vicksburg, MS: U.S. Army Engineer Research and Development. el.erdc.usace.army.mil/elpubs/pdf/eba10.pdf

The accompanying paper (Zedler 2017 in *Estuaries and Coasts*) has illustrations and ~200 references.

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