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OPINION ARTICLE

Restoration and Science: A Practitioner/Scientist's View from Rare Habitat Restoration at a Southern California Preserve

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Abstract

Researchers reexamining the relationship between restoration science and practice report a continuing scientist-practitioner gap. As a land manager with scientific training, I offer my perspective of the chasm and describe a restoration practice infused with as much science as the realities of limited budget and time allow. The coastal sage scrub (CSS) restoration project at Starr Ranch, a 1,585 ha Audubon preserve in southern California, combines non-chemical invasive species control, restoration, and applied research. Our practices evolve from modified scientific approaches and the scientific literature. Results from experiments with non-optimum replication (on effects of seed rates, soil tamping, and timing of planting) nonetheless had value for management decisions. A critical practice came from academic research that encouraged cost-effective passive restoration. Our passive restoration monitoring data showed 28–100% total native cover after 3–5 years. Another published study found that restoration success in semiarid regions is dependent on rainfall, a finding vital for understanding active restoration monitoring results that showed a range of 0–88% total native cover at the end of the first season. Work progresses through a combination of applied research, a watchful eye on the scientific literature, and "ecological intuition" informed by the scientific literature and our own findings. I suggest that it is less critical for academic scientists to address the basic questions on technique that are helpful to land managers but rather advocate practitioner training in methods to test alternative strategies and long-term monitoring.

Key words: **coastal sage scrub restoration, non-chemical invasive species control, science-driven restoration, science-practice gap.**

Introduction

At 1,585 ha Audubon Starr Ranch Sanctuary in southeast Orange County, California, we take a research-based approach to land management (i.e. adaptive management). But in reality the process combines not only our applied research but also tracking of the scientific literature for useful studies and the project manager's (my) "ecological intuition" which is informed by research, observations, and experience. Cabin et al. (2010), in a discussion of results from a survey at the 2009 Society for Ecological Restoration International meeting, identify a "science-practice gap" whereby scientists who do *restoration ecology* have different expectations and values (i.e. seek generalizable knowledge and conceptual frameworks) than practitioners who do *ecological restoration* (i.e. seek site-specific knowledge and timely on-the-ground solutions). Using examples from our work at Starr Ranch, here I provide my perception of the science-practice gap.

Starr Ranch restoration projects include upland invasive species control and restoration in rare habitats (native grassland and coastal sage scrub [CSS]), initiated in 1997, and riparian invasive control and restoration, initiated in 2003. Examples from our CSS project will demonstrate not only how academic science has informed practice but also how we use our own applied research and (my) "ecological intuition" to move the project ahead.

Applied Research at Starr Ranch

All CSS restoration at Starr Ranch begins in degraded grasslands with adjacent pristine CSS and presence of the invasive non-native *Cynara cardunculus* (artichoke thistle), which has invaded 283 ha of native and degraded grasslands at Starr Ranch. Through a series of three experiments, we developed a non-chemical method to control *C. cardunculus* (DeSimone 2006) and within one season we now reduce its cover by 95% per site. Long-term (5 years) monitoring of aboveground *C. cardunculus* seedling densities helped us understand seed

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bank longevity (60–98% reduction in seedling densities after two seasons). The second season of *C. cardunculus* control we initiate either restoration to CSS or enhancement of the existing native needlegrass grassland. Experiments on techniques (effects of soil tamping, different seed rates, and a comparison of planting techniques; DeSimone 2011) helped us understand when and how to plant native CSS species. However, a continuing problem of low power in our experiments made the ongoing debate in the literature over science-driven restoration and the value of "quick and dirty data" for land managers of particular interest (Cabin 2007; Giardina et al. 2007; Klein 2007), since it is an adaptive management dilemma: how to balance the rigor required of experiments with time and space constraints (see Section "Ecological Intuition").

As one land manager states in her discussion "in praise of dirty data for weed managers": "... we ... rely on quick-and-dirty data that get right to [the] heart of what we most need to know." (Klein 2007). Rather than advocate for closing the science-practice gap as per suggestions of Cabin et al. (2010), I agree with Wagner et al. (2008) who suggest that whenever possible practitioners take an "adaptive restoration" approach and do field tests of alternate restoration approaches with plots distributed over large areas and replicated to the degree that time and space will allow.

Academic Science and Land Management

I regularly examine scientific journals, especially those with applied emphasis, for studies that will contribute to our land management practices. I was encouraged by researchers who found that not only is there high temporal variability in rainfall in semiarid regions but also that restoration may be more effective during wetter years (Bakker et al. 2003; Cox & Allen 2008). These findings helped us understand our highly variable long-term monitoring results in active restoration sites at the end of the first season that indicated both total native cover (0–88%) and native shrub height (2.2–36.3 cm) were higher in years of above average precipitation.

Rice and Emery (2003) state that "... one of the first tenets of ecological restoration is to consider the option of doing nothing. Rather than spending time and money on the introduction and establishment of species at a restoration site, it may be cost effective to allow natural recruitment processes to take place." This opinion, expressed in a discussion of restoration genetics, had great impact on our restoration practices. Previous research helped me understand that many of the dominant CSS shrub species had high potential for passive recruitment (Gray 1981; Keeley 1991; DeSimone 2001). Over 10 years of monitoring, passive colonization by shrub natives from pristine CSS into non-native control areas showed 28–100% total native cover after 3–5 years, indicating to us that passive restoration is an efficient alternative approach to compensate for lack of time and funding necessary to implement widespread active restoration.

However, though some academic research has helped us understand mechanisms or stimulated new practice, because the goals of sciences such as restoration ecology often conflict with goals of restoration practitioners (Cabin et al. 2010), I have found that more often than not the scientific literature has provided little guidance with on-the-ground restoration decision-making. At a recent county-wide meeting of scientists and land managers, it was clear to me that many scientists had little appreciation of the challenges that practitioners face and the very basic questions we need to answer. One scientist asked what we monitor and measure and several land managers answered that we measure what we can, which are often the most basic, easily measured, and least expensive parameters that help us understand which treatments or techniques work. Thus, a "Restoration Extension Service" as advocated by Cabin et al. (2010) for dissemination of scientific knowledge to practitioners might be less valuable than regional workshops offered by the growing number of practitioner/scientists on simple techniques for practicing an adaptive restoration approach that combines experiments or trials with long-term monitoring.

Ecological Intuition

Land managers, especially in semiarid southern California with its highly variable rainfall, must make and change decisions on how to approach issues such as invasive control techniques and which invasives to fight, when and where to plant natives, how often and when to collect monitoring data. We most often cannot predict which invasives will predominate in any given rainfall season, which natives will germinate and survive (if any) in active restoration sites, or if passive restoration will proceed. To inform decisions on practice that must be made quickly during the busy growing season, it is critical to not only continuously peruse the scientific literature for useful research but also to build a body of on-site research that tests alternate management strategies and monitors invasive control and restoration (both active and passive) progress. Experiments build an arsenal of approaches in preparation for management decisions to be made in response to not only variable rainfall seasons but also to a changing climate.

However, as discussed, land managers do not often have adequate time or space to do rigorous experiments with sufficient power to reject a false null hypothesis. As our project has grown, we have less time for well-replicated experiments, so have implemented more informal trials, sometimes with only one treatment and one control plot. During the high rainfall 2009–2010 season, a dicot invasive (*Torilis nodosa*, hedge parsley) exploded in one of our passive CSS restoration sites. The same day that our field crew visited the site and discovered the invasive explosion, I quickly designed an informal trial composed of one non-chemical treatment plot and a control plot and the field crew implemented the treatment after taking baseline data. The crew returned one month later to find the invasive suppressed to less than 5% cover in the treatment plot relative to baseline treatment plot (75%) and control plot (80%) cover data. Native cover was relatively unchanged in both treatment and control. So we implemented the treatment and had success in suppressing the invasive. A similar explosion of a different dicot invasive (*Carduus pycnocephalus*, Italian thistle) during mid season of 2011–2012 stimulated design of another informal trial to test two different timings of a non-chemical treatment (at rosette and bolt stage) plus a control plot. Since site-to-site physical conditions such as topography and soils are highly diverse at Starr Ranch, we placed three 5 × 5 m plots (i.e. no replication) in two different sites. Within a month, the crew recorded a strong negative effect of the early rosette stage treatment and we implemented it immediately in targeted areas. From data that track field crew time and task, I calculated the cost of our small trial (@$20/person/hour) at approximately $420. Three of our five-person seasonal field crew took data in all six plots and implemented treatment over a total of 7 hours. In an informal, unconventional use of a priori power testing to obtain a rough idea of sample size for sufficient power to detect a false null hypothesis, I used G*Power (Erdfelder et al. 1996) with Cohen's s standardized effect size ($d = 0.4$) among three groups and $\alpha = 0.10$ for an estimate of $n = 28$. The total time for $n = 28$ in two sites, based on the original work rate per six total plots (2.5 hours for data collection plus treatments per each of 2-monthly visits, 1.0 hours for data collection only per two additional monthly visits) is 196 hours with a total cost of $11,760, both figures beyond our time and budgetary constraints.

Small informal trials are sometimes but not always helpful, yet with so little time and effort required I continue to implement these "quick and dirty" methods to answer questions on technique and infuse a degree of rigor to inform my "ecological intuition" when making decisions on practices during a busy invasive control and restoration season. That results of these trials with low or no replication can be spurious is of major concern for, and in fact would preclude, publication in a peer-reviewed journal. However, for making decisions in a semiarid climate with not only variable annual rainfall but also spatially and temporally variable invasive populations and restoration success, I appreciate the added rigor that these trials provide but limit application of results to smaller spatial scales. After promising results from the *C. pycnocephalus* control trial previously described, we instituted treatment in a 25 × 25 m invaded area in only one site and had successful results (i.e. the invasive was suppressed after one treatment). We plan to implement a similar trial in the 2012–2013 rainfall season and in two different sites. A conservative, cautious approach allows for corrections in response to unexpected results and without large-scale negative impacts.

I disagree with Cabin (2007) that a tinkering, trial-and-error approach might work best for efficient restoration. Alternately, I propose that land managers take the most rigorous approach that any particular season can sustain, forfeiting as little rigor as possible to reach project goals. As per suggestions of Geupel et al. (2011), the Starr Ranch approach combines experiments and more informal trials complemented with as extensive a long-term restoration and invasive control monitoring program as budget and time allow.

Conclusions

Through my experience with CSS restoration at Starr Ranch, I would suggest that academic research does have value for restoration practitioners. Tracking the applied literature can inform restoration practice with new information on species and ecological relationships and stimulate new practice or support current procedures. Practitioner research on invasive control and restoration techniques is critical in an adaptive management approach but often with reduced rigor for efficiency and a need to repeat experiments over space and time to compensate for variable rainfall and diverse topography. Ecological intuition is an essential component of my approach to land management, but intuition informed by both academic research and our own findings, so that I am ready to make and change decisions with ever-changing biotic and abiotic conditions.

Implications for Practice

- Because of the potential contribution of some academic research to restoration practice, I suggest scientists who do applied studies prepare concise summaries of findings for distribution as PDFs via e-mail to land managers as is already the practice of some researchers and agencies.
- Busy restoration practitioners attempting a scientific approach might take heart from our experience that "quick and dirty" methods can help guide practice.

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