Designing for Biodiversity: Data, Regulation, and Lore[1]

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Abstract. This paper first asks "Can we construct biodiversity?" I consider what knowledge we have and what ingredients we use to design and plan for landscapes of high biodiversity. At the heart of the discussion is the validity of the information in the knowledge base: is it based on research, empirical observation, folk/professional lore, "common sense"? Then I look at how the ingredients and knowledge lead to standardized design and planning methods for reclaiming disturbed landscapes. Finally, I ask if these methods can produce either the mandated (regulatory) or the desired results.

Additional Key Words: landscape planning, disturbed land reclamation

Introduction

My approach to biodiversity is as a layman since my job as a landscape architect is to apply best environmental reclamation practices and principles to landscape restoration design and planning. Consequently I have a simple, pragmatic understanding of 'biodiversity' which is that, within a specific "biodiverse" landscape, there are lots of plant and animal species with lots of interactions/relationships and alternative interactions/relationships. This is what I call "high quality habitat" because manifold interactions among species contribute to each species' survival. These many avenues of interaction and relationships create robustness and stability: most systems with high biodiversity can sustain themselves if undisturbed or can recover if disturbed. Systems with low biodiversity cannot, or else they require maintenance to recover.

Designers and planners are often called upon to restore or mitigate disturbed landscapes to a state of high quality habitat. We do not do this directly; at best, we facilitate the evolution of what we do create into high quality habitat. The design tools we use to do this are rules and knowledge that are derived primarily from very large scale ecological and restoration studies (such as surface

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mine reclamation, forestry, and agriculture) and then applied to smaller scales. (There is intense, long-standing debate about how to transfer rules and knowledge from one temporal or spatial scale to another, but we do it anyway). In my professional experience, working scales range from a residential backyard to a 100-acre quarry. These design tools need to be very good indeed, because they define both the design/planning process and the product, i.e., a particular landscape. This is especially true since what we 'know' is translated into regulations that mandate specific landscape results.

Designers and planners use four types of tools: data-based knowledge, lore, regulation, and technology. Data-based knowledge is gained through rigorous scientific study and observation, and can be confirmed or validated to varying degrees. Examples are predatory relationships, growth rates, plant species' needs for certain chemicals, territorial behavior. Lore is that reservoir of wisdom that can be thought of as wishful thinking, long-term empirical knowledge, or simple common sense. Sometimes the boundary between data and lore is fuzzy. Regulations are where goal and policy "shall/should" language is interpreted. They apply knowledge to process and product in order to standardize both and achieve a given, "good" outcome. Technology enables implementation of designs and plans. Within each of these categories are buried assumptions that may or may not be valid, and may or may not be benign.

Design Tools

Data comes in at least two forms. One is 'how-to' technical or empirical information such as data on soil structure, how to plant and when, how to construct a wetland, backfill a highwall, stabilize a steep slope and so on. The other form of data is the conceptual or paradigm level of understanding, especially of processes. Both forms contain significant bodies of negative ("this didn't work"), but useful data. There are areas where the information simply is insufficient to produce successful results (wetlands are particularly problematic) and cases where what we 'know' proves to be wrong. Not long ago engineers 'knew' that the best way to control surface water was to build linear, straight-sided and preferably concrete-lined channels. The Army Corps of Engineers is now restoring many such Corps-engineered waterways to a more natural state.

Decades of research have helped us understand natural ecosystems and have resulted in different theories of how a healthy, diverse ecosystem functions. Regardless of which theory one subscribes to, certain elements have proven to be critical to biodiversity:

Availability of water

Biological and physical complexity

Patchiness

Edges and transitions, vertical and horizontal

Nooks, crannies, and niches

Connectivity

A range of time and space scales for all of the above.

Characteristic, rhythmic self-maintenance processes.

A case in point is that we know that large-scale agricultural lands are not biologically diverse in comparison with woodlands, meadows and wetlands. They have connectivity but do not offer patchiness, transitions, or much in the way of physical microstructure, nor are they self-maintaining.

One measure of how thoroughly the elements listed above are integrated into our thinking is their prevalence and use at all scales and for all purposes for designing or restoring habitat. This moves information that may be lore into the data category by virtue of being generally accepted and believed to be true. A list of design criteria, similar to the critical elements list, for creating habitat in one's own backyard can be found in the local native plant newsletter (Douglasia). Similarly, a recent edition of the Audubon Society's magazine included a primer on what constitutes good wildlife habitat that was essentially a scaled-down, detail-level version of the critical elements (Audubon) appropriate at the residential neighborhood scale. Data will eventually be incorporated into such public regulations as buffer widths, tree planting densities, and mandated greenbelt corridors.

Lore is that which we "know" to be true even though the information has not been formally or rigorously confirmed, and includes what we are or should be studying. My grandmother 'knew' that spreading coffee grounds and planting fish heads around her roses was responsible for the roses' magnificent blooms. Lore is often true, but even lore based on some history of observation can turn out to be wrong. For example, it was 'known' that the range of each individual of an endangered bird species (the marbled murrelet) in the Pacific Northwest was confined to a single coastal valley. Reclamation plans and forestry practices were based on that thinking. A special new radar designed to track such small birds immediately showed that individuals routinely moved from valley to valley across ridges. The entire premise of the plans and practices was faulty because the lore was wrong. What do we do now? Ignore the regulations?

It is difficult to assess the impact on habitat design rules of things we 'know', things that (right or wrong) are more or less engrained in the collective database. It would be worthwhile to generate a master list of assumptions relating to habitat and ecosystems (if that does not yet exist) and see if they hold up to scrutiny. Concepts that are of particular importance to planners and designers are physical parameters such as buffers (who establishes the width?), patches, corridors (for what purpose? Do they actually work?), and plant material choices for habitat.

Regulations define what will be reclaimed and how. They establish milestones and metrics, interpret public will, and are based on negotiated data, i.e., the result of considering simultaneously private property rights, economics, social and planning constraints, and scientific data. Regulations are local interpretations of state and federal policies and goals, which means that planning and design regulations are influenced strongly by economic and social considerations. Guidelines and regulations of necessity focus on things measurable and verifiable, such as short-term milestones, or corridor and buffer sizes. For example, a Washington state county requires that any mitigation plan plant western redcedars (Thuja plicata) in groups of three only. The explanation offered is that owls will not use single or double redcedars. On the larger scale, the Endangered Species Act is generating immense changes in how development and construction happens, probably for the good. The hope of creating salmon spawning habitat in every neighborhood stream has fired the imagination of everyone in the Pacific Northwest from elementary grades upward. This is independent of whether any given stream actually ever supported salmon.

Technology defines the limits of what we can do at the largest scales. At smaller scales we can employ more hand-crafted and detail-oriented tools and techniques. Technology tools range from soil amendments (moisture retention, microbiota) to earth-moving equipment. As a rule, if we CAN do it, we DO do it and declare it good long before we know the actual, long-term consequences. A current example might be the use of myccorhizal fungi inoculants to stimulate soil regeneration. Several companies sell this new technology, but most of the products offered in Washington state are from California, which has a completely different soil system and climate. The effect of introducing an exotic fungal species to an area is not yet known but the product is being heavily promoted as the solution to plant health and survival rates.

Clearly we have the means to construct landscapes of high biodiversity at all scales. We have extensive technical and practical information about how to create a landscape that approximates the one required or desired. Observational, common sense frequently has a grain of truth and may even produce positive results (e.g., buffers are essential). Knowledge-based data provide measurable, repeatable standards (buffers must have certain characteristics) and technology enables our doing virtually anything we want. Given this, we should have a successful track record of rich and diverse constructed landscapes. However, while we can go a long ways toward creating initial conditions required for biodiversity, I question how successful we have been at producing the end result.

Constructing Biodiversity

In any constructed landscape there are three stages: design, construction, and maintenance. Design is a result of the complex interplay between site conditions, regulatory requirements, and social and economic factors. In theory we can balance these differing forces well and create a diverse landscape. Constructing a designed landscape is usually not an engineering problem because technology tools are very powerful. It is in design and maintenance that part of our failure lies, because maintenance typically receives minimal attention and budget, or else it forces a simplistic design.

Effective design for biodiversity means to specify an initial condition that (1). is simple enough for us to construct, (2). can defend itself from invasion while accepting beneficial immigration and inoculation, and (3). can sustain itself long enough for the system to become self-maintaining. This requires getting the physical details right at all scales, from the whole mine to the individual animal or plant, and then providing the necessary maintenance as long as it is needed (which may not be known). All scales interact, therefore the design must address all scales simultaneously, not just the largest, which can easily dominate. Diversity cannot exist over thousands of acres unless it also exists with that plot on scales of 100s of meters (streams), 10s of meters (woodpile, ditch), meters (stumps, rock piles), and centimeters (pebbles, twigs).

Physical scales are easier to manage than temporal scales. Dealing with long time scales, e.g., for establishment periods, involves recurring expense and therefore is seen as a burden. It is this final stage, however that determines whether a biodiverse landscape results or not, and here a lesson can be learned from the "accidental" wetlands observed in pre-SMCRA surface mined lands. These wetlands were formed by the sort of randomness that is the hallmark of nature: water accumulated in any low spot and a wetland gradually, naturally evolved into a more complex state over several decades. In contrast, constructed wetlands (located in logical places relative to mining operations) did not exhibit the complexity and richness of the unconstructed wetlands (Atkinson, 1997). The key points here are that accidents (i.e., inoculation, immigration) create diversity and they need time to happen. Thus the goal of reclamation for biodiversity should be to begin succession through best design and implementation practices, and then let diversity happen, assisted by appropriate maintenance. This is a long-term process and requires commitment on the part of the restorer.

Surface mining leaves a scoured, uniform landscape behind. If biodiversity is in the details, re-introducing a variety of detail at all scales as part of a large scale, budget-limited reclamation process is crucial. Large machinery cannot create this detail, but humans can. After the rough grading and landforming is completed, the details can be introduced. Details that could be included as part of the large scale, rough construction are (e.g.) basins, berms, larger rock piles, log and root ball placement. People can do a lot at the smaller scales: build brush piles and small rock piles, and do detailed, rich plantings in small areas. Mines where this has worked are the Powell River Project (Virginia), Sudbury (Canada) and the Homestake McLaughlin Gold Mine (California). Reclamationists at these sites were experimentalists and they extrapolated what are typically 'backyard' scale details and applied them to the sites. Volunteers spread soil amendment and seed, bat houses were built, and butterfly populations were monitored.

Maintenance is the final piece of the process, yet is the core. It is not unreasonable to have to maintain a "natural" landscape – agriculture and rangelands receive considerable, on-going care after the preliminary establishment phase. Mining reclamation requires five or ten years before bonds can be released, but this relates to soil development, not habitat or ecosystem development. Duration for the latter is a gray area in terms of how long is long enough and what is the right kind of maintenance. This knowledge may be available, but it needs to be summarized and be at the core of the maintenance portion of the reclamation plan. If the actual goal of the process is establishment of a biodiverse, stable system, then a bond/maintenance period of five to ten years is not enough.

Proposed Guidelines

It would be of great value to generate and critique a master list of working wisdom, everything from assumptions to best management practices to paradigms. There is a large enough body of information now, real and apocryphal, to begin synthesizing a model of how to design, construct and nurture biodiversity that accounts for wildlife, water, sustainability and habitat. In particular, it would be instructive to know answers to the following:

How successful are large scale restoration projects in general on any site? Is it too soon to tell?

How many pre-SMCRA landscapes qualify as having high biodiversity?

How many post-SMCRA landscapes qualify as having high biodiversity?

What is the status of constructed wetlands in any site for supporting biodiversity?

What is the proportion of post-SMCRA lands restored to agriculture? Forestry? Woodlands? Habitat? Recreation? Development? Why?

How long must maintenance continue, and in what form?

In advance of having this grand summary and assessment of successful biodiversity experiments, I restate the critical habitat criteria (given earlier) as proposed design guidelines:

Get the baseline right: set up good soil conditions, understand the hydrologic system and find a good ground cover that protects the soil and sets up good successional possibilities. (This is the focus of most reclamation plans and we are becoming very knowledgeable here.)

Let water accumulate somewhere; where there is exposed water there is wildlife.

Create 'islands' of richness if the site is too large to plant densely and diversely. These islands can serve as plant and animal seed sources and as oases.

Design the island to fit the native wildlife: bring in habitat vegetation for the wildlife that is wanted.

Don't clean up too much. Be strategically messy: leave many different sizes of piles of rock, brush and/or logs to create nooks and crannies for small animals and to act as seed catchers.

Create connections at various scales: flyways, rills, windrows and hedgerows, and avenues between the islands.

Commission a nursery when mining begins, to grow native stock so that when reclamation planting begins the plant stock will be locally grown and therefore more likely to survive.

Encourage randomness, avoid uniformity.

Use volunteers and community members when possible.

Maintain the new system until it is self-sustaining.

Conclusion

We do have tools to create good design that sets up the initial conditions and to provide the necessary maintenance that will foster (eventual) biodiversity in a landscape. But for a variety of reasons, we do not build for biodiversity on surface mined lands, except in special cases. How successful we have been needs to be assessed by looking at existing projects, pre and post-SMCRA and in non-mining restoration situations, and by testing data and practices currently in use.

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