***Reclamation Benchmarks Write-Up*** A. Heller

**Approaches**

*The overarching goal is to compare two quantitative methods for setting oil and gas reclamation benchmarks using monitoring data at an EPA Level 3 Ecoregion scale.*

*Benchmark indicators*

Indicators will include foliar cover of functional groups (based on growth habit, duration, and exotic/invasive/noxious status; P. Alexander’s species list), total foliar cover, percent bare ground, proportion of plot in canopy gaps > 100 cm, and species richness (may also use perennial richness as per reclamation handbook).

*Initial data stratification*

All EPA level 3 ecoregions in the western U.S. with greater than 20 oil and gas wells will be included in analysis, regardless of the number, density, and spatial distribution of monitoring plots. AIM and LMF data will be subset to the selected ecoregions. Ecoregions will be compared with each other along elevation and precipitation (and maybe temperature) gradients. This will help apply benchmarks to ecoregions lacking monitoring data, by identifying “closest analog” ecoregions with monitoring data present based on similar elevation and moisture regimes.

Questions:

* Should monitoring plots be separated by ecological site type (grassland at reference vs. woody component at reference) to better fit with generalized state theory? If so, can automate the process to pull species composition data from EDIT and assign ecological sites as type 1 or type 2 based on proportions of herbaceous to woody species in reference list. What to do with plots that don’t have an ecological site assignment? Use ecological site key? This doesn’t help for areas with lacking good ecological site development.
* Should an index based on elevation/moisture/temperature be developed for ecoregions?

*Quantitative method 1: multivariate approach to setting benchmarks*

I will use a fuzzy-clustering approach on monitoring plot data to approximate generalized states. The fuzzy-clustering routine will use foliar cover of plant functional groups, percent bare ground, and proportion of large canopy gaps to approximate generalized states. Benchmarks will be derived from the ranges of indicator values taken from the generalized state clusters. Clusters representing reference states, bare/annualized states, or exotic-dominated states will be excluded. The logic behind these exclusions is that reference states are likely not attainable on reclaimed sites, and bare/annualized and exotic dominated states likely indicate a degree of degradation and lack of function that is not acceptable for reclaimed sites deemed “successful”. Benchmarks will be plotted using an ordination technique to look at trends in indicator ranges along elevation and moisture gradients. Benchmarks may be further narrowed by placing BLM Field Office (or other management unit) on moisture/elevation gradients.

Strengths:

* Strongly quantitative
* Considers vegetation community types and associated sets of ecosystem services/ecological function

Weaknesses:

* Not known yet how it will perform in this application
* Subjective choices to be made (e.g., parameters for cluster analysis and cutoff values of plots that are “too fuzzy” to include in developing generalized states)
* Requires specialized skillset to repeat (comfort with multivariate statistics)
* Not known what ecosystem services/sets of ecosystem functions are actually represented by the generalized states and resulting benchmarks

Questions

* What to do with plots that are too fuzzy? Exclude from analysis? There will likely be too many to move through plot by plot. Could set parameters for minimal fuzziness so only the most poorly matched plots are “fuzzy”.

*Quantitative method 2: quantile approach to setting benchmarks*

Distribution ranges of indicators within the initial strata (ecoregions) will be taken. Quantiles will be applied to those ranges, and will represent the benchmarks. Low quantiles will be taken for indicators such as percent bare ground and invasive plant cover, and high quantiles for indicators such as total foliar cover of number of native plant species. Benchmarks will be plotted using an ordination technique to look at trends in indicator ranges along elevation and moisture gradients. Benchmarks may be further narrowed by placing BLM Field Office (or other designation) on moisture/elevation gradients.

Strengths:

* Doesn’t require a specialized skillset to run or interpret analysis
* Fewer user choices to be made in comparison with multivariate approach

Weaknesses:

* No incorporation of vegetation state/community concepts
* Not known what ecosystem services/sets of ecosystem functions are actually represented by the generalized states and resulting benchmarks

Questions:

* What quantiles should be used? Quartiles? Deciles?
* Would it be best to take a quantile “one in ” from the desired extremity (i.e., to not capture reference-type or highly degraded indicator ranges)