Compare ESD and ESG Quantitative Benchmarks

Introduction

The development of Ecological Sites (ES) and their descriptions (ESD's) represent an enormous effort on behalf of the Natural Resources Conservation Service (NRCS) (Bestelmeyer (2015)). As mentioned in section XX, they do not yet form a continuous coast to coast, nor even across the field office data set (Twidwell et al. (2013)). In order to allay the significant amounts of effort required to develop these, and to make land management decisions in the interim alternative classification systems have been proposed (Nauman et al. (2022)). One system which incorporates the NRCS ESDs, and which provides continuous coverage across our study area, are the Ecological Site Groups (Nauman et al. (2022)).

The Ecological Site Groups developed largely by United States Geological Survey (USGS) researchers at the Southwest Biological Science Center in Moab Utah, with assistance from BLM Colorado State Office Staff, are meant to both bridge the spatial gap in ESD development, and to provide a framework for land management decisions at a larger scale than that which generally occurs at a BLM Field Office. The Ecological Site Groups were developed by grouping together similar ESD's, akin to the strictly interpretive approach - which seeks to reduce conceptual fineness - in section XX, and which will respond in a similar fashion to management actions (Duniway et al. (2016)). To these initial groups the field data which largely informed the ESD creation, most notably soil physical parameters, and with the use of an objective and quantitative approaches, which make use of simple *Machine Learning (ML)* method *Random Forest* **section XX** were used to identify recurring themes in the dataset into groups, and then project these onto a 'map' which covers the Upper Colorado River Basin.

While for most land management decisions at the UFO ESD's, when available, represent the best available scientific evidence upon which to inform decisions, ESG's provide the best alternative for much of the field office, and in the future are likely to be influential for large scale decisions at the UFO. Herein we address questions regarding the similarity of estimates arising from ESG's and ESD's. In this report, we are using ESD's for the *reference state benchmarks* which they contain, in other words quantitative goals which we seek to compare land to, and seek to visualize the relationship between the standards of ESD's and ESG's.

The goals of this section are to 1) determine which ESD's constitute the ESG's across the UFO? And 2) visualize the similarity in benchmarks within an ESG and the ESD's which it contains. A short investigation of how different methods of extracting the spatial dataset to the ground truthed data, as well as a comparision of the accuracy of the predicted ESG's limited to the UFO area and ground truthed plots, is also included.

In the publication of Nauman et al. 2022 the accuracy of the final product was calculated as being 57.4% (Nauman et al. (2022)). However, In our expereince certain groups are often more difficult to reliably predict, and without sufficient testing sample sizes many spatial products will score higher, or lower, than these averages in areas with/without these features.

Methods

The mean fractional cover of vegetation was manually transcribed from Table 3 of Appendix A from Nauman et al. 2022. The spatial data product, a gridded surface of predicted ESG's, which was the outcome of the study was accessed from sciencebase.gov catalog on (Dec. 16, 2022, https://is.gd/c89lNz), three additional layers predicting soil geomorphological groups and another predicting climate zone were also downloaded.

ESD quantitative benchmarks values, and AIM plot locations were cleaned in previous work (Section XX ESD Completion). All analyses were performed in R version 4.2.2 using RStudio on Linux Ubuntu 22.04 LTS (R Core Team (2022), Sobell (2015), RStudio Team (2015)).

Test Raster Extraction Methods

To test whether we were extracting and processing the correct ESG from the gridded surface two comparisons of raster extraction methods were attempted. The first (hereafter: 'polygon'), which is typically performed at UFO, is to buffer the point to represent the actual area of the entire AIM plot and extract to that area, and choose the categorical class with the most cells per value (in other words the statistical mode). The second (herafter: 'point') option is to extract values from the gridded surface directly to the point geometry. The idea behind this is that the pixels from the gridded surface featured a 'splotchy' characteristic, a byproduct of not performing spatial operations to clean up the predictions (e.g. 'Focal Statistics'); oftentimes these central isolated cells are not artifacts of analysis, but rather true points which are swamped by the adjacent cells. The slightly higher performing method, 'polygon', was used for the duration of the analyses.

Test Local Accuracy of Raster Dataset

To determine whether the raster dataset gives a higher or lower performance accuracy in the UFO portion of it's range the 157 AIM plots in 18 ESD's which are known to map directly to 10 ESG's were utilized. These plots were extracted from the ESG gridded surface and the proportion of each ESG which was correctly and incorrectly mapped were calculated.

Determine ESD and ESG Groupings

To inform a strategy for mapping individual ESDs directly to ESG's a bipartite network was created using all AIM plots with verified ESD's, all statistics (**not reported in text**) were calculated using the package 'bipartite' (Dormann et al. (2008)). This approach was deemed neccessary given how many erroneous relationships were returned by the ESG extraction method.

All observed ESD's were matched to ESG's in an incremental fashion. ESD's which were used directly in the creation of ESG's were removed based upon a noted association in Appendix 6 of Naumen et al. 2022. ESD's for which only a single AIM plot existed, had the ESG which values were extracted from it listed as it's ultimate mapped association. ESD's with greater than 1 AIM plots associated with them, and which had all plots match an ESG were classified as such. ESD's with over 65%, our local accuracy of the gridded surface, of their AIM plots mapping to a single ESG.

Following the removal of these ESDs from the initial dataset, the three Soil Geomorphologic Units (SGU) surfaces, and the Climate Zone surface were used to match the remaining ESDs to an ESG. Each of the remaining points had values extracted from each layer of the SGU surfaces, each representing the classification prediction from the three top performing classifier models. The most commonly occurring ESG (in others words the statistical mode), was then calculated considering each of the SGU layers per point, across all points in the ESD simultaneously. All climate zones were also extracted to the points, and the most commonly occurring climate zone per ESD was selected as the climate zone to classify these sites in the SGU framework, thus forming the ESG.

The results of these analyses led to the development of a draft ESD-ESG lookup table for the Uncompahgre Field Office for this project.

Results

157 AIM points were in the 18 ESD's which were directly involved in the creation of 10 ESG's and could be used for assessing the results from the alternative raster data extraction methods and for assessing the

accuracy of the ESG gridded surface in the area of analysis.

The method of extracting the ESG from the gridded surface to plot had little influence on the accuracy of the ESG. Regardless the method of buffering the point to the real size of the AIM plot was used as it slightly outperformed plot centers on the 157 known sites, 0.65 to 0.637.

157 AIM points were in the 18 ESD's which were directly involved in the creation of 10. The ESG gridded surface was able to correctly place 0.65 plots to the appropriate ESG, rather than the 57.4% reported for the entire study area (*Figure 1*). A caveat associated with this result is that our value is likely to be biased towards more common ESG classes. We accept this bias as the scale at which we make management decisions is so great.

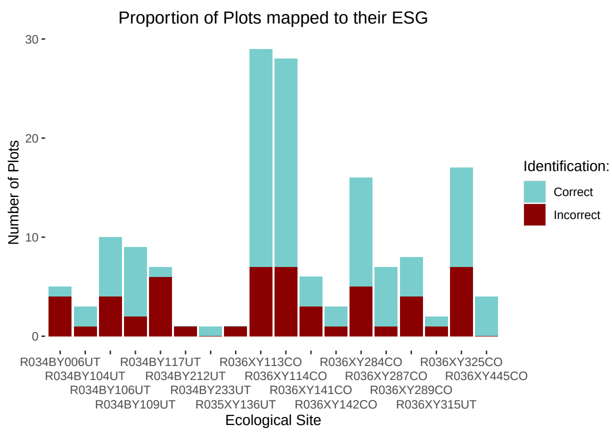

Figure 1: Proportion of Plots in ESDs which were included in the ESGS and should map over unequivocally to an ESG

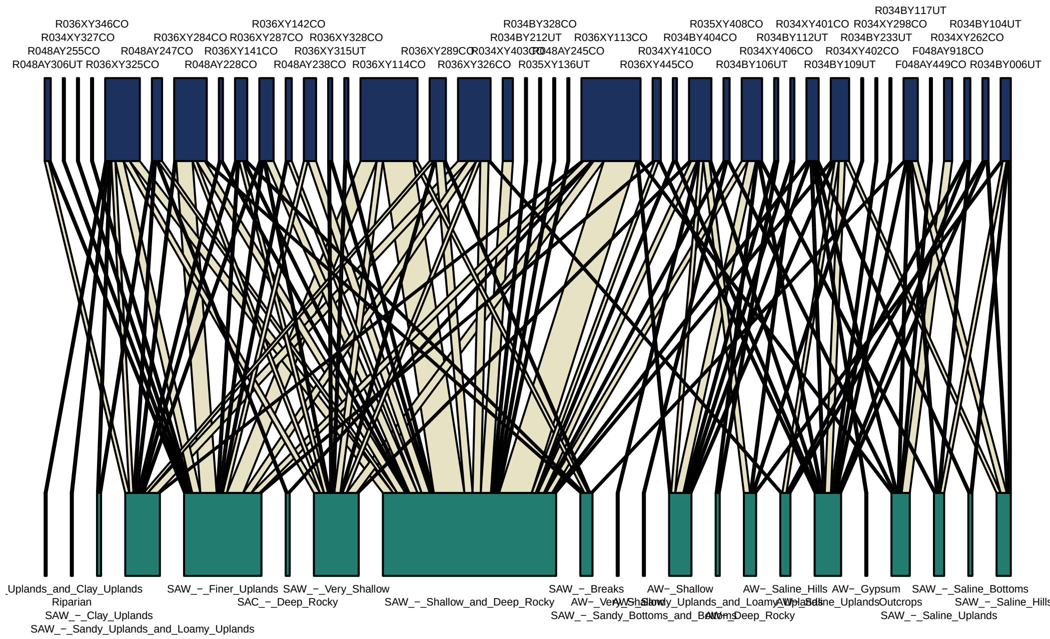

Figure 2: Initial Relationship Between Field Verified ESD and ESG extracted from the gridded surface

The initial extraction of ESG to AIM points was problematic (*Figure 2*). We were able to improve upon these results via multiple steps in sequential order. 1) Look up table values form publication (as mentioned 157 plots, 18 esds, and 10 ESGs), 2) 8 plots/ESD's had a sole representative, 3) 9 plots where all ESDs were in one ESG where > 2 plots per ESD 2, 4) 9 plots where > 65% of the 2 (*Figure 3*).

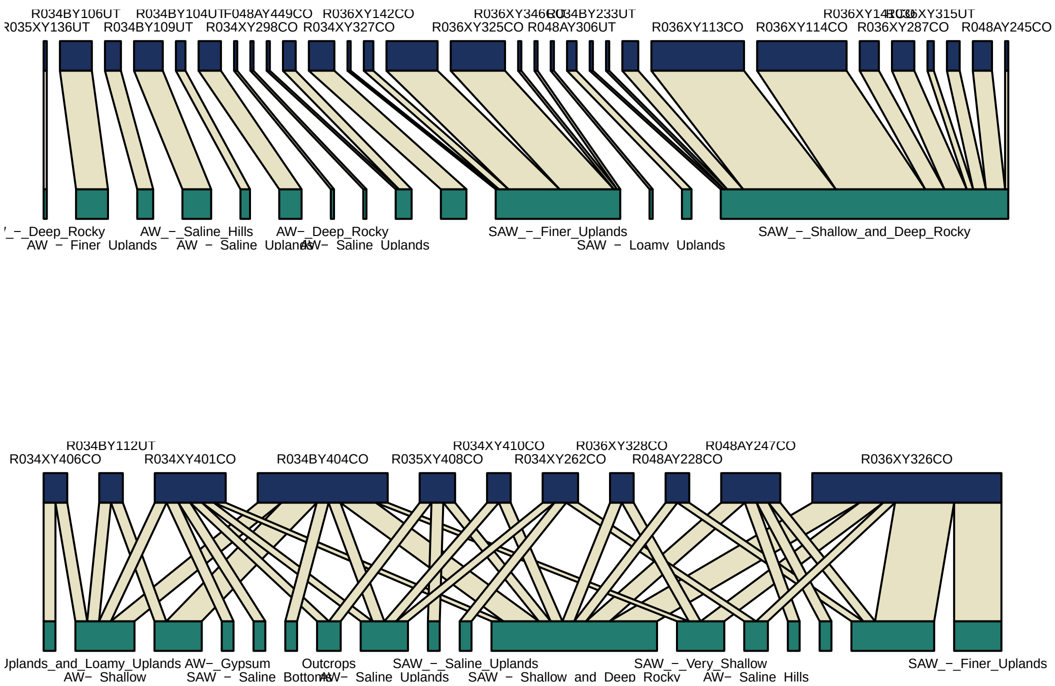

Figure 3: Relationships Between ESDs and ESGs midway through the cleaning process

The remaining 11 ESD's were all mapped to 6 ESG via the methods of summarizing both the SGU and climate zones. The final lookup table of ESD to ESG mapping is in Figure 4.

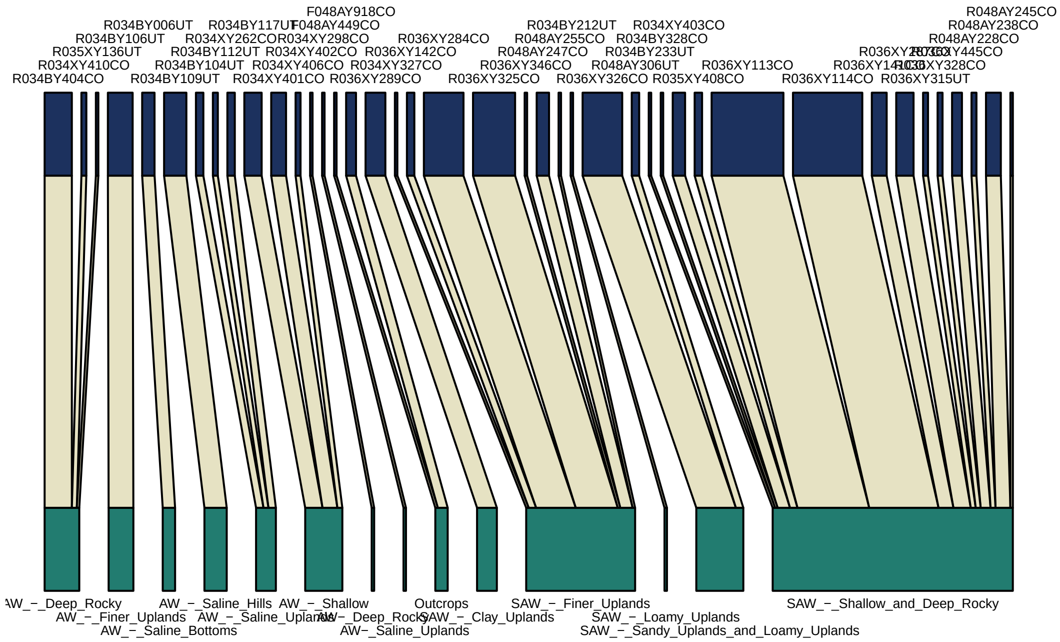

Figure 4: Relationship between ESDs and ESGs at end of process

Conclusions

The relationship between the novel ESG's and the ESD's...

For best accuracy using the ESG's it is best practice to verify the ESD using traditional methods rather than spatial operations.

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