Plot Weights & Locations

steppe

This AIM study was designed with three major principals in mind. The first, was maximizing the number of environments which it represents across the field office. The UFO field office varies by nearly XXXX feet, XXXX average precipitation, XXXX average temperatures, and displays a diversity of environments; and this sample design included this entire range of variation. To ensure that these diverse areas were represented, ten major strata were identified *see table*, in order to ensure that they had plots located in them in order to evaluate their ecological *integrity*. However, the management concerns, actions, and heterogeneity (internal dissimilarity) of these strata differ. To best understand the ecological context of these strata, and what management actions the BLM may take, the proportion of plots were tailored to each stratum. The third principal was that all plots be randomly placed within the stratum, which allows *inference* to be made from plots to the, unsampled, entirety of the stratum. This *weighted sample design* allows us to maximize statistical understanding while minimizing the field effort required to undertake it. Finally, the entire field office was designated as the *sample frame*, i.e. the area of analysis (or a spatially explicity population), which we can make statistical inference to.

The initial sample design followed the general AIM implementation design to contain 255 plots to be sampled across five years. Sampling over a five year period is essential in order to ensure that plots are visited during periods wherein the vegetation is *reproductively active*, hence identifiable. A benefit of this prolonged time frame is that anomalous weather conditions are unlikely to affect the plots across the entire time period. For example, the condition of plots may be compared in a wet year, to a dry year, as referenced from a year with typical rainfall. In order to avoid random unexpected processes which cluster in space which may occur over the period of conducting the sample design, the entire design is split into a *panel* for each year of sampling. Each panel is composed of a subset of randomly selected points within the sample design and avoids missing swathes of the *target frame* during the sample period due to an event such as a prolonged wildfire.

The location of the random plots for AIM are generated via computer and a number of them may not feasibly be sampled. In general potential plots are most often, anecdotally, rejected for: being located on steep slopes which are dangerous for field crews to sample, requiring access to cross private land to access BLM which landowners deny. The inability of these plots to be sampled reduces the spatial extent of the strata which we may use statistics to infer across, and increases the measures of uncertainty associated with these areas. In this section we review the original sample design, derive original sample weights for sub-units of the field office, and calculate the weights for each of these units after the sample design has been completed.

the design may be represented in simple mathematical terms

Using an example from a stratum which is of high land management importance, sagebrush-steppe, we illustrate the site selection process. While the aerial extent of sagebrush-steppe in the target frame is roughly one quarter (0.246), the stratum makes up one third (0.33) of all plots

In order to convey the number of plots drawn in any stratum the following equation is representative.

$$n = \frac{N * \pi_i}{1/panels}$$

- N the total number of plots in the sample design, *i.e. 255*

- π_i the inclusion probability of a plot in each stratum being drawn, *e.g. 0.33 targets the placement of a third of all plots to be put into the Sage-steppe Stratum*
- *panels* the number of design panels, *i.e. the number of years to stretch sampling across*

For sagebrush steppe we will then have:

$$16.83 \ = \ \frac{255 * 0.33}{1/5}$$

plots for each panel, which will round down to 16 in order to accommodate representation of some of our other strata.

The **weight** of a plot is the amount of acres it represents within a stratum, we utilize this metric to help derive *measures of uncertainty* while making inference from our sampled plots to the whole stratum.

$$W_i = \frac{Stratum_{area}}{n}$$

- W_i the weight acres, *i.e. the area which a plot represents within the target frame*
- $Stratum_{area}$ the total area of the stratum in the area of analysis *e.g. 214,023 acres of sage-steppe*
- n the total number of plots in a stratum *e.g. for a panel of sage steppe 16*

Each sagebrush-steppe plot will have a weight of

$$13,376 \ = \ \frac{214,023}{16}$$

acres per plot, which it represents.

Areas of Analysis

The original AIM design covers the entire target frame of the UFO field office. However, a few additional analytical and management sub-units exist within this extent. There are three planning areas each with their own management objectives. The two National Monuments associated with the UFO - the Gunnison Gorge & Dominguez-Escalente - the latter of which is partially administered by the Grand Junction Field Office (GJFO), are associated with their own Planning Areas. Likewise both within those, and across the Field office, there are numerous Wilderness Study Areas (WSA's), and Area's of critical Environmental Concern (ACEC's). As discussed later, the UFO intends these areas to have higher proportions of certain vegetation metrics relative to the remainder of BLM land.

The Uncompahgre Resource Management Plan, completed in June 2019 covers 675,800 acres of the field office, and provides the definitive source of management objectives for the Field Office (summarized in VEG-OBJ-01 in Section II p. 23):

> "*Maximize native vegetation and natural processes by ensuring upland vegetation communities are within the range of natural variability, with an appropriate mix of plant functional groups, cover, and diversity, according to best available science on greater than 80 percent of vegetation communities in ACECs, WSAs, suitable WSR segments, and lands managed to minimize impacts on wilderness characteristics and on greater than 70 percent of vegetation communities on the remaining BLM- administered lands, over 10 years with 80 percent confidence.*"

Table 1: Original Sample Design for the Entire Sample Frame

Stratum	Total Area (acres)	Prop. Area	Prop. Site	No. Plots	Plot Wt.
PJ	354,850	0.41	0.12	25	70,970
SS	211,832	0.24	0.33	80	13,239
SD	118,664	0.14	0.30	75	7,911
MMS	61,862	0.07	0.10	25	12,372
RI	46,769	0.05	0.05	15	15,590
GR	17,867	0.02	0.02	5	17,867
OT	16,685	0.02	0.01	5	16,685
MC	15,338	0.02	0.05	15	5,113
PP	14,716	0.02	0.01	5	14,716
AS	12,932	0.01	0.01	5	12,932

Table 2: Realized Weighted Sample Design for the Entire Sample Frame

Stratum	Inf. Prop.	Area Inf.	Plot Wt.	Sampled	Rejected
PJ	0.80	283,880	14,194	20	5
SS	0.89	188,001	2,648	71	9
SD	0.88	104,424	1,582	66	9
MMS	0.84	51,964	2,474	21	4
RI	0.60	28,062	3,118	9	6
GR	1.00	17,867	3,573	5	0
OT	0.60	10,011	3,337	3	2
MC	0.27	4,090	1,023	4	11
PP	0.80	11,773	2,943	4	1
AS	0.40	5,173	2,586	2	3

"*greater than 70 percent of vegetation communities on (the remaining) BLM-administered lands*"

Areas of Critical Environmental Concern (ACEC's) and Wilderness Study Areas (WSA) The reporting units of Areas of Critical Environmental Concern (ACEC's), and Wilderness Study Areas (WSA), have different management objectives relative to the remaining BLM administered surface area. Loosely, they are intended to have a higher percentage of the vegetation communities within the natural range of variation:

> "*greater than 80 percent of vegetation communities in ACEC's, WSA's...*"

These areas were not intensified units within the original sample design, rather we split them out here using the original point draw for the field office. Here we calculate the initial sample weights for them using the same approach as for the remainder of BLM land, i.e. the acreage of each stratum is weighed against a targeted proportion of plots in the region. As our sample design was initiated and completed during a period of drought (See...), we dismiss the possibilities of making temporal comparisons across the sample panels. Accordingly, we have strata within these management units which: do not have a point per year panel (i.e. cannot be sampled each year). Subsequently, we do not have the initial ability to infer across the entire acreage of each stratum within them.

Table 3: Original Sample Design for Areas of Critical Environmental Concern & Wilderness Study Areas

Stratum	Total Area (acres)	Prop. Area	Prop. Site	No. Plots	Plot Wt.
PJ	36,832	0.39	0.12	3	22,099
SS	21,272	0.22	0.33	11	9,669
SD	14,215	0.15	0.30	10	7,108
MMS	11,924	0.12	0.10	3	7,154
RI	4,147	0.04	0.05	2	1,659
OT	2,294	0.02	0.01	1	459
AS	1,429	0.01	0.01	1	286
GR	1,175	0.01	0.02	1	235
MC	1,064	0.01	0.05	2	426
PP	785	0.01	0.01	1	157

Strata with five or more plots, would allow for temporal analyses to be conducted on their data. Strata with less than five plots can only be treated as static entities within this time period

Table 4: Realized Sample Design for Areas of Critical Environmental Concern & Wilderness Study Areas

Stratum	Inf. Prop.	Area Inf.	Plot Wt.	Sampled	Rejected
PJ	0.67	24,555	12,277	2	1
SS	0.73	15,471	1,934	8	1
SD	0.80	11,372	1,422	8	2
MMS	0.50	5,962	994	6	0
OT	1.00	2,294	2,294	1	1
GR	1.00	1,175	1,175	1	0

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## [1] "0"
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Dominguez-Escalente National Monument

Table 5: Original Sample Design for Dominguez-Escalante National Monument

Stratum	Total Area (acres)	Prop. Area	Prop. Site	No. Plots	Plot Wt.
PJ	50,474	0.43	0.12	3	30,285
SD	21,461	0.18	0.30	10	10,731
SS	21,014	0.18	0.33	11	9,552
RI	6,619	0.06	0.05	2	2,648
GR	3,703	0.03	0.02	1	741
MMS	3,193	0.03	0.10	3	1,916
OT	2,607	0.02	0.01	1	521
PP	1,166	0.01	0.01	1	233
MC	694	0.01	0.05	2	278
AS	120	0.00	0.01	1	24

Strata with five or more plots, would allow for temporal analyses to be conducted on their data. Strata with less than five plots can only be treated as static entities within this time period

Table 6: Realized Sample Design for Dominguez-Escalante National Monument

Stratum	Inf. Prop.	Area Inf.	Plot Wt.	Sampled	Rejected
PJ	1.00	50,474	16,825	3	1
SD	0.77	16,508	1,270	13	1
SS	0.82	17,193	1,910	9	0
RI	0.50	3,310	3,310	1	0
GR	1.00	3,703	3,703	1	0
MMS	1.00	3,193	1,064	3	0
OT	1.00	2,607	2,607	1	0
PP	1.00	1,166	1,166	1	0

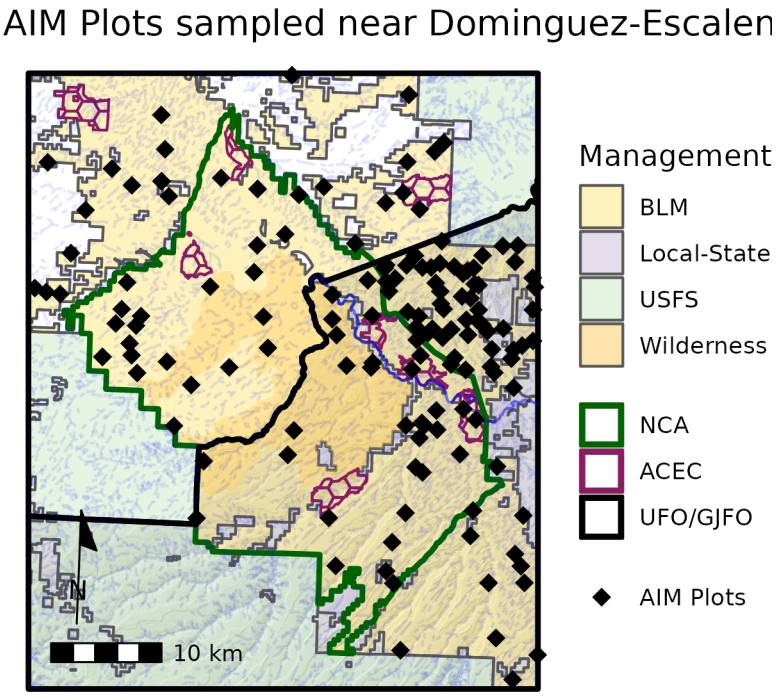

Figure 1: All plots sampled in the vicinity of the National Conservation Area, by both the UFO and Grand Junction Field Office. The GJFO is North (towards the top of the page) of the black line running across the map.

Gunnison Gorge National Monument

Table 7: Original Sample Design for Gunnison Gorge National Monument

Stratum	Total Area (acres)	Prop. Area	Prop. Site	No. Plots	Plot Wt.
SD	18,659	0.33	0.30	6	15,549
PJ	16,191	0.29	0.12	2	6,477
SS	13,037	0.23	0.33	7	9,312
RI	2,445	0.04	0.05	1	489
OT	2,282	0.04	0.01	0	0
MMS	1,617	0.03	0.10	2	647
GR	921	0.02	0.02	0	0
MC	383	0.01	0.05	1	77
AS	104	0.00	0.01	0	0
PP	22	0.00	0.01	0	0

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## [1] "six"
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The Gunnison Gorge National Monument encompasses 56,320 acres, and contains only a few of the strata types covered in the design. It is the only sub-unit of the AIM sample design which is comprised primarily of salt desert, which is featured prominently along the Western portions of it. It also contains significant portion of Pinon-Juniper, adjacent to the cliffs overlooking the gorge, and some of the Target Frames best Sagebrush-Steppe along the Eastern portions. The area features only trace amount of six of the original strata, resulting in them being devoid of any plots in the original draw. There were two strata only present in minor amounts which had fewer than five plots drawn.

Table 8: Realized Sample Design for Gunnison Gorge National Monument

Stratum	Inf. Prop.	Area Inf.	Plot Wt.	Sampled	Rejected
SD	0.60	11,195	1,120	10	1
PJ	0.50	8,096	8,096	1	0
SS	0.86	11,174	1,862	6	1

Of the six strata which had plots drawn within the monument, only four were successfully sampled. The Pinon-Juniper stratum, representing 29% of the area, only had one point sampled, accordingly no temporal analyses can be performed using this stratum. However, both the Salt Desert and Sagebrush-Steppe stratum, which compose roughly 55% of the monument, had enough plots sampled for temporal analyses. ...

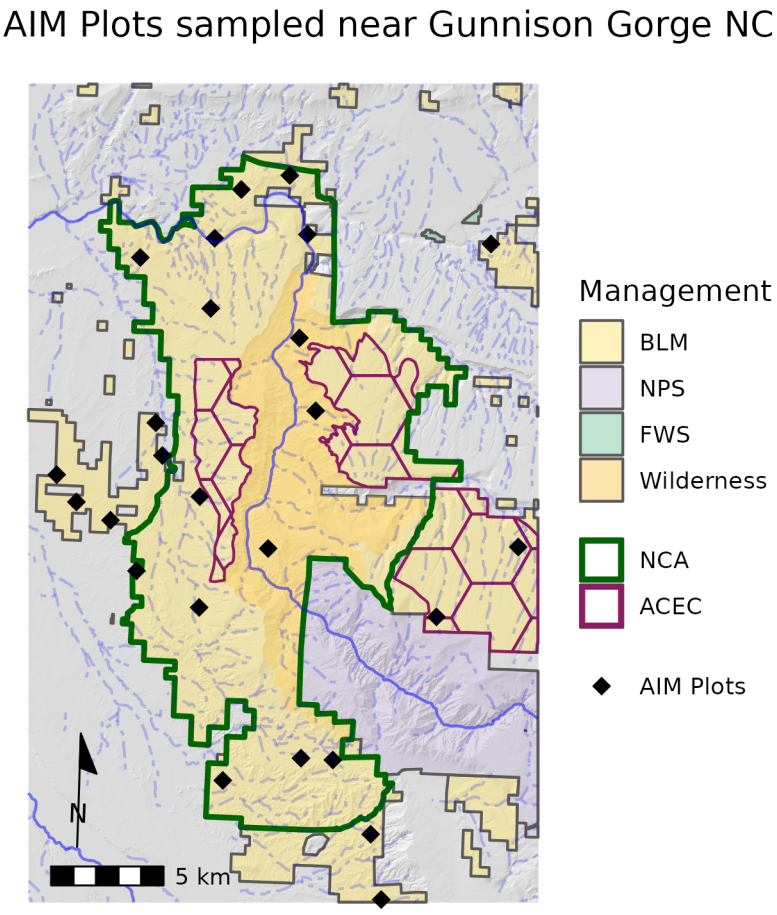

Figure 2: All plots sampled in the vicinity of the National Conservation Area

Summary of Plot Sampling Efforts

No clear biases existed in the success of plot sampling efforts with the exception of Mixed Conifer plots.

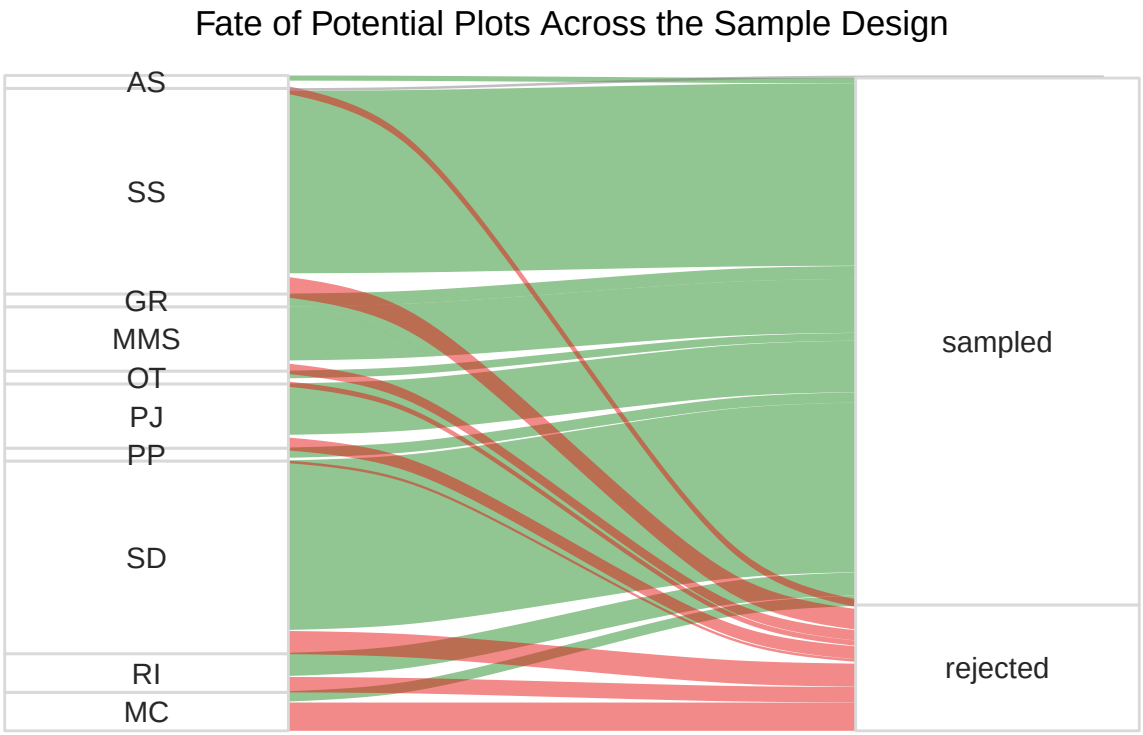

Figure 3: Fates of all potential AIM plots from the Sample Design