Plot Weights & Locations

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 explicit population), which statistical inference can be made 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 *reproductively active* 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 Conservation Areas 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.*" — RMP 2019

All land, less species status

> "*greater than 70 percent of vegetation communities on (the remaining) BLM-administered lands*"
>
> — RMP 2019

Table 1: Original Sample Design for the Entire Sample Frame

Stratum	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

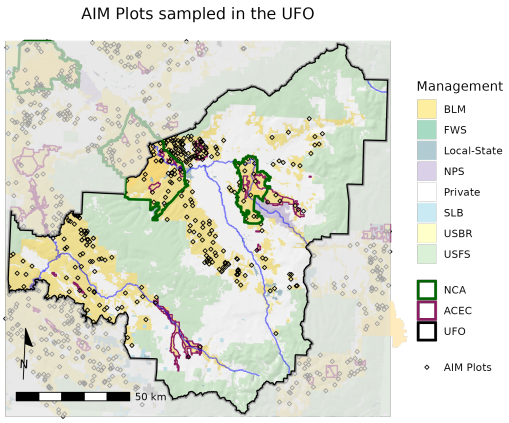

Figure 1: All plots sampled across the entirety of the field office

The majority of land administered by the field office does not fall under any special regulatory status, such as those which are present for the Areas of Critical Environmental Concern (ACEC's), Wilderness [Study] Areas, and National Conservation Areas. The initial AIM sample design covered the entirety of the Field Office, and did not separate out, or weigh, the special regulatory areas from the majority of BLM administered land. However, given that this area is managed differently than the following three other areas, and that it has different management objectives with more tolerance to certain kinds of uses, we split this area out retroactively. Here we assess the location of the AIM plots drawn in the original sample design, and using spatial techniques assign them to this area. We then determine the weights of plots under the scenario that all plots were sampled (Table 1), and under the realized condition that only certain plots were sampled (Table 2). Generally, we would only be performing the second action at the end of the sampling.

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

			No. Plots	
Stratum	Plot Wt.	Plot Wt. Ac.	Sampled	Rejected
PJ	0.781	55,445.348	32	8
SS	0.909	12,035.897	88	12
SD	0.915	7,235.583	82	12
MMS	0.893	11,046.779	28	12
RI	1.000	15,589.791	15	15
GR	0.625	11,167.130	8	12
OT	0.833	13,904.484	6	14
MC	1.667	5,112.779	9	21
PP	0.625	9,197.409	8	12
AS	1.250	12,932.249	4	16

The strata of Mixed Conifer and Aspen, both had fewer plots sampled than the sample design called for. Both of these areas are relatively rare across the field office, and accordingly had very few initial plots drawn for each of them. The inability to sample these is due to several of the drawn base points and over sample

plots being located on parcels of land, which required permission from private land owners to access, but which were denied; or were on areas with very high slopes, which were unsafe to sample. While we are able to use these plot weights to infer across the field office on the whole, we note that a discrepancy existed between the actual distribution of these areas in the office and the plots classified as such **SECTION XX**. While we regret not being able to sample these plots, most of the drawn locations were actually in Mixed Mountain Shrub, an area which was weighed to have extra plots and which was successfully sampled.

Aside from these two strata, all other strata had more plots sampled than expected. Because the area of inference which these plots speak to cannot change, the weight of each individual plot decreases in this scenario. In simpler terms, each plot represents a smaller unit of area. In the case of the Mixed Conifer and Aspend plots, each plot represents more area than intended.

Areas of Critical Environmental Concern (ACEC's) and Wilderness Study Areas (WSA) The Uncompahgre Field office has 11 unique Areas of Critical Environmental Concern. The focus of these areas range from conserving Archaeological sites, sections of Rivers, and rare plant localities. Many of these areas are relatively small, and scattered across the entirety of the field office, the locations under this analytical unit will include those which cannot be combined the National Conservation Areas. Three of the ACEC's are nearly entirely contained within National Conservation Areas, and will not be included in the analyses for this section, but rather the NCA which they are surrounded by. Both of the field offices two wilderness areas, are also contained entirely within National Conservation Areas, and they also will be included in analysis and discussion within the NCA which contains them.

The office has four Wilderness Study Areas, one of which is largely encompassed by a National Conservation Areas, and will be included in the analyses there, rather than here.

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

Stratum	Area (acres)	Prop. Area	Prop. Site	No. Plots	Plot Wt.
PJ	16,057	0.25	0.12	3	9,634
SS	13,427	0.21	0.33	8	8,392
SD	13,384	0.21	0.30	8	8,365
MMS	11,318	0.17	0.10	3	6,791
OT	3,601	0.06	0.01	1	720
RI	3,493	0.05	0.05	2	1,397
AS	1,444	0.02	0.01	1	289
PP	1,093	0.02	0.01	1	219
MC	754	0.01	0.05	2	302
GR	100	0.00	0.02	1	20

The reporting units of Areas of Critical Environmental Concern (ACEC's), and Wilderness Study Areas (WSA), and Wilderness Areas, 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...*" — RMP 2019

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 (**SECTION** 5), 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.

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: Number of Plots Drawn per ACEC

		No. Plots	
Name	Area (ac.)	Drawn	Sampled
Gunnison Sage-Grouse IBA	22,146	6	7
Adobe Badlands	6,380	10	6
San Miguel River	5,115	2	1
Paradox Rock Art	1,083	1	2
Fairview South (BLM Expansion)	608	1	1
Biological Soil Crust	385	0	0
Dolores River Riparian ACEC	1	0	0
Fairview North RNA	0	0	0

As can be seen in table 4, not every Area of Critical Environmental Concern was able to have an AIM plot located in it. Roughly only half of them had an AIM plot located in them. This is due to them being relatively small in size, the number of AIM plots being relatively few. An alternative AIM sample design, for one of the frames, may require the placement of a plot into each of these individual areas in order to determine long term trends in them. This would allow for determining whether passive management actions in these areas were achieving goals.

Two of the ACEC's which had AIM plots located in them, Adobe Badlands and San Miguel River, did not have as many plots sampled within them as the sample design called for. In both instances this is most likely due to the plots being on hill slopes which were unsafe to sample. However, oversample plots were sampled in other ACEC units, leading to an appropriate number of plots being sampled across the entire area.

Table 5: Realized Weighted Sample Design for the ACEC-WSA

			No. Plots	
Stratum	Plot Wt.	Plot Wt. Ac.	Sampled	Rejected
PJ	1.5	9,634.03	2	0
SS	2.0	8,391.92	4	1
SD	1.0	8,365.05	8	4
MMS	0.5	3,395.33	6	2
OT	1.0	720.13	1	4
PP	1.0	218.56	1	3

More AIM plots in Mixed-Mountain Shrub and Pinyon-Juniper were sampled than drawn in the sample design. Accordingly, these plots are weighted to speak to lower amounts of area than initially noted in the sample design. Fewer Sagebrush plots were sampled than intended, and the weight of the sample plots has been increased to compensate for the deficit.

Dominguez-Escalente National Conservation Area The Dominguez-Escalente National Conservation Area is joint administered with the Grand Junction Field Office, all values here refer only to the portions administered by the UFO field office. As mentioned previously, any lands within Wilderness Study Areas within the National Conservation Areas are included with the ACEC-WSA strata.

River Rims ACEC, Escalante Canyon ACEC - SURROUNDED BY DE.

Table 6: Original Sample Design for Dominguez-Escalante NCA

Stratum	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

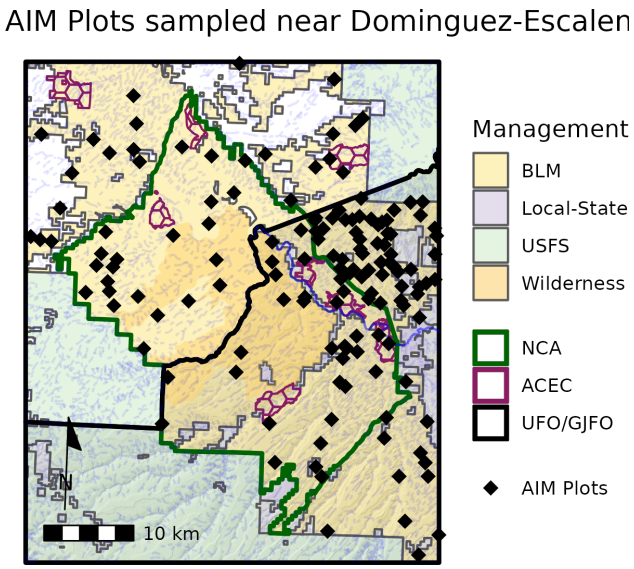

Figure 2: All plots sampled in the vicinity of the National Conservation Area, by both the UFO and Grand Junction Field Office. The GJFO is North (towards the top of the page) of the black line running across the map.

The total area of the Monument which is administered by the Uncompahgre Field Office is roughly 116,796 acres. However due to the large WSA within it, and assorted ACEC's the total area is reduced to only 116,796 acres...

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 7: Realized Weighted Sample Design for Dominguez-Escalente

Stratum	Plot Wt.	Plot Wt. Ac.	No. Plots	
			Sampled	Rejected
PJ	0.60	18,170.78	5	1
SD	0.62	6,706.58	16	1
SS	1.22	9,551.73	9	1
RI	2.00	2,647.73	1	1
GR	0.50	370.32	2	3
MMS	1.00	1,916.08	3	0
OT	1.00	521.44	1	3
PP	1.00	233.21	1	1

Gunnison Gorge National Conservation Area
The Gunnison Gorge National Conservation Area 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 field offices 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

Native Plant Community ONA - SURROUNDED BY GG

Table 8: Original Sample Design for Gunnison Gorge NCA

Stratum	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

Of the six strata which had plots drawn within the NCA, 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 NCA, had enough plots sampled for temporal analyses. . . .

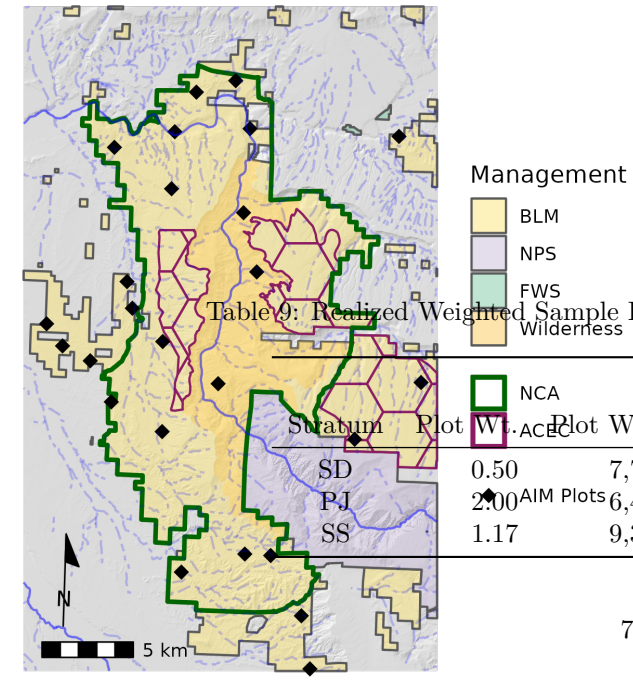

Table 9: Realized Weighted Sample Design for the Entire Sample Frame

Stratum	Plot Wt.	Plot Wt. Ac.	No. Plots Sampled	No. Plots Rejected
SD	0.50	7,774.38	12	3
PJ	2.00	6,476.56	1	0
SS	1.17	9,311.86	6	1

Figure 3: 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.

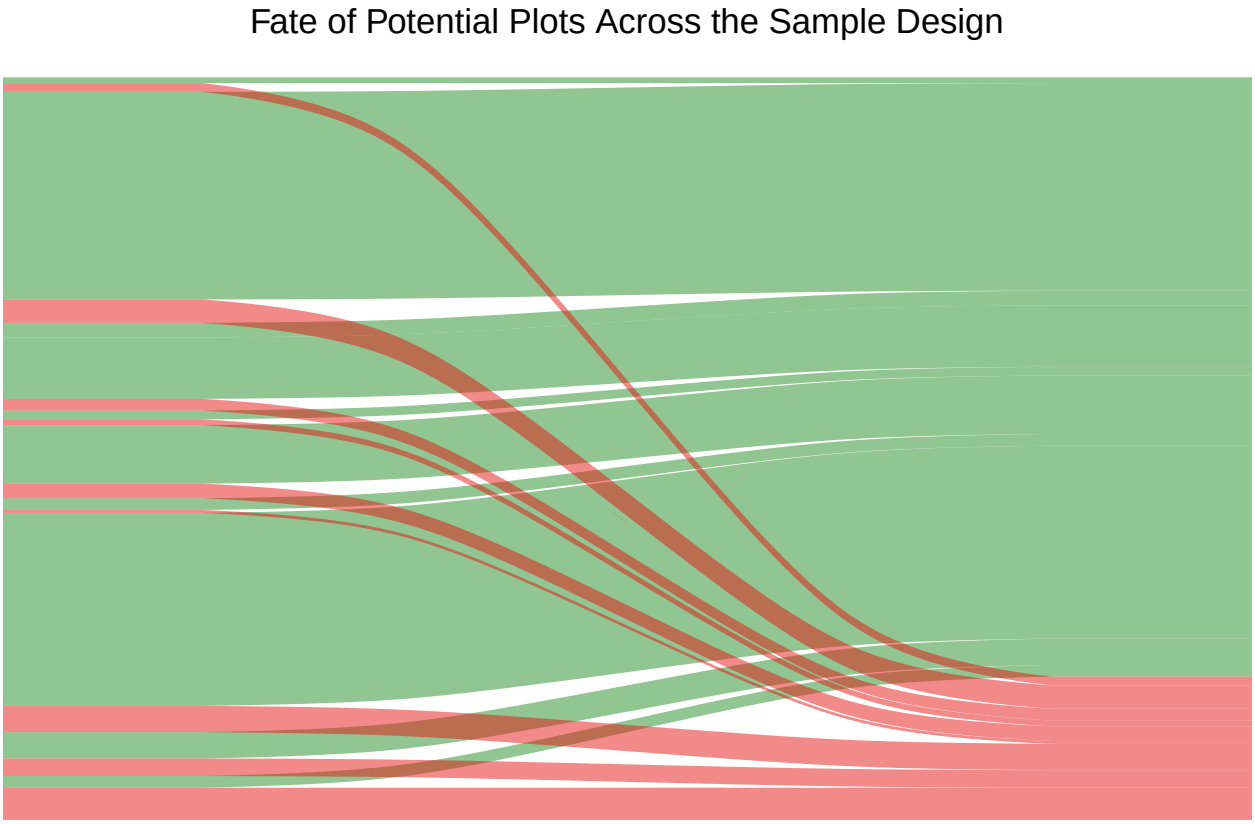

Figure 4: Fates of all potential AIM plots from the Sample Design