Using the Assessment, Inventory, and Monitoring Strategy to Measure Treatment Effectiveness in Pinyon-Juniper Woodlands

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It is increasingly important to understand how different management actions affect public lands and renewable resources. In response to a lack of standardized monitoring, the Bureau of Land Management (BLM) developed the Assessment, Inventory, and Monitoring (AIM) strategy (Toevs et al. 2011). The AIM approach is based on five key elements: 1) a standardized set of core and contingent indicators, 2) a statistically valid sampling design, 3) a structured implementation process, 4) electronic data capture, and 5) integration with remote sensing. This strategy can help to more efficiently meet national, regional, and local resource information needs. The Taos Field Office (TFO) of the BLM has used the AIM protocol for 3 successive years to monitor vegetation treatment effectiveness and to inventory wildlife habitat. Here we discuss the implementation of AIM protocols and use AIM data to describe five, two-needle pinyon pine (*Pinus edulis*) and oneseed juniper (*Juniperus monosperma*) treatment areas in and around Taos, New Mexico. The use of AIM data shows us the complex consequences of these management actions and illustrates the advantages of ongoing monitoring at the field office level.

The BLM's AIM protocol includes both core and supplementary methods of data collection; core methods are used on every AIM plot and supplementary methods may be added at the project level to suit any additional data needs. More detailed information on AIM methods and implementation can be found in Herrick et al. (2009) and Taylor et al. (2014). Core methods include: plot characterization, line point intercept (LPI), vegetation heights, species inventory, canopy gap intercept, and soil stability. Core methods were executed in the present study in addition to belt vegetation measurement transects and tree density measurement (AIM supplemental methods) to characterize ecological trends and treatment effectiveness. Data were collected at a total of 19 treatment plots from five individual treatment areas named A-E (four thinning plus prescribed burning and one with thinning only, table 1). Each treatment area varied in the date of treatment, method of burning/thinning and size. These 19 plots were then compared to 24 AIM plots from untreated sites within respective Ecological Sites (ES). Plots within the same ES share similar soil, vegetation, topography, and climate thus representing areas within the landscape that are likely to respond similarly to disturbances. Both treated and untreated plots consisted of a sample area of 2,827.4 square meters and were distributed across the landscape using a stratified, spatially balanced random sample design as described by Stevens and Olden (2004). The ES were used as strata for both the treated and untreated sample designs. Data collection from treated and untreated areas occurred over a span of three years from 2014-2016 during the peak plant growth seasons for each plot area.

Table 1—Description of each treatment area including methods of treatment, year of treatment, and size of treatment area. Each treatment area, A-E, is a geographically distinct area within the Rio Grande del Norte National Monument, within the BLM Taos Field Office, New Mexico.

Treatment area	Thinning	Pile burn	Broadcast burn	Jackpot burn	Size (acres)
A	2005	2011	2011	2014	646
B	2013	--	--	2015	191
C	2013	--	--	2014	39
D	2015	--	--	--	236
E	2005	2008-2104	--	--	231

In order to evaluate treated areas, data were reduced to the subset of indicators that best represented the management objectives of treatments. Data were then summarized within treatment areas and within the ES. These data included: tree density, number and size of canopy gaps, desirable species cover, and soil aggregate stability. Desirable species were defined as those species which are desired and preferred forage for wildlife species and cattle within each relevant Natural Resources Conservation Service (NRCS) Ecological Site Description (ESD). These ESDs included: F048AY015NM (Mixed Conifer), R048AY005NM (Mountain Malpais), R036XA004NM (Gravelly slopes), R036XB007NM (Malpais), and F036XA001NM) (PJ-Oak Woodland) (Sylvester et al. 2003a,b; Wright and Bishop 2003). Since there is no published ESD for the PJ-Oak Woodland site, desirable species were defined from the similar ES Mountain Malpais. Data were analyzed using standard statistical methods without adjustment; these include calculating the mean values and standard deviation for tree density, canopy gaps, species cover, and soil stability values.

With the exception of the thinning only area (D) and the thinning and jackpot burn area (C) all other treated areas had a lower mean tree density than non-treatment areas within the same ES (table 2). Tree foliar cover from LPI shows a similar pattern.

Desirable species cover was the indicator that varied the most among ecological sites and treatment areas. Within area A across all ESs, the treated plots had a similar or higher average cover of desirable species when compared to untreated plots within respective ESs (table 3). Similarly, treatment areas B and E had slightly higher average values within the Mixed Conifer site compared to untreated plots. Conversely, area C had significantly lower average cover of desirable species within the Mountain Malpais site when compared to untreated areas (5.1% compared to 23.3%).

When evaluating canopy gap size classes, almost all treatment areas across all ESs had significantly more large gaps (greater than 200cm) when compared to non-treated areas (table 4). The exception to this was treatment A in the Malpais and Mountain Malpais ESs, which had a similar proportion of large gaps compared to non-treated plots in the same ES. No significant differences in soil aggregate stability were found when comparing untreated and treated areas.

When comparing among treatment areas, area A, treated with thinning, pile, broadcast, and jackpot burning, was the most successful across all AIM indicators. This area achieved a reduction in tree density, had similar or greater average cover of desirable species compared to untreated areas, had similar amounts and distribution of large canopy gaps compared to untreated sites, and showed no signs of reduced soil stability. Despite similar precipitation, soils, and treatment methods this treatment has responded better than the four other treatment areas and provides better wildlife habitat and a more hydrologically stable site. The success of this treatment is most likely a product of the mosaic nature of the multiple treatment methods (a combination of thinning, pile, jackpot, and broadcast burning), the size of the treatment area, and the longer time to recover from treatment as compared to the other areas. Treatment area A underwent a combination of thinning and burning treatments spread out over 646 acres (table 1). This approach allowed a mosaic structure of treated and untreated patches providing cover and forage for wildlife species as well as a sufficient seed bank for recovery.

Table 2—Average tree density and standard deviations for each treatment area A-E (Table 1) and non-treated areas summarized by ecological site. An X represents an ecological site that was not found in the respective treatment area. Data were collected between May 2014 and October 2016. Non-treatment data were not collected from the Gravelly ecological site. Number of plots (n) within each treatment area and ecological site are shown below the average values.

Ecological Site	Tree Density (adult trees/hectare)											
	A		B		C		D		E		Non-Treatment	
	Average	**Std Dev**	**Average**	**Std Dev**	**Average**	**Std Dev**	**Average**	**Std Dev**	**Average**	**Std Dev**	**Average**	**Std Dev**
Mixed Conifer	28.29 *(n=2)*	0.00	0.00 *(n=1)*	n/a	X	X	X	X	36.78 *(n=5)*	34.16	114.36 *(n=3)*	68.61
Gravelly	0.00 *(n=1)*	n/a	X	X	X	X	X	X	X	X	X	X
Malpais	0.00 *(n=2)*	0.00	X	X	X	X	X	X	X	X	2.72 *(n=13)*	7.93
Mountain Malpais	10.61 *(n=2)*	5.00	19.45 *(n=2)*	7.50	73.09 *(n=3)*	20.72	X	X	X	X	60.13 *(n=3)*	104.14
PJ-Oak	X	X	X	X	X	X	74.27 *(n=1)*	n/a	X	X	38.91 *(n=5)*	23.46

Table 3—Average desirable species cover for each treatment area A-E (Table 1) and non-treated areas summarized by ecological site. An X represents an ecological site that was not found in the respective treatment area. Data were collected between May 2014 and October 2016. No non-treatment data were collected from the Gravelly ecological site. Number of plots (n) within each treatment area and ecological site are shown below the average values.

Ecological Site	**Average of Desirable Species Cover**					
	A	**B**	**C**	**D**	**E**	**Untreated**
Mixed Conifer	8.7% *(n=2)*	4.7% *(n=1)*	X	X	3.9% *(n=5)*	1.6% *(n=3)*
Gravelly	4.7% *(n=1)*	X	X	X	X	X
Malpais	20.0% *(n=2)*	X	X	X	X	14.2% *(n=13)*
Mountain Malpais	21.7% *(n=2)*	12.7% *(n=2)*	5.1% *(n=3)*	X	X	23.3% *(n=3)*
PJ-Oak Woodland	X	X	X	4.7% *(n=1)*	X	0.46% *(n=5)*

Table 4—Average proportion of plots with large canopy gaps (greater than 200cm) for each treatment area A-E (Table 1) and non-treated areas summarized by ecological site. An X represents an ecological site that was not found in the respective treatment area. Data were collected between May 2014 and October 2016. No non-treatment data were collected from the Gravelly ecological site. Number of plots (n) within each treatment area and ecological site are shown below the average values.

Ecological Site	**% area with canopy gaps >200cm**					
	A	**B**	**C**	**D**	**E**	**Non-Treatment**
Mixed Conifer	32% *(n=2)*	40% *(n=1)*	X	X	33% *(n=5)*	21% *(n=3)*
Gravelly	0% *(n=1)*	X	X	X	X	X
Malpais	5% *(n=2)*	X	X	X	X	6% *(n=13)*
Mountain Malpais	12% *(n=2)*	20% *(n=2)*	33% *(n=3)*	X	X	13% *(n=3)*
PJ-Oak Woodland	X	X	X	40% *(n=1)*	X	23.7% *(n=5)*

Continued monitoring with the AIM protocols is important because it will allow land managers to understand the recovery of these treatments over time. The utility of these data could be improved by increasing sample sizes within treatment areas to add more power to conclusions drawn between different treatment methods. This is particularly important to BLM management as different treatment methods vary in terms of cost, practicality, and complexity.

These AIM data also support the idea that similar management actions will have varied results across different ecological sites. This is particularly evident in the treatment that was jackpot burned two years post-thinning, [treatment B] in which the same method of thinning and burning produced an increase in desirable species in one ES (Mixed Conifer) and a decrease in desirable species cover in another site (Mountain Malpais).

However, it is assumed that the untreated data provide a reliable proxy for the pretreatment condition. While this is the best available option when evaluating treatment effectiveness, there is still a large range of variability within the data from untreated sites. Moreover, the untreated data set did not cover all the relevant ecological sites that occurred in the treatment areas—the Gravelly site (R036XA004NM) did not have any untreated data. Continued monitoring of sites following treatment has the potential to better inform management in an adaptive framework. Ideally, it would also be possible to collect data using the standard AIM protocols before any management action occurs. Thus, AIM indicators could be used to directly assess pre and post treatment.

AIM provides an effective and standardized approach to assessing outcomes of various management actions within Pinyon-Juniper habitat types. In particular, AIM data provide a thorough assessment of ecosystem attributes that can inform evaluations of wildlife habitat and forage. Wildlife biologists can use the detailed data on understory vegetation cover and heights, species composition, soil surface cover, canopy gaps, and soil stability to accurately evaluate habitat suitability for many wildlife species, including game birds, pinyon-juniper obligate bird species, mule deer, and elk. Furthermore, supplemental indicators can be added to provide more specific data relevant to each wildlife species.

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