Restoration of the Ponderosa Pine Ecosystem and Its Understory

Lee E. Hughes[1]

Abstract—*Restoration of the Mt. Logan ponderosa pine ecosystem has been on-going since 1995. This effort included tree thinning to a density based on what the tree density was in 1870. The desired plant community objectives from the Mt. Trumbull Resource Conservation Area Plan had a forest objective as 50% trees to be in old-growth — i.e., a diameter class of 20-31.9+ inch diameter at breast height (dbh). The other 50% of the trees were to be spread amongst the diameter classes ranging from openings to 19.9 inch dbh trees. The two Lava Units, on Mt. Logan, were logged, thinned, burned in 1996; one was seeded (13 acres), and the other was not seeded (33 acres). Using plot data, the seeded and unseeded units were compared. The seeding of native grass cultivars and imports increased species diversity of grasses, but seemed to suppress the native grasses (squirreltail, muttongrass, and blue grama) already present in the ecosystem. The other reason for seeding was to prevent annual bromes from becoming a major presence. The data on annual bromes in the Lava seeded unit and unseeded units show annual bromes equally evident in both, to the present.*

Introduction

During the early 1990s, the ponderosa pine ecosystem on the Arizona Strip was termed a forest in poor health by the Bureau of Land Management (BLM). This was largely due to the density of its trees (hundreds per acre). The pre-settlement forest, which existed prior to Europeans settling in Arizona, had in general, 15-40 trees per acre with some patches of denser stands. The latest year fixed for this condition is 1870, as determined from old photographs taken during the 1860s to 1880s in the ponderosa pine areas around Flagstaff, Arizona. Counting annual tree growth rings aided in establishing that date. This, pre-settlement forest density was corroborated by counting old-growth stumps and snags on the Arizona Strip. Currently, the Arizona Strip has around 15,000 acres of ponderosa pine. Approximately 12,000 acres of that is in the Mt. Trumbull-Mt. Logan area. Pre-settlement forests occupied, as best can be determined, about the same acreage. Critics claimed that the decline of the ponderosa pine ecosystem from the pre-settlement time period was largely due to livestock grazing, a lack of logging, and fire suppression efforts.

Regardless of the cause for the decline, the thick forest on the Arizona Strip was already at a high potential for disease and damaging wildfire. Consequently, there were forces to change management habits from within the BLM and by the public. A movement was implemented to balance the Mt. Trumbull-Mt. Logan forest size class and structure.

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[1] *Arizona Strip Field Office, Bureau of Land Management, St. George, UT.*

Planning the Forest Structure

The Arizona Strip Field Office developed a Resource Conservation Plan (RCA) for the Mt. Trumbull (includes Mt. Logan) area from 1993 to 1995. During development of the plan, objectives were designed to describe quantitatively the diameter size of trees and structure stages desired for the Mt. Trumbull/Mt. Logan forests. From initial inventories the size class/structure of the Mt. Logan forest showed a large quantity of small trees – 90% with a 1-19" diameter at breast height (dbh) size class. Only 6% of the forest had areas dominated by 20" dbh trees or larger size class.

Six tree size diameter classes /structure stages were described in the RCA plan ranging from: openings or meadows, seedling/sapling (1-5" dbh), young trees (5-12" dbh), middle-aged trees (12-20" dbh), mature trees (20-24" dbh), old-growth trees (24"+ at dbh). The Mt. Trumbull interdisciplinary team, which involved BLM, Arizona Fish and Game, affected citizens, and academia, came to a consensus that the Mt. Trumbull landscape would be healthiest and meet multiple use objectives, at 50% old-growth trees (20-32" + dbh) and the remaining 50% of the forest needed to consist of openings and of trees up to middle age (12-20" dbh).

Getting There by Prescription

Early in 1995, Dr. Wallace Covington and a restoration team from the Northern Arizona University (NAU) Ecological Restoration Institute (ERI) visited the Arizona Strip and began a process to provide the BLM with a tree-density, prescription to restore the Mt. Logan forest to its 1870 density levels (15-40 trees per acre). The 1870 level was just prior to European settlements, subsequent fire suppression efforts, and livestock grazing. One of the first steps was to identify spacing of the trees to pre-settlement levels. The process of marking trees to leave began by locating evidence of dead, old-growth trees such as cut stumps and snags. Most were easily found, but on occasion, remnants were merely a woody outline on the ground or a portion of a log. For each old-growth stump, snag, or remnant of old-growth, one and a half leave trees were marked. In other words, two leave trees were marked one time and the next stump had one leave tree marked. That process was then repeated. The leave tree was the tree left after logging and thinning. The leave tree had to be greater than 16 inches in dbh. If only smaller trees were available, three times as many trees were marked. More smaller ones were marked due to their higher mortality from the post-thinning prescribed fire. This then left the desired amount of trees needed as replacements after the restoration. All existing old-growth, yellow-bark ponderosa were marked as leave trees.

The first marking of leave trees started in the fall of 1995. Two small units (both are designated Lava or 96-1) were marked and cruised (volume of timber estimated in board feet) and readied for harvest. One unit was 13 acres and the other 33 acres. They were both commercially logged, after which post-commercial thinning was done. Post-commercial thinning occurred where small trees were left uncut by the logger. Thinning involved cutting the small trees. The slash from the thinning was then burned and the 13-acre unit was seeded. The 33-acre unit was not seeded. The unseeded unit was done to compare unseeded to seeded understory. This completed the restoration effort for the units.

At the same time, the NAU team established fire monitoring plots to monitor vegetation and fuels. The plots were laid out in a 300-yard grid pattern across Mt. Logan's entire 8,500 acres of ponderosa forest. The study was to demonstrate the non-treatment, pre-treatment, and post-treatment impacts to vegetation. Other studies on wildlife were established to study the effects of restoration on wildlife populations.

Planning the Understory Vegetation

No vegetation objectives were set for the ponderosa pine understory in the 1993-1995 planning. A vegetation inventory provided information of understory characteristics. Across the landscape a grid of plots, each 50x20 meters in dimension, was established at 300 meter spacing. Inside the plots herbaceous plants were counted on two point-intercept transects. Each transect had 166 points along each 50 meter side of the inside the plot. Outside the plot, on both 50 meter sides, were belt transects of 10x50 meters and all species are listed that occur within the two belt transects.

The 1996 NAU pretreatment inventory of the ponderosa pine in the Lava Units (the 13 and 33 acre units) showed the top four understory species in frequency were big sage (*Artemesia tridentata*), squirreltail (*Elymus elymoides*), silver lupine (*Lupinus argenteus*) and cheatgrass (*Bromus tectorum*). New Mexico locust (*Robinia neomexicana*), beardlip penstemon (*Penstemon barbatus*), and mullein (*Verbascum thapsus*) were present but less common (table 1).

Seed bank studies were conducted in the late 1990s in a subset of plant communities on Mt. Logan by Judy Springer of NAU. She found that early successional and non-native forbs dominated the seed bank, whereas seeds of shrubs and perennial grasses were scarce. In ponderosa pine plant communities (old-growth and pole-size) squirreltail, a native, had a presence in the seed bank. Mullein and horseweed, however, were the dominant viable seeds by a large margin in the seed-bank. The seed bank and extant vegetation proved to be the best predictor of what the restored plant community would have as vegetation cover in the first few years after treatment.

Table 1—Vegetation trend plot data, lava unit plots, frequency data.

	13-acre Seeded Unit 1384				33-acre Unseeded Unit 1385 and 1435							
Species	**1995***	**1997**	**2001**	**2003**	**1995***	**1997**	**2001**	**2003**	**1995**	**1997**	**2001**	**2003**
	(%)											
Native Perennial (Squirreltail Blue Grama Muttongrass)	13	2	4	0	6	9	41	10	8	10	19	8
Seeded (Wheatgrass Mt. Brome Junegrass)	0	3	62	3	0	0	0	0	0	0	0	0
Forbs (Horseweed chenopods Mullein, etc.)	9	7	108	58	7	35	48	26	2	52	57	29
Shrubs (Locust) Browse	15	0	0	0	7	33	33	14	8	31	44	13
Cheatgrass	4	0	11	60	0	1	0	92	4	0	3	66
Percent Native to Non-Native	85:15	100:0	80:20	17:83	95:5	97:3	93:7	41:59	69:31	92:8	98:2	53:47

1995 is pre-treatment, 1997 is one year after treatment, 2001 is six years after treatment.

Seeding

As a result of the inventories and seed-bank studies, seeding of native grasses appeared necessary for perennial grass diversity. Fifteen species of perennial grass were seeded in designated-to-be-seeded units. Eight species of perennial forbs and five species of shrubs were seeded one time only due to extreme high cost ($15 to $82 per pound). The seeded Lava Unit (13 acres) had to be reseeded the following year, as the first seeding failed to survive a drought.

Four experimental units that were restored outside the Lava units on Mt. Logan were not seeded. This was done to determine the kind of understory plant community that would result after different year intervals in these restored units. Inventories have shown that in old wildfire burns, grasses such as squirreltail, blue grama (*Bouteloua gracilis*), and muttongrass (*Poa fendleriana*) have come in vigorously and abundantly in some locales in the ponderosa zone, without seeding.

In 1989, a 78 acre fire occurred in the wilderness area on the top of Mt. Trumbull. Weight transects, where vegetation is clipped and weighed at points along the transect to determine species composition by weight, were done in 1992 and 2001 in the fire scar and adjacent unburned forest (table 2). The transects in the fire scar had a range of 23-42% squirreltail and 16-35% oak with 18 other species weighing in at much lesser rates. The adjacent unburned forest had trace amounts of squirreltail with upland sedge occurring at up to 24%. Few other species occurred under the pine.

Table 2—Mt. Trumbull 1989 fire scar vegetation, unseeded area. Values are species dry weight as a percentage of total dry weight sampled on the transect.

	Dry weight (%)	
Species or group	**1992**	**2001**
Oak	35	16-28
Ponderosa	11	0-14
Locust	0	2-10
Ribes	0	1-4
Rabbitbrush	0	1
Wormwood	0	1-2
Muttongrass	2	9
Squirreltail	32	23-41
Blue grama	2	0
Carex	0	5-9
Mullein	1	0
Golden rod	0	7
Mahonia	0	1
Daisy	0	5
Lotus	0	2
Penstemon	0	2
Milkweed	0	3
Chenopodia	15	2-4
Aster	0	1-6
Knotweed	0	1

Cost of Going Native

In the first restoration units treated, seeding costs were high due to using very expensive forbs and shrubs, along with the native grasses (table 3). The forbs and shrubs ranged in price from $15 to $82 a pound, with most in the $40 to $60 per pound range. Native grass costs ranged from about $1 to $40 per pound with most in the range of $5 to $20 per pound. The costs shown in table 2 are seed costs, the labor and operating equipment costs only. All seeding was done by using hand powered broadcasters and dragging the area after seeding with all-terrain-vehicles pulling small chains. The seeded and unseeded units were fenced with an electric fence to prevent livestock from grazing the forage prior to good establishment.

Table 3—Cost per acre of seeding on other units.

Year seeded	Logged unit	Seeded	Seed	Labor / Equipment	Total cost
		(acres)	- - - - - - - - - - - - *($/ac)* - - - - - - - - - - - -		
1997	96-1	13	$214	Not figured	
1998	96-1	13	$228		
1998	96-2	156	$73	$34	$107
1999	96-2	80	$79	$38	$117
2000	96-3	110	$103	$38	$141

Conclusion

The forest diameter size class and structure objectives of 50% old-growth and 50% smaller trees and openings, in the higher elevational units were close to being met after the logging, thinning and burning. Reaching stability on the forest floor, however, will take longer, even with seeding, due to successional processes.

Seeding native grasses, shrubs and forbs greatly added grass diversity and cost in the seeded unit. Five years after seeding took place, the understory became co-dominated by seeded grasses (see table 1), but forbs and non-native forbs still were dominant and abundant in the seeded unit. The unseeded understories were dominated by shrubs, annuals, and forbs with less diversity of grasses. Is the seeded native grass diversity worth the cost? Could the understory restoration still be considered restoration with the species that are already present such as blue grama, squirreltail, muttongrass and the numerous native forbs and shrubs shown in the inventories?

The resulting vegetation after logging, post-commercial thinning and burning, has not resulted in a total takeover, as yet, by non-native weeds, which was of some concern. As table 1 shows, it is other natives that remain in dominance until 2001. The 2002-2003 very dry part of the drought killed seeded and native grasses and allowed cheatgrass to increase to dominance in the seeded and unseeded unit. One encouraging item was the native grass in the unseeded unit. The drought did not kill the native squirreltail totally but left a good remnant to grow from after the drought. With rest-rotation grazing and rest from grazing, and maturing of the plant community after treatment, over the years, a stable perennial plant community would probably result without expensive seeding or at least a reduced amount of seeding, as it did on Mt. Trumbull. Need for seeding can be ascertained and done at a later date – for example, after one of the repeat burns that will be conducted at 5-year intervals, as specified by the future the restoration plan to keep tree densities low.