

# Forest and Range Research on the “Wild Bill Plots” (1927-2007)

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**Abstract**—In 1927, the Fort Valley Experimental Forest initiated a range-timber reproduction study. The study was one of the first attempts to experimentally isolate the agents responsible for injury to ponderosa pine regeneration, and at the same time assess the impacts of livestock grazing on herbaceous vegetation. The study was conducted on the USFS range allotments northwest of Flagstaff, Arizona, known as Wild Bill and Willaha, and covered ~12,000 ha (~30,000 acres). Fifty-five permanently marked ponderosa pine “reproduction plots” were established to follow the fate of ponderosa pine seedlings, while an additional 28-1 m<sup>2</sup> chart quadrats were established to quantify herbaceous vegetation composition and cover. In 2006, most of the Wild Bill and Willaha plots were relocated and remeasured and examples of key preliminary findings are reported in this proceedings paper.

## Introduction

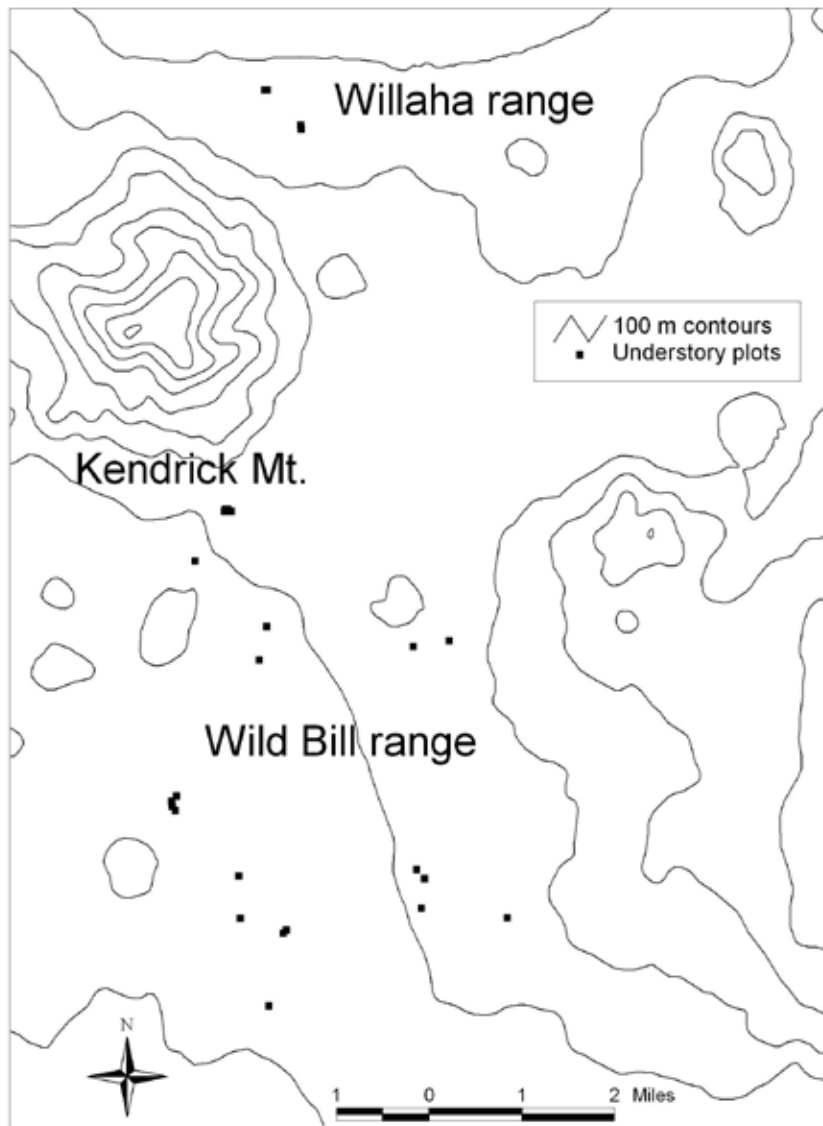
One of the first major management conundrums in the ponderosa pine-bunchgrass ecosystem of northern Arizona was how to manage public land for optimum use of both range and timber resources. The heart of the conflict was due to livestock grazing impacts on ponderosa pine (*Pinus ponderosa* Laws. var. *scopulorum* Engelm.) reproduction. Cattlemen and sheep men wanted to fully utilize the productive forage resources on the rangeland, but they could not guarantee that their livestock would not damage woody seedlings. This alarmed the foresters who were already concerned about the lack of pine reproduction in the ponderosa pine regions of the Southwest. Therefore, it was up to the forest and range scientists to quantify the impact of livestock on pine reproduction and forage production, to determine whether wild herbivores or other agents may be responsible for pine seedling demise, and to define proper grazing management for ponderosa pine-bunchgrass rangelands.

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**In:** Olberding, Susan D., and Moore, Margaret M., tech coords. 2008. Fort Valley Experimental Forest—A Century of Research 1908-2008. Proceedings RMRS-P-53CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 408 p.

In 1927, the Fort Valley Experimental Forest initiated a range-timber reproduction study. The study was one of the first attempts to experimentally isolate the agents responsible for injury to ponderosa pine regeneration, and at the same time assess the impacts of livestock grazing on herbaceous vegetation. The study was conducted on the United States Forest Service (USFS) range allotments northwest of Flagstaff, Arizona, known as Wild Bill and Willaha, and covered ~30,000 acres (~12,000 ha; Figure 1). Locally, the project was known as the “Cooperrider-Cassidy study.”

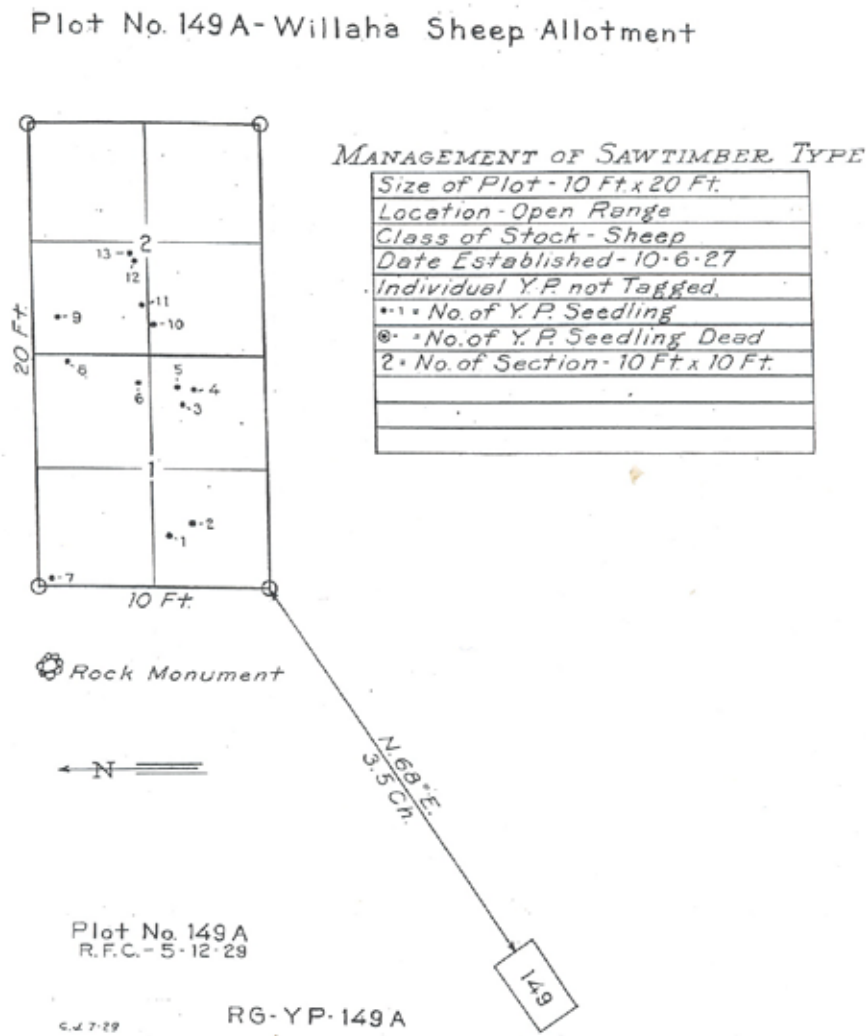
Two types of plots were established. First, 55 rectangular plots of variable size and dimension were established on patches of pine regeneration. Second, 28 1 x 1 m chart quadrats (Clements 1905) were established to study the herbaceous vegetation.



**Figure 1.** Wild Bill and Willaha study sites are located northwest of the San Francisco Peaks near Kendrick Mountain in northern Arizona.

# Pine Reproduction Study

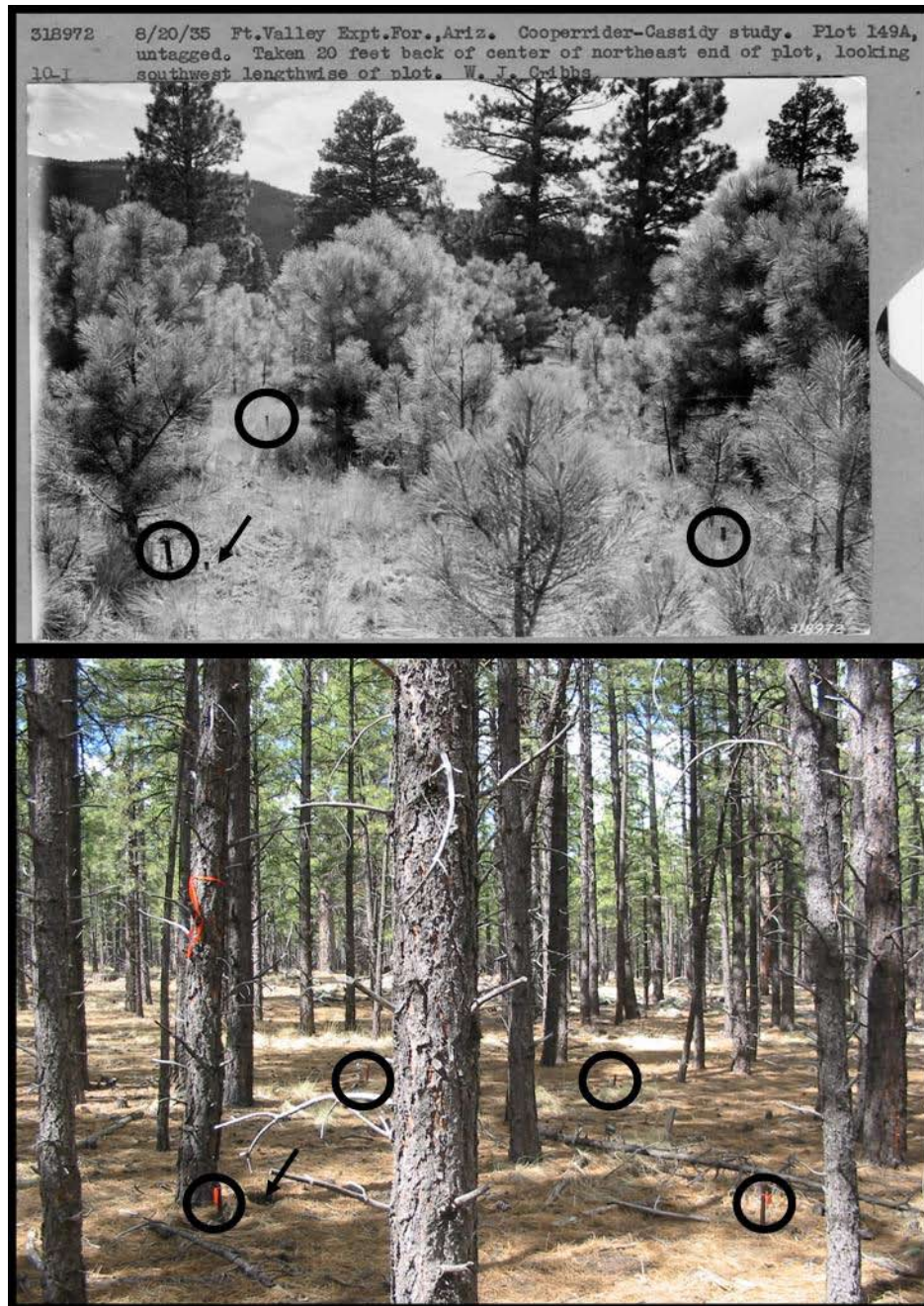
Fifty-five permanently marked ponderosa pine “reproduction plots” (ranging from 0.005 to 0.01 ac in size) were established throughout the range. Thirty plots were established on the open range (where livestock had free access to forage from June through October), while 25 were established within grazing enclosures. The enclosures were used to control the duration and timing of livestock use during the grazing season. These plots were centered on existing patches of “scattered” or “dense” ~seven-year old ponderosa pine regeneration within areas represented by “badly overgrazed,” “properly utilized” and “under used” (these categories were determined by the expert opinions of the range scientists). Within each plot, the researchers numbered, mapped, and tagged all the seedlings and small saplings (Figure 2). Over the grazing season, they recorded pine seedling height, condition, and apparent injury agent, and followed the fate of these seedlings from 1927 until 1938. Repeat photos were taken throughout the original study (1927-1938) and again in 2006 (Figure 3). A series of photographs of plot 149A on the Willaha range



**Figure 2.** Pine reproduction plot 149A on the Willaha range north of Kendrick mountain.

north of Kendrick Mountain illustrate the abundance of ponderosa pine regeneration in 1935 and the dramatic shift in the forest structure (tree size, density, and canopy closure) during the 71-year period.

C.K. Cooperrider and H.O. Cassidy published a number of research notes and reports from the Wild Bill and Willaha reproduction plots on the how to manage cattle and sheep on cut-over ponderosa pine-bunchgrass ranges to prevent injury to pine regeneration (Cassidy 1937a, b; Cooperrider and Cassidy 1939a, b). Cooperrider



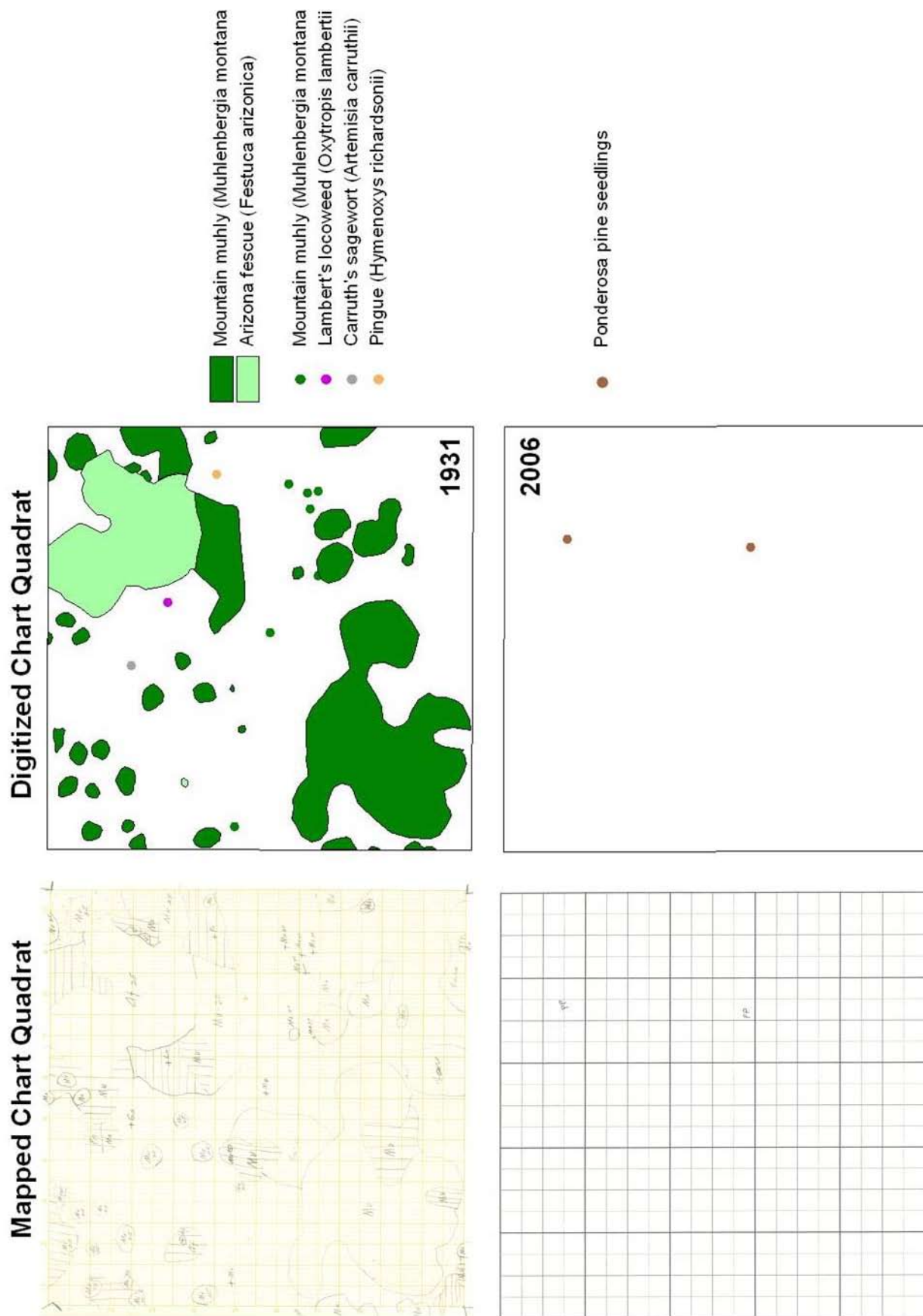
**Figure 3.** Repeat photograph (1935, top; 2006, bottom) of pine reproduction plot #149A in the Willaha range north of Kendrick Mountain. The black circles show the same galvanized steel pipes that mark the corners of the reproduction plot, and the arrow indicates the location of the angle iron that marks one corner of chart quadrat #1. Photo credit: 1935 by W. J. Cribbs; 2006 by D. C. Laughlin.

(1938) also produced a seminal study in *Plant Physiology* about the recovery capacity of regenerating ponderosa pine following damage by animals. He observed that cattle, browsing game animals, sheep and tip moths did the most injury to seedlings older than three years, whereas rodents tended to damage the younger seedlings. Rodents and tip moths tended to induce the most damage. Of the 2,139 ponderosa pine seedlings in the study, 69% were browsed one or more times; only 3% of these browsed seedlings died. Additionally, 8% of the total number were injured by rodents, and 74% of these injured pines died. The young pines exhibited an extraordinary capacity to produce substitute buds and shoots to recover from shoot injury. Overall, only 2.1% (44 seedlings/2139) died from browsing while 5.9% (127 seedlings/2139) died from rodent damage. No data were available for comparing dead tree seedlings from natural causes such as drought, wildfire, or other vegetation competition. Cooperrider (1938) concluded that if the southwestern ponderosa pine species did not have this capacity, then grazing would have seriously jeopardized future forests. Cooperrider (1939) also reviewed the problems of grazing on timber lands of the Southwest and gave suggestions to range managers about how to prevent livestock from damaging reproduction and from creating conditions that are not conducive to pine seedling establishment. He emphasized that livestock should not be allowed on the open range during times when water and forage are scarce, since these are the situations when pine seedlings are browsed the most heavily (Cooperrider 1939).

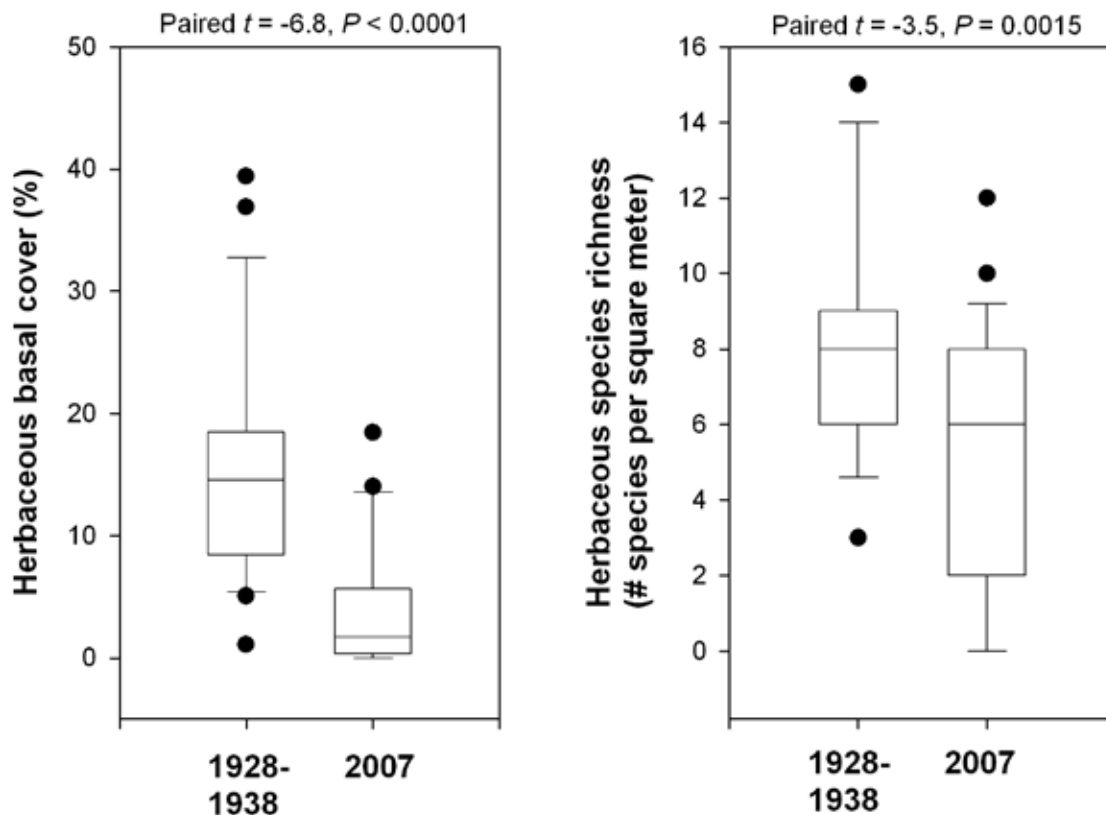
## Herbaceous Utilization and Production Study

In addition to the pine reproduction plots, 28 1 x 1 m plots were established to quantify herbaceous composition and cover within grazing enclosures and in the open range. To our knowledge, the data that were gathered on the 28 chart quadrats was never formally published. However, all of the original data, complete with chart quadrat maps and summaries, were stored in the Fort Valley Experimental Forest Archives at the USFS Rocky Mountain Research Station (RMRS) in Flagstaff, AZ (<http://www.rmrs.nau.edu/fortvalley/>). Hand-drawn cloth maps and a metal detector were used to locate the historical plots and 27 of the 28 quadrats were found. The only missing quadrat was apparently buried in a slash pile.

We have mapped the plant species found on the chart quadrats to quantify the long-term changes in plant community composition, diversity, and abundance (Figure 4). We digitized the maps in a Geographical Information System (GIS) to facilitate the calculations of individual plant and total basal cover and density. We used a repeated measures analysis (paired *t*-test) to evaluate whether changes in plant species richness and basal cover between 1928 and 2007 differed significantly from zero. On average three species were lost per plot (mean difference = -3.1 species; paired *t* = -3.5, *P* = 0.0015), and 12% plant basal cover was lost per plot (mean difference = -12.0, paired *t* = -6.8, *P* < 0.0001) over the past 80 years (Figure 5). The reduction in plant diversity and abundance was likely caused by the increase in pine overstory dominance and subsequent reduction of light and other critical resources (Figure 3). We are currently reconstructing historical forest structure (Bakker et al., this proceedings) on 20 x 20 m plots centered on the chart quadrats to estimate forest structural changes on each plot.



**Figure 4.** Changes in herbaceous vegetation on chart quadrat #1 (located inside pine reproduction plot 149A in Figure 3 and noted by arrow) on the Willaha range north of Kendrick mountain. The left panels illustrate the chart quadrats as they are mapped in the field, and the right panels illustrate the digitized data. Note large reduction in herbaceous production, cover and species richness from 1931 to 2006.



**Figure 5.** Significant declines in plant cover and species richness have occurred on the 1 m<sup>2</sup> Wild Bill and Willaha chart quadrats (n = 27) from 1928-1938 to 2007. A paired *t*-test was used to perform a repeated measures analysis to test whether changes in species richness and plant cover were significantly different than zero.

In addition, Canfield (1941) evaluated and tested his line intercept method for measuring the density and composition of herbaceous vegetation and shrubs in rangelands and forests on the Wild Bill allotment. This method, which was an important methodological advancement, was subsequently used on a related set of long-term historical plots (the ‘Hill plots’; also see Bakker et al., this proceedings) by Glendening (1941) and Bakker and Moore (2007), and proved to be of great value for evaluating long-term vegetation changes in southwestern ponderosa pine forests.

Currently, we are relating long-term shifts in plant community composition to physical and chemical soil properties and changes in overstory structure. We are also using these data to link the above-ground plant community to below-ground ecosystem processes to better understand the complex interactions and feedbacks that occur between plants and soil. We will use these data to predict how ecosystem process rates (e.g., decomposition and nitrification) have changed over time due to changes in forest structure that have occurred over the last century in ponderosa pine forests.

## Summary

In 1927, the Fort Valley Experimental Forest initiated a study on the Wild Bill range to experimentally isolate the agents responsible for injury to ponderosa pine regeneration and assess the impacts of livestock grazing on herbaceous vegetation. Cooperrider (1938) showed that young pines exhibited an extraordinary capacity to produce substitute buds and shoots to recover from shoot injury and suggested that if the pines did not have this capacity, then grazing would have seriously jeopardized future forests. Cooperrider (1939) made recommendations to range managers about how to avoid excessive damage to timber resources by using proper timing of livestock grazing on the open range.

In addition to the pine reproduction plots, 28 1 x 1 m plots were established to quantify herbaceous composition and cover within grazing enclosures and in the open range. We have found 27 of the 28 quadrats, and our initial analyses show that plant basal cover and species richness have significantly declined on the Wild Bill range between 1928 and 2007.

Long-term datasets are extremely valuable for studying the factors that control vegetation. The permanent plots that were established on the Wild Bill range date to a time when ecology was a very young discipline. The fact that we located 27 of the 28 permanent chart quadrats is a testament to the quality of work done by the first range and forest scientists in Arizona. In addition, the care and storage of the historical data in the USFS RMRS Fort Valley archives was critical for making this long-term study possible.

## Acknowledgments

We thank Warren P. Clary and Henry A. Pearson for providing valuable comments on this manuscript. Funding was provided by McIntire-Stennis appropriations to the School of Forestry, and additional financial and logistical support were provided by the Ecological Restoration Institute (ERI). We thank S. D. Olberding for maintaining the historical data collections in the Fort Valley Archives (US Forest Service, Rocky Mountain Research Station, Flagstaff, AZ). We also thank the staff and students at the Ecological Restoration Institute (ERI) for assistance with field and lab tasks, and the Coconino National Forest for permission to sample study sites. Lastly, we recognize C. K. Cooperrider and H. O. Cassidy for establishing these sites in 1927 and plot remeasurement between 1927 and 1938.

## References

- Bakker, J.D.; Moore, M.M. 2007. Controls on vegetation structure in southwestern ponderosa pine forests, 1941 and 2004. *Ecology*. 88: 2305-2319.
- Canfield, R.H. 1941. Application of the line interception method in sampling range vegetation. *Journal of Forestry*. 39: 388-394.
- Cassidy, H.O. 1937a. How cattle may use cut-over ponderosa pine-bunchgrass with minimum injury to reproduction. Res. Note 15. Tucson, AZ: U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 3 p.
- Cassidy, H.O. 1937b. How to handle sheep on cut-over ponderosa pine-bunchgrass ranges to keep injury to reproduction to a minimum. Res. Note 16. U.S. Department of Agriculture, Forest Service, Southwestern Forest and Range Experiment Station. 2 p.
- Clements, F.E. 1905. *Research methods in ecology*. Lincoln, NE: The University Publ. Co.
- Cooperrider, C.K. 1938. Recovery processes of ponderosa pine reproduction following injury to young annual growth. *Plant Physiology*. 13: 5-27.
- Cooperrider, C.K. 1939. Grazing and western timber production. *Proceedings of the Range Research Seminar, USDA Forest Service*: 375-380.
- Cooperrider, C.K.; Cassidy, H.O. 1939a. Cattle grazing in cutover timberlands in relation to regeneration of ponderosa pine forests of the Southwest. Southwestern Forest and Range Experimental Station. Unpub. Pap. on file at Flagstaff, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Valley Experimental Forest archives.
- Cooperrider, C.K.; Cassidy, H.O. 1939b. Sheep grazing in cutover timberlands in relation to regeneration of ponderosa pine forests of the Southwest. Southwestern Forest and Range Experimental Station. Unpub. Pap. on file at Flagstaff, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Valley Experimental Forest archives.
- Glendening, G.E. 1941. Work plan—summer 1941: Hill study plots, Coconino. Unpub. Pap. on file at Flagstaff, AZ: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Valley Experimental Forest archives.

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