EFFECTS OF GAMBEL OAK ON WATER HOLDING CAPACITY AND CARBON STORAGE WITHIN THE LITTER OF A PONDEROSA PINE-OAK FOREST

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The forest floor is more than an accumulation of organic debris separating the soil from the atmosphere. Physically, it has been shown to prevent erosion and store water (Neary, 2003). Chemically, it has been shown to store nitrogen and carbon and improve nitrogen and carbon storage in the mineral soil beneath (Lefevre and Klemmedson, 1980). As the components of litter change, the capacity to store nitrogen, carbon, and water also changes. In Arizona, the predominate forest type is ponderosa pine (Pinus ponderosa). While generally thought of as miles and miles of uninterrupted pure pine, the stand composition varies considerably as a variety of other tree species are also found. These include Gambel oak (Quercus gambelii), Douglas-fir (Pseudotsuga menziesii), pinyon pine (Pinus edulis), and juniper spp. (Juniperus spp.). The effects these other species have can be significant.
In this study, some specific effects on Gambel oak are examined.

MEHTODS AND MATERIALS

Study Area

The data were collected between 1972 and 1974 on Watersheds 16 and 18 of the Beaver Creek Watersheds in north central Arizona. At that time, a great many studies were conducted in the area, and greatly contributed to our understanding of the pine forests of Arizona and New Mexico. Precipitation at the time averaged over 28 inches on Watershed 16 and 27 inches on Watershed 18 annually. Precipitation records for the Beaver Creek Watersheds have not been kept since 1982.

Study plots were chosen to minimize experimental error by limiting sites to Brolliar stony clay loam where tree species were limited to ponderosa pine and Gambel oak. Total basal area was greater than 140 ft^2 per acre. The plots had a range from 100% ponderosa pine and 0% oak by basal area to 25% pine and 75% oak. Twenty-five plots were selected at random and litter and 30 cm of soil was sampled from the center of each plot. The litter was separated into three layers, labeled L, F, and H. The L layer was material whose source was easily identified. The F layer was made up of particles that could still be identified as plant material, while in the H layer particles were broken down to a level that the source of individual particles could not be identified. It was often difficult to tell the separation between the H layer and mineral soil. Soil samples were removed in three segments, the 0 – 5 cm, 5- 15 cm, and 15-30 cm.

Water-Holding Capacity

The five arbitrary litter types exhibited different hydrologic properties. Oak in the litter statistically increased the capacity of litter to retain water at saturation. Oak-influenced litter retained significantly higher amounts of water per unit weight than pure pine litter (Table 1). Litter from stands with large amounts of oak (52-66%) did not retain significantly larger amounts of water than litter from stands with small or intermediate amounts of oak indicating that presence of some oak and not the relative amount of oak was the important factor affecting water-holding capacity of litter.

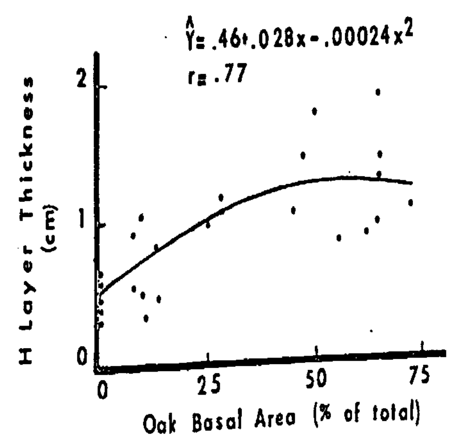

Figure 1. Variation of humus layer (H layer) as oak basal area increases in the stand.

Because of this greater retention, runoff from oak-influenced areas may be expected to be less than from areas uninfluenced by oak. It appears that

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the humus fraction of the litter was the dominating factor, since fresh hardwood litter generally does not hold as much water as coniferous litter (Blow, 1955; Metz, 1958; Helvey, 1964; Mader and Lull, 1968; Bourn and Brown, 1971). Humus is capable of holding considerably more water than undecomposed organic matter or mineral soil (Kittredge, 1948). As shown in Figure 1, litter influenced by oak has a thicker humus layer than pine-dominated litter. The initial rate of moisture loss for different litter types was similar (Figure 2). However, with time, pine-dominated litters (A and B) began to give up moisture less rapidly, and after about 10 days were losing moisture at only one-half the rate of oak-dominated litters (Table 2). Oak dominated litters (C, D, and E) continued to lose moisture fairly steadily. Pine dominated litters had almost ceased to give up moisture after 20 days (Table 2), suggesting that under field conditions evaporation loss of soil moisture may become significant at this point. Oak-dominated litters continued to lose moisture after 20 days of drying. This suggests that oak-influenced litter could be important in preventing soil moisture loss in a pine forest during dry periods.

Table 1. Influence of oak in the stand on moisture-holding capacity of litter at saturation. (All values not followed by the same letter are significantly different from each other at 0.05 confidence.)

Litter Type	Oak in Stand (% by basal area)	Moisture Content at Saturation (% of litter weight)
A	0	189.8 a
B	9	231.2 b
C	22	293.5 c
D	52	264.7 bc
E	66	253.3 bc

Table 2. Influence of oak in the stand on rate of moisture loss from litter as expressed by slope of percentage moisture-time curve in Figure 2.

	Days Elapsed			
	0	10	15	20
Litter Type	Slope of curve in Figure 11			
A	-42.13	-4.17	-1.54	-0.44
B	-50.40	-5.49	-2.16	-0.90
C	-58.66	-9.13	-4.45	-2.54
D	-49.49	-8.47	-4.15	-2.42
E	-47.25	-8.16	-4.09	-2.32

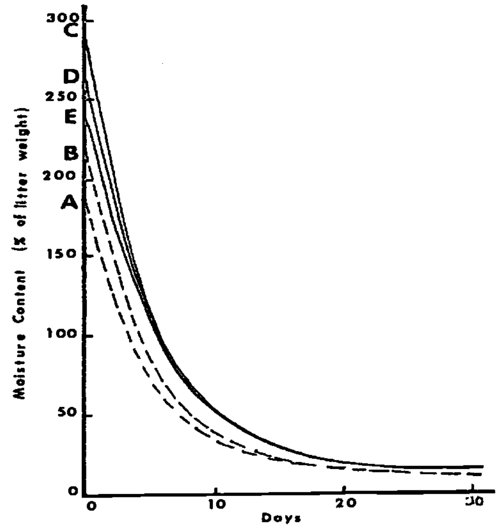

Figure 2. Changie in moisture retained by litter over the period of time sampled

CARBON IN THE SOIL

Amount of oak in the stand had no influence on the amount of carbon stored in litter, but significantly effected the amount of carbon in the surface soil. The effect was most noticeable in the 0-5 cm soil layer and diminished with depth. There was no significant effect beyond 15 cm depth. Figure 3 illustrates the findings.

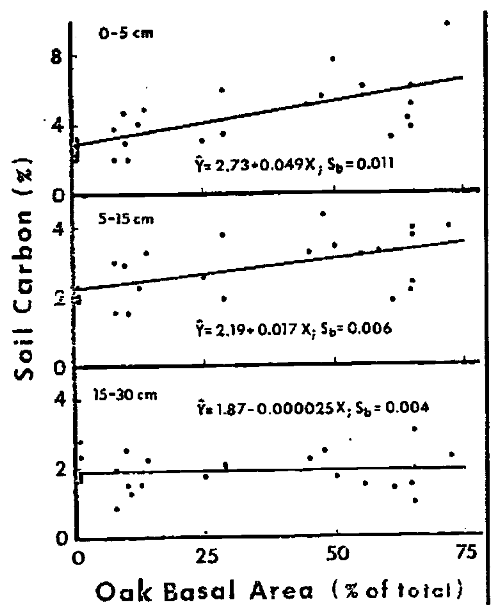

Figure 3. Carbon storage in surface soil.

CONCLUSIONS

Gambel oak mixed in with a stand of ponderosa pine may be a welcome addition to the forest. Water retention in the litter immediately after precipitation will be higher where oak is present, and water loss from the soil beneath may begin later as well. This could prove important in times of moisture stress. Carbon storage in the mineral soil beneath stands containing some oak will be higher than in pure pine stands, an interesting discussion point in light of the apparent need for carbon sequestration.

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