should be minimized because deer appear to show a preference for Sandberg's bluegrass rather than crested wheatgrass. Early spring diet overlap could be minimized by grazing cattle on the crested wheatgrass pastures early and allowing time for native range to recover from late winter deer use. Late spring grazing on native range by cattle should remove the current year's herbaceous growth thereby stimulating fall regrowth and subsequently providing a palatable, seasonal nutritious forage for deer during the early winter period.

THE EFFECT OF TRACTOR LOGGING ON UNDERSTORY PRODUCTION IN EASTERN OREGON'S BLUE MOUNTAINS

M. D. Snider and R. F. Miller

The economy of eastern Oregon relies heavily on its forested lands to provide renewable resources in the form of timber and forage for livestock and big game. The passage of logging vehicles and skidded logs over the forest floor has the potential of profoundly modifying soil properties which, in turn, affect the growth of marketable trees and forage species beneath them. Timber harvesting also can alter runoff, erosion, and sedimentation characteristics of the forest watershed.

In the Pacific Northwest, research into the impact of logging on soils and plant growth, particularly tree growth, has focused on the Douglas-fir (Pseudotsuga menziesii) region. There has been little investigation of timber harvesting's impact on understory and soil properties east of the Cascades. Tractors have been, and will continue to be, the principal method of timber yarding in eastern Oregon.

The objective of this study was to determine the extent to which tractor logging and follow-up slash disposal influence understory production, composition, and soil features in the mixed-conifer forest. This plant community occupies extensive areas in the Blue Mountains and is economically important as a source of harvestable timber and summer range for livestock.

THE STUDY SITE

This study was conducted on a 5-acre stand near Crane Prairie on the Malheur National Forest in the southern Blue Mountains. Soil consisted of a loam and silt loam surface layer derived from recent volcanic ash, and a gravelly loam and clay loam subsoil derived from basalt and andesite. Natural mixing of these layers had occurred. Soil depth ranged from 12 to 36 inches. The site was situated on an east aspect with a slope averaging 15 percent. Elevation was 6,500 feet.

The undisturbed plant community was two-layered: ponderosa pine (Pinus ponderosa), grand fir (Abies grandis), and Douglas-fir composed the overstory. Principal understory grass forms were pinegrass (Calamagrostis rubescens) and elk sedge (Carex geyeri). Heartleaf arnica (Arnica cordifolia) was the prevalent forb. Shrubs were scarce.

Heavy overstory removal by tractor occurred in August 1974. In the summer of 1975, slash was machine-piled and burned. Logging and slash disposal machinery were not confined to skid trails; about 50 percent of the site showed some form of soil disturbance.

Skid trails, landings, and other areas of major disturbance were seeded with a mixture of orchardgrass (Dactylis glomerata), timothy (Phleum pratense), mountain bromegrass (Bromus marginatus), and intermediate wheatgrass (Agropyron intermedium).

The site was situated within a Forest Service grazing allotment. Though cattle were annually allowed into the area for summer grazing, animals were kept off the study site the summer data were collected.

EXPERIMENTAL METHODS

Soil disturbance from logging was separated into five classes:

I. NO SOIL DISTURBANCE: characterized by an intact litter layer and the presence of perennial native vegetation.

II. LIGHT TO MODERATE DISTURBANCE: where at least some of the litter layer had been removed and mineral soil exposed. This broad class included "ruts" caused by compression from tractor treads.

III. BERM: characterized by heavy soil displacement where mineral soil had been shoved into mounds.

IV. SKID TRAIL: an obvious path caused by the repeated passage of tractors and logs.

V. SLASH BURN RING: an obvious area where the soil surface had been altered by the burning of piled logging debris.

Each of the five disturbance classes was represented by 40 plots, 5.4 square feet in size, randomly located across the study site. Herbage production and composition data were collected on the 200 plots by double sampling-weight estimate technique. Plants were clipped by species, oven-dried, and weighed. Important forage species were sampled at the peak of the growing season. Shrub and tree seedling production on the site was insignificant and, therefore, ignored in determining production.

Below-ground plant biomass was obtained with a coring device from a subsample of 12 plots representing each disturbance class. Samples were taken to a depth of 4 inches, then washed, oven-dried, and weighed. Roots were not distinguished from rhizomes; nor was dead material distinguished from live. Tree roots were not segregated from the samples.

RESULTS AND DISCUSSION

As depicted in Figure 1, the great majority of forest understory biomass was concentrated below the soil surface. The principal understory species of the undisturbed community--pinegrass, elk sedge, and heartleaf arnica--are highly rhizomatous. Together these three species formed a dense mat of roots and rhizomes immediately below the surface of the forest floor. In the undisturbed class, only 8 percent of the total understory plant biomass was top growth. Compared with the undisturbed control, underground production markedly diminished in the four classes of disturbance examined.

Six years after timber harvesting, total aboveground yield of disturbance classes II (light to moderate) and III (Berm) was similar and not significantly different from the control (no disturbance). Moreover, the ratio of grasses and sedges to forbs varied little among all disturbance classes, except skid trails. As would be expected, this latter class contained a higher percentage of grasses.

Fire rings were considerably less productive than the other disturbance classes in both above- and below-ground yields. Five years after burning, the rings were producing only 44 pounds of top growth per acre. These rings typically were blanketed by a light-colored mantle of fluffy mineral "ash", several inches thick, which appeared to preclude plant establishment. Productivity of slash burn rings (which constituted about 3 percent of the study site's total area) might be greatly enhanced by mixing the surface "ash" with underlying soils through machine scarification.

An obvious conclusion from this study is that, in terms of producing forage, it is advantageous to artificially seed skid trails. Six years after tractor logging, seeded skid trails produced 65 percent more herbage than did the next most productive class, the undisturbed control.

Overall logging disturbance, in its various forms, did not appear to impair the site's understory productivity. On the other hand, all classes of disturbance exhibited profound drops in below-ground plant biomass, compared with the control. The thick mat of roots and rhizomes developed by the native undisturbed species may play an important role in soil containment. Forest managers might take this natural erosion deterrent into account when planning timber sales on areas vulnerable to erosion. For instance, tractor movement might be restricted to designated skid trails to minimize disturbance of the native understory.

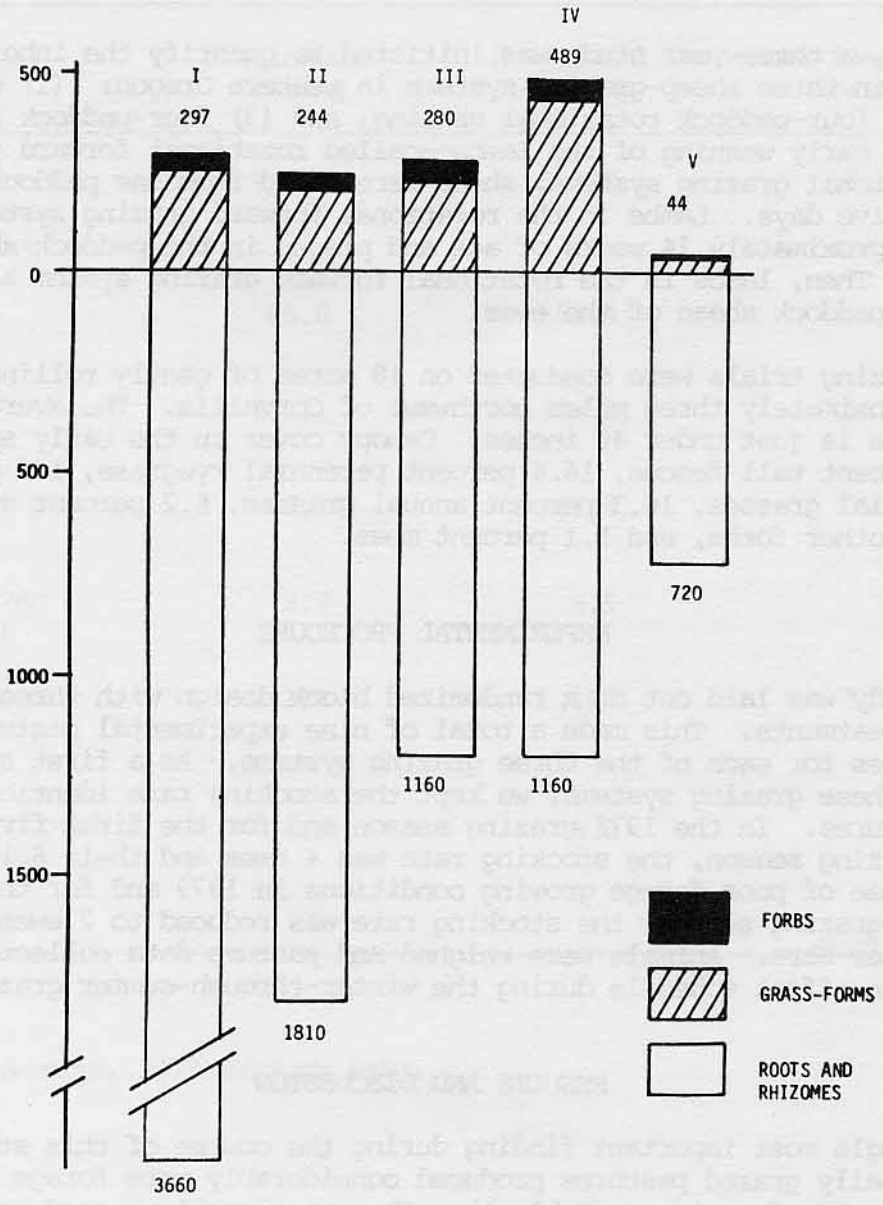

Figure 1. Total top and below-ground production (lb/acre) for each of the five soil disturbance classes resulting from tractor logging.