# Root Biomass on Native Range and Mine Spoils in Southeastern Montana

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## Abstract

**Research was conducted on native range and revegetated strip mine spoils near Colstrip, Montana, in August of 1975 to determine the weight and distribution of root biomass at five locations. Study sites included native range in excellent, good, and poor condition; a naturally revegetated 40-year-old leveled, ungrazed strip mine spoils; and a 5-year seeded and fertilized mine spoils. Total root biomass was highest on the 5-year-old seeded and fertilized mine spoils. Good condition native range had a higher root biomass than excellent or poor condition native range. The root biomass of the 40-year-old mine spoil did not differ from excellent condition native range. Root biomass distribution in the four zones studied did not differ between sites. Over 55% of the root biomass was in the upper 15 cm of the soil profile at all five locations.**

Plant roots in the range ecosystem play a vital role in supporting the plant, providing the plant with water and nutrient, and in stabilizing the soil. A knowledge of the impact of herbivores on this component of the ecosystem is useful in understanding and managing range ecosystems. Presently research quantifying belowground biomass on revegetated strip mine spoils in the Northern Great Plains is limited to one study reported by Wyatt et al. (1980). In this study it was found that old mine spoils had substantially more roots below 100 cm than new spoils or undisturbed soils. This was attributed to the fact more tap rooted species occurred on the old spoils.

Quantitative measurements of roots on the various grassland types have been reported by Weaver and Zink (1946), Weaver (1958), and Bartos and Sims (1974) for the shortgrass prairie; Bray (1963), Lorenz and Rogler (1967), and Wyatt et al. (1980) for the northern mixed prairie; and Dahlman and Kucera (1965) for the tallgrass prairie. In Colorado shortgrass prairie (Bartos and Sims 1974) and North Dakota mixed prairie (Lorenz and Rogler 1967) studies no significant differences were found in root biomass distribution between heavily and moderately grazed pastures. Pearson (1965) and Smoliak et al. (1972) found root biomass decreased with increased grazing pressure. Other studies have shown that herbage removal has a negative effect on root growth (Biswell and Weaver 1933, Hanson and Stoddart 1940, and Schuster 1964).

The objective of this study was to determine root biomass weight and distribution on native range sites in different condition and revegetated strip mine spoils of different ages in southeastern Montana.

## Study Area and Methods

This study was conducted on mixed prairie and on revegetated coal mine spoils near Colstrip in southeastern Montana in August of 1975. Native range sites in excellent, good, and poor condition were selected for study. These sites were in close proximity to each other and had similar soils and climate. Range condition was quantified with the climax approach presently used by the Soil Conservation Service and developed by Dyksterhuis (1949). Soils on the study sites are of the order Entisol, with a sandy clay loam texture. The mean annual precipitation for Colstrip area is approximately 40 cm. The common forage species found on the study areas are green needlegrass *(Stipa viridula)*, needle-and-thread grass *(Stipa comata)*, western wheatgrass *(Agropyron smithii)*, prairie junegrass *(Koeleria cristata)*, blue grama *(Bouteloua gracilis)*, Sandberg bluegrass *(Poa sandbergii)*, big sagebrush *(Artemisia tridentata)*, silver sagebrush *(Artemisia cana)*, western yarrow *(Achillea millefolium)* and plains prickly pear *(Opuntia polyacantha)*. When degradation by overgrazing occurs, increased amounts of blue grama, annual bromegrasses (*Bromus* spp.), silver sagebrush, and big sagebrush comprise the vegetation composition.

A 5-year-old artificially revegetated mine spoils and a 40-year ungrazed naturally revegetated mine spoils at Colstrip were also selected for study. The 40-year mine spoils had been leveled after mining and was dominated by the plant species previously mentioned. The 5-year-old site had been ripped, topsoiled, and seeded. Major plant species on the site were crested wheatgrass *(Agropyron cristatum)*, smoothbrome *(Bromus inermis)*, tall wheatgrass *(Agropyron elongatum)*, yellow sweetclover *(Melilotus officienatis)*, and Ladak alfalfa *(Medicago sativa)*. Other species were present but comprised only a minor amount of the aboveground biomass. This area had been fertilized annually with about 60 kg of nitrogen and 60 kg of phosphorus ($P_2O_5$) per hectare for 5 years from the time it was seeded until data for this study were collected.

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**Table 1. Root biomass (kg/ha) distribution in August of 1975 for the five study sites near Colstrip, Montana.**

| | Native range excellent condition | Native range good condition | Native range poor condition | Mined site 40 years old | Mined site 5 years old |
|---|---|---|---|---|---|
| Soil zone | | | Root biomass[1,2] | | |
| 0–15 cm | 452[bc] | 587[b] | 358[c] | 463[bc] | 1267[a] |
| 16–30 cm | 178[bc] | 175[bc] | 121[d] | 140[cd] | 326[a] |
| 31–45 cm | 97[b] | 92[b] | 64[b] | 81[b] | 126[a] |
| 46–60 cm | 81[a] | 63[a] | 58[a] | 67[a] | 90[a] |
| Total biomass | 808[c] | 917[b] | 601[d] | 751[c] | 1809[a] |
| Soil zone | | | Percent biomass[1,2] | | |
| 0–15 cm | 56[a] | 63[a] | 59[a] | 62[a] | 70[a] |
| 16–30 cm | 22[a] | 19[a] | 20[a] | 18[a] | 18[a] |
| 31–45 cm | 12[a] | 10[a] | 11[a] | 11[a] | 7[a] |
| 46–60 cm | 10[a] | 7[a] | 10[a] | 9[a] | 5[a] |

[1]Means with one or more letters in common are not significantly different ($P<.05$) according to Duncan's multiple range test.
[2]Statistical comparisons are valid only across columns.

A description of the physical and chemical characteristics of mine spoils at Colstrip is given by Sindelar et al. (1973) and Holechek (1976).

The methods used in collecting root biomass were modified slightly from those used by Bartos and Sims (1974). Root biomass samples on each study site were collected by subsampling along five randomly placed transects with a pneumatic hammer. A total of five subsamples were collected along each transect. Prior to sampling, aboveground vegetation was clipped to ground level and removed. Some plant crown material was included in each subsample. However, all the study sites were heavily dominated by grasses, and the effect was uniform between sites. Soil cores were divided into four 15-cm increments representing soil depths of 0–15 cm, 16–30 cm, 31–45 cm, and 46–60 cm. The roots were extracted placing the soil in screens and flushing with water. Screens of 20, 40, and 60 mesh were used for each extraction. Root biomass values were reported on an ash-free basis.

All data were analyzed by analysis of variance and ranked using Duncan's multiple range test.

## Results and Discussion

The 5-year revegetated mine spoils had a significantly higher ($P<.05$) root biomass than the other four treatments (Table 1). Good condition native range was significantly higher in root biomass than excellent or poor condition native range.

The percent root biomass in the four rooting zones did not differ significantly ($P<.05$) between sites. All five study sites showed a reduction in root biomass with increasing soil depth. Over 55% of the root biomass was in the first 15 cm of soil at all five study sites. Data from this study on root distribution are comparable to other investigations in the Central and Northern Great Plains. Bartos and Sims (1974) found 55% of the root biomass was in the upper 10 cm of soil on shortgrass range in Colorado, and 69% was in the upper 20 cm of the soil profile. On this same range type Weaver (1958) reported 79% of the roots were in the upper 15 cm of soil, and Weaver and Zink (1946) found 80% of the roots in the upper 35 cm of soil. On mixed prairie near Colstrip, Wyatt et al. (1980) reported data suggesting that root biomass was highly concentrated in the top 15 cm of the soil profile on both native soils and mine spoils; however, qualitative rather than quantitative data were given.

In the present study native range in good condition had more root biomass than native range in excellent or poor condition. Grazing intensity on the good condition site was moderate. In contrast, the poor condition site had a past history of heavy grazing. The excellent condition site had not been grazed for the past 4 years. Prior use on the excellent condition site had been light. Other studies are available which have shown root biomass under different grazing intensities (Lorenz and Rogler 1967, Bartos and Sims 1974), but not under different range condition classes. Several studies have been reported, however, showing vegetative production was higher on good condition ranges than those in either poor or excellent condition (Klipple and Costello 1960, Launchbaugh 1957, Hanson et al. 1970, Valentine 1970, Reardon and Merrill 1976, Skovlin et al. 1976).

The high root biomass on the 5-year-old revegetated coal mine spoils can be attributed to the plant species composition it supported and the fact that it received fertilization. Crested wheatgrass dominated this site comprising over 50% of the aboveground biomass. This species is highly adapted to harsh sites in the Northern Great Plains (Houston 1957, Rogler 1960, Holechek 1981, 1982). Production of crested wheatgrass seedings has been found to be generally higher than native range in the Northern Great Plains (Houston 1957, Lodge 1972). Crested wheatgrass is highly responsive to nitrogen and phosphorus fertilizer application (Rogler et al. 1962, and Rogler and Lorenz 1969, Power and Alessi 1971, Holechek 1982, Holechek et al. 1981). This further explains the high root biomass on the 5-year old revegetated mine spoils compared to other sites.

The 40-year-old naturally revegetated mine spoils showed no difference from native range in excellent condition in either total root biomass or root distribution. Data reported by Wyatt et al. (1980) also showed that native soils and naturally revegetated 44- to 48-year-old mine spoils in the Colstrip are showed little difference in root biomass distribution or total quantity. This and the present study indicate that leveled mine spoils at Colstrip will approach native soils in development within a 40-year time span if a seed source is available.

## Conclusions

The results from this study suggest that good condition mixed prairie ranges in the Northern Great Plains support a higher root biomass than those in excellent or poor condition. It appears that root distribution is similar between condition classes. The 40-year naturally revegetated mine spoils supported a root biomass that did not differ from excellent condition native range in quantity or soil profile distribution. This suggests that soil development on mine spoils at Colstrip may approach that of native range within 40 years if the spoils are merely leveled and a seed source is available. With inputs such as topsoiling, ripping, seeding and fertilization, this time period may be greatly reduced.

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