LIVESTOCK IMPACTS FOR MANAGEMENT OF RECLAIMED LAND AT NAVAJO MINE: VEGETATION RESPONSES[1]

by

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Abstract. The post-mining land use for Navajo Mine, a large surface coal mine in northwest New Mexico, is livestock grazing. Reclamation began in the early 1970's and has been primarily directed toward the development of a grassland with shrubs. However, none of these lands were grazed before 1994 and none have been released back to the Navajo Nation. Therefore, it is not known how these reclaimed lands will respond to livestock impacts once the lands are released. Livestock impacts include grazing, trampling, and adding feces and urine. Cattle impacts were applied in 1994 to a land that had been reclaimed in 1978, 1991 and 1992. Vegetation monitoring procedures were implemented to detect and document successful and unsuccessful impact practices for both impacted areas and areas excluded from cattle. After three impact seasons, there were similar levels of perennial plant cover, production, and density on impacted lands compared to excluded lands. Based on age structure analysis, there is a trend that establishment of seedlings is stimulated by cattle. Cattle also decrease the amount of previous years' growth of standing phytomass with a trend to stimulate new growth. It is possible that some of the previous year's growth was reduced by cattle trampling as much as by grazing because cattle generally prefer to eat the current year's growth before it cures. No differences in number of seedheads per plant, animal sign, plant pedestals, and soil rills could be detected after three seasons of impacting.

Additional Key Words: cover, production, density, trampling, age structure, animal signs, pedestals, and rills.

Introduction

The post-mining land use for Navajo Mine, a large surface coal mine in northwest New Mexico, is livestock grazing. The reclaimed lands are required by law to support livestock at levels approximately equal to or greater than for the pre-mined lands. Reclamation began in the early 1970's and has been primarily directed toward the development of a grassland with scattered shrubs. None of these reclaimed lands have been used by livestock before 1994, and none have been released back to the Navajo Nation. Therefore, it is not known how these reclaimed lands will respond to livestock impacts once the lands are released.

The Watson and Bitsui reclamation lands of Navajo Mine are pre-law (pre-SMCRA or Surface Mining Control and Reclamation Act of 1977) lands because they were mined before 1977. These lands were reclaimed in 1978, 1991, and 1992. Cattle use began in 1994. The Grazing Management Program (GMP) was introduced to stimulate seedling establishment, enhance mature plant health, and develop successful grazing techniques for all reclaimed lands on the mine. To detect and document successful practices for the grazing program, vegetation and soils were evaluated along with the monitoring of other effects of cattle impacts.

Methods

Three reclaimed lands were impacted by cattle in the Watson and Bitsui Reclamation Land at Navajo Mine in 1994, 1995, and 1996. On April 7, 1994, 112 head of cattle were applied until August 30, 1996. On December 1, 1995, 48 cattle were applied until April 30, 1996. These lands included a 1978 Watson reclamation (26 ha), a 1991-1992 Bitsui reclamation (81 ha), and a 1991-1992 Watson reclamation (202 ha). To evaluate ecosystem responses to cattle impacts, sampling sites were located on 100 m centers throughout each reclaimed land. At each site, five 10

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m transects were established radially 72 degrees apart with transect number one placed due north at each sampling site.

A total of 179 sampling sites were used to represent the impacted areas. Twelve exclosures, each 0.57 ha in size and each containing three sampling sites, were randomly located in grazed areas and used to represent the non-impacted areas. The 1978 Watson reclamation land had a total of 27 sampling sites, 18 in the impacted area and a total of 9 in the three exclosures. The 1991/1992 Bitsui reclamation land had a total of 26 sampling sites, 17 in the impacted area and 9 exclosures. The 1991/1992 Watson reclamation land had a total of 162 sampling sites, 144 in the impacted area and a total of 18 in the six exclosures. Sampling was conducted at the end of the growing season in October 1994 and 1995 and September 1996.

Total cover of each species' current year's growth was measured along each 10 m transect by the line intercept method (Canfield 1941). The line intercept method was used because it is often considered one of the most reliable methods for determining cover and is often used for comparing other methods (Hormay 1949, Whitman and Siggeirsson 1954, Johnston 1957, Kinsinger et al. 1960, Brun and Box 1963, Hanley 1978).

Current year production of each grass and forb species was measured by clipping an area 30 cm wide and 3 m long adjacent to the 10 m line intercept transect. Production samples were dried at 60°C until all moisture was removed, and weighed. Weight of herbage or biomass was determined because it is one of the most important characteristics of range vegetation and may be the best single measure of growth (Cook and Stubbendieck 1986). Cook and Stubbendieck (1986) also stated that all the factors that affect plant vigor are integrated in production. Therefore, production or herbage yield is undoubtedly a more accurate measure of plant vigor than any single vegetation characteristic. Plant vigor is synonymous with the status or health of the plant. It denotes the relative appearance, vitality, rate of growth, and herbage production of the plant. Maximum vigor requires a favorable environment.

Shrub density of each species was determined by counting the total number of shrub bases within 1 m of each side of each 10 m line intercept transect. Density is the number of individuals per unit area and is useful in evaluating a shrub or tree stand (Cook and Stubbendieck 1986). Perennial grass density was collected by counting the total number of grass bases within a 0.25 m^2 plot randomly located along each of the five 10 m transects at each sampling site.

Many investigators measure and evaluate several characteristics of plant vigor or health in addition to production. Cook and Child (1971) found percentage dead crown cover to be a reliable index of low vigor in desert grasses and shrubs of Utah. Therefore, age structure (seedlings, mature, and decadent) data were collected for each perennial species within a 0.25 m^2 plot randomly located along each of the five 10 m transects at each sampling site. The percentage of the total plants in each category was calculated. Also, the percentage of current year's growth compared to the total standing volume of perennial grass species was estimated in each 0.25 m^2 plot. Additionally, the number of seedheads per perennial grass plant was counted in the 30 cm x 3 m plots used for determining production. The number of flower stalks is another commonly used and easily measured criteria for determining and evaluating plant vigor (Weaver and Hougen 1939).

Subjective evaluations of animal sign, plant pedestals, and soil rills were made at each sampling site. Animal sign evaluations included the presence or evidence of (1) insects, (2) birds, (3) rodents, and (4) large animals. Pedestal evaluations included (1) no evidence, (2) small plant and rock pedestals, (3) most plants and rocks on pedestals, and (4) root exposure. Soil rill evaluations included (1) rills absent, (2) rills 2.5 to 15 cm wide and greater than 3 m long, (3) rills occur frequently, and (4) rills join at short intervals and denude large areas.

Results

Cover

The majority of the total perennial cover was composed of grass species. Cover in the 1978 Watson land was slightly lower in the impacted areas than the excluded areas before applying cattle impacts in 1994 (Fig. 1). In 1995, precipitation (Fig. 8) and soil moisture were higher than during 1994, therefore, cover in the impacted and excluded areas increased proportionately over 1994 levels. However, in 1996, a dry year, cover in the impacted areas was proportionally lower than the previous year's growth, more so than the reduction of cover in the excluded areas.

Cover in the 1991/1992 Bitsui land for areas to be impacted was less than 50% of the cover in areas to be excluded in 1994 (Fig. 1). After 1995, cover in the impacted areas had increased greatly and was nearly as high as the excluded areas. After 1996, cover in the impacted areas was as low as in 1994, and cover in the excluded areas was lower than 1994 although not as low as in the impacted areas.

Cover in the 1991/1992 Watson land in areas to be impacted was less than cover in areas to be excluded in 1994 (Fig. 1). After 1995, cover in the impacted areas had increased, while cover in the excluded areas had decreased. After 1996, cover in the impacted areas had decreased greatly from the 1995 level, and cover in the excluded areas had continued to decrease from 1994 and 1995 levels, although not as low as in the impacted areas. However, cover was greater in the excluded area versus the impacted area in 1996.

Production

Like cover, the majority of the total perennial production was composed of grass species. Production was not measured in 1994 prior to impacting, but was measured after grazing at the end of the growing season in 1995 and 1996.

Production in the 1978 Watson land was slightly lower in the impacted areas than the excluded areas in 1995 (Fig. 2). After the dry year of 1996 (Fig. 8), the impacted areas had a higher portion of production relative to 1995 than production in the excluded areas.

Production in the 1991/1992 Bitsui land was higher in the impacted areas than the excluded areas in 1995 (Fig. 2). After the dry year of 1996, the impacted areas had a similarly low portion of production relative to 1995 as the excluded areas.

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Grass Density

Grass density in the 1978 Watson land was slightly lower in the impacted areas than the excluded areas in 1995 (Fig. 3). After the dry year of 1996 (Fig. 8), the impacted areas had a similar portion of grass density relative to 1995 as the excluded areas.

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Shrub Density

Shrub density in the 1978 Watson land was slightly lower in the impacted areas than the excluded areas in 1995 (Fig. 4). After the dry year of 1996 (Fig. 8), the impacted areas' shrub density did not decrease as much as in the excluded areas. High mortality rates of shrubs is attributed die-off of broom snakeweed (*Gutierrezia sarothrae*). This species is short-lived with huge annual population fluctuations (McDaniel 1989).

Shrub density in the 1991/1992 Bitsui land was higher in the excluded areas than the impacted areas after applying cattle in 1995 (Fig. 4). After the dry year of 1996, impacted areas had a shrub density that was a similar portion of the previous year's growth compared to the excluded areas in 1995.

Shrub density in the 1991/1992 Watson land was higher in the impacted areas than the excluded areas after applying cattle in 1995 (Fig. 4). After the dry year of 1996, the impacted areas had a shrub density that was a similar portion in the excluded areas in 1995.

Age Structure

A high percentage of seedlings in the 1978 Watson land were found on the impacted areas in 1995 (Fig. 5). Seedlings were not found on the same areas in 1996. Few seedlings were found in the excluded areas in 1995 and 1996. The majority of plants were mature on both impacted and excluded areas. A higher percentage of the plants were decadent in impacted areas in 1996 than in 1995, while a lower percentage were decadent in the excluded areas in 1996 than 1995.

A high percentage of seedlings in the 1991/1992 Bitsui land were found on the impacted areas in 1995 (Fig. 5). Seedlings were not found on the same areas in 1996. A few seedlings were found in the excluded areas in 1995 but not in 1996. The majority of plants were mature on both impacted and excluded areas. A higher percentage of the plants were decadent in both impacted and excluded areas in 1996 than in 1995.

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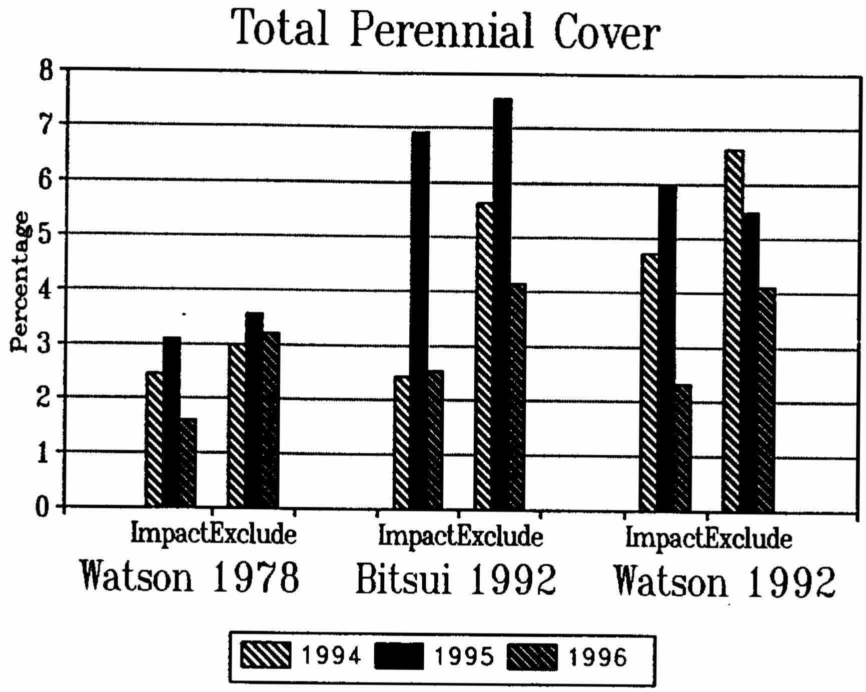


Figure 1. Total perennial plant cover for each reclamation area and each year.

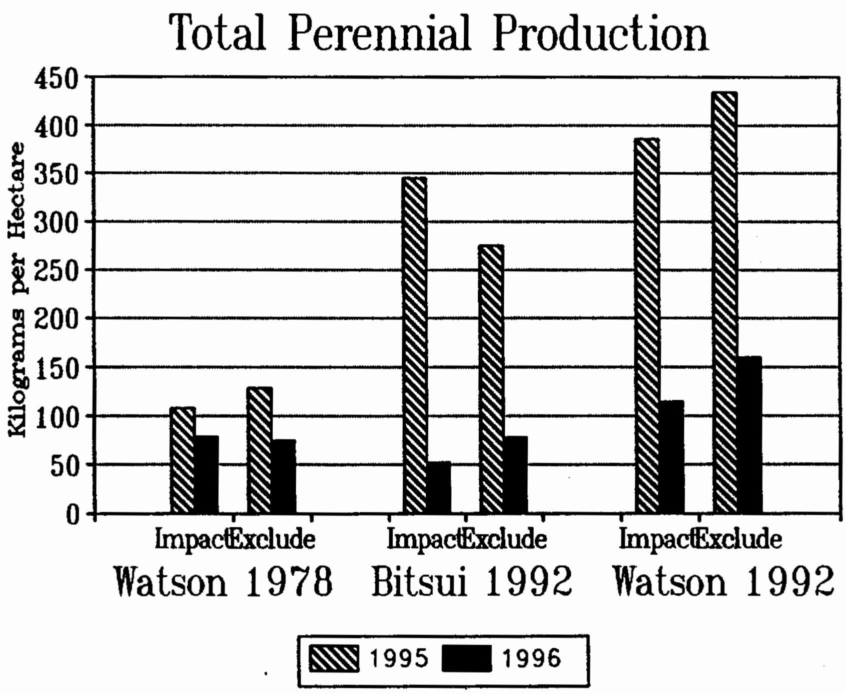


Figure 2. Total perennial plant production for each reclamation area and each year.

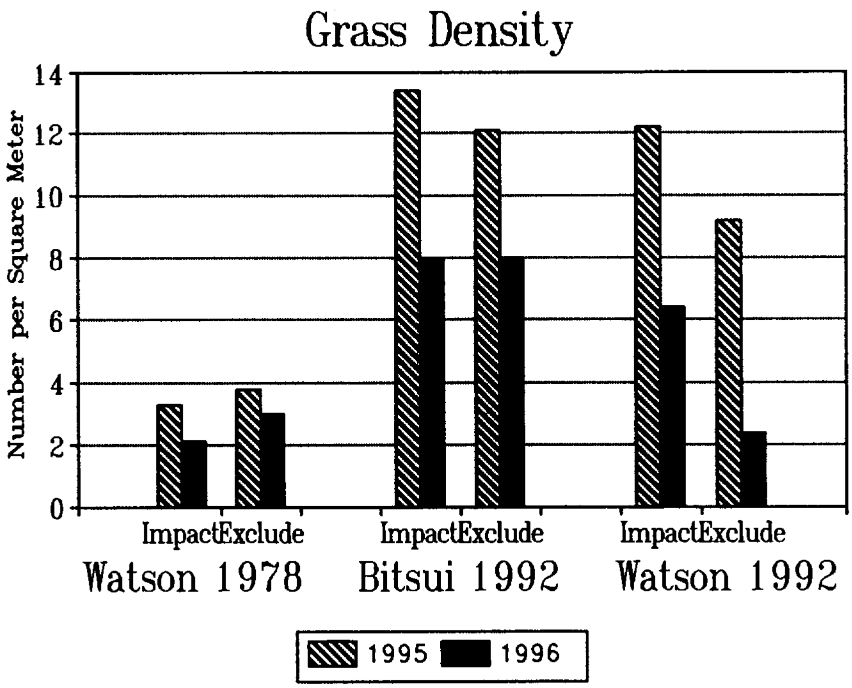


Figure 3. Grass density for each reclamation area and each year.

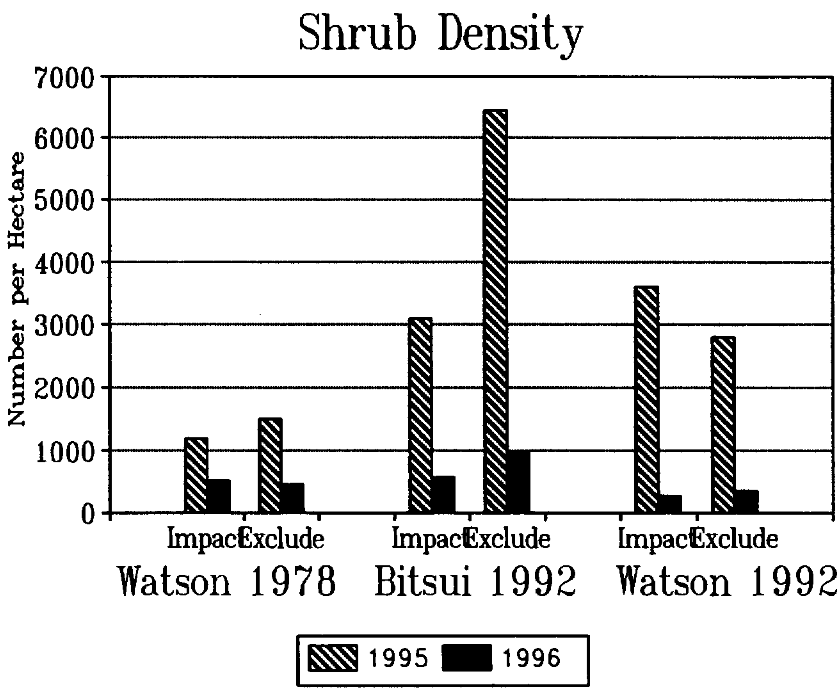
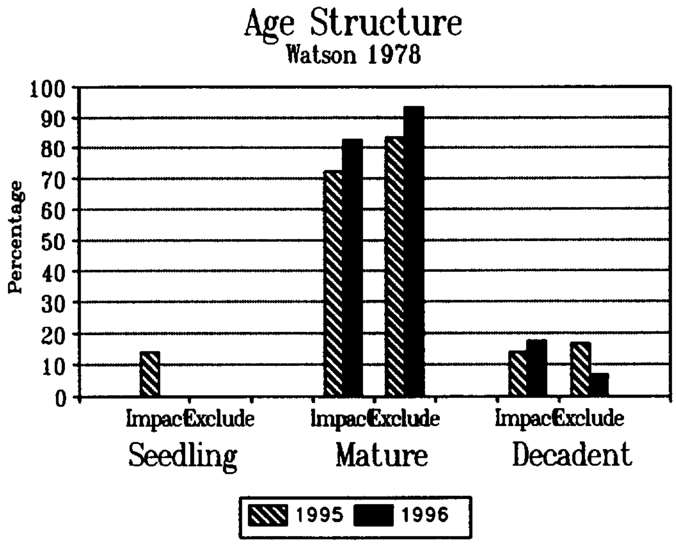
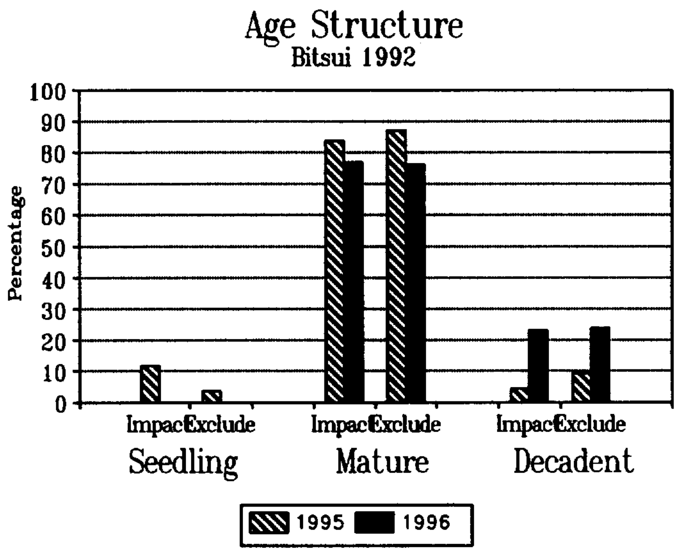


Figure 4. Shrub density for each reclamation area and each year.





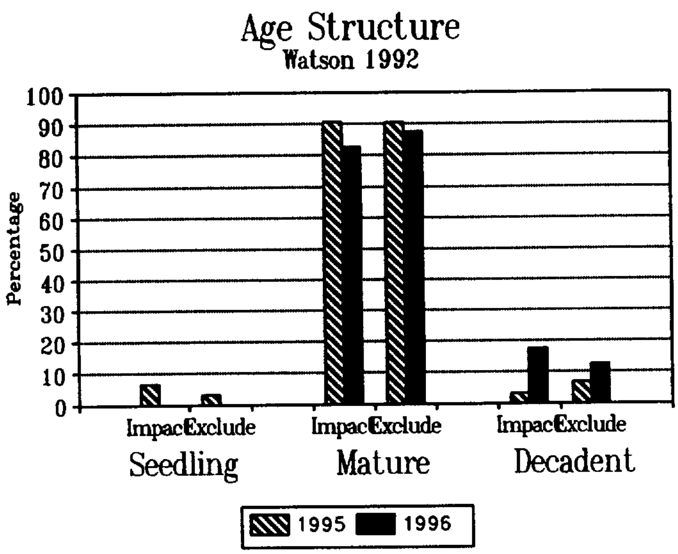


Figure 5. Perennial plant age structure for each reclamation area and each year.

Current Year's Growth

A large portion of the plants in the 1978 Watson land contained mostly the present year's growth in impacted areas during 1995 (Fig 6). New growth was a low portion of the plants in excluded areas in 1995. During 1996, new growth was less evident in impacted areas compared to 1995 and scarce in excluded areas compared to the previous year. These differences and trends for the 1991/1992 Bitsui and 1991/1992 Watson lands were similar to the 1978 Watson land (Fig. 6).

Number of Seedheads

More seedheads per perennial grass plant in the 1978 Watson land were found in the excluded area than the impacted area in 1995 (Fig. 7). The opposite was true at the other two lands. In 1996, few seedheads were found in impacted or excluded areas.

Animal Signs

Insect signs were more common in the impacted areas than the excluded areas and more common during the drought of 1996 than in the more moist year of 1995 (Table 1, Fig. 8). The differences between impacted and excluded areas was not as great in 1996 as in 1995. About 95% of the insects were ants, darkling beetles, and grasshoppers. The majority of insects were ants, and besides animal material, they eat plant pollen and seeds. The darkling beetles eat dead plant material. Both of these insect groups could be considered indicators of good range health. The grasshoppers eat plant material with the majority of plant material being alive. Grasshoppers are often indicators of stress conditions.

Few bird signs were found in either impacted or excluded areas. Rodents were found in both impacted and excluded areas with neither type of area consistently having more rodents than the other. Rodent signs were mostly jack rabbits and some prairie dogs. More large animal signs were found in impacted areas than excluded areas. These included coyotes and domestic dogs. The reasons they were found more abundantly in impacted areas is not known.

Pedestals

Plant pedestals are indicators of sheet erosion from water and wind. Water erosion is expected to be low because of the coarse nature of the soils, which allows high water infiltration rates. Wind erosion is also expected to be low because the Navajo Mine is generally in an area of deposition for aeolian sediments coming from Chaco, Wash. Plant pedestals were not common in either impacted or excluded areas. In 1995, the severity of pedestals was higher in excluded areas than impacted areas (Table 2). In 1996, no differences were found. Of all the variables measured in this evaluation, the pedestalling process is probably the slowest to change, so that no differences in just 2 years would be expected.

Soil Rills

Soil rills result from water causing rill erosion. Some are natural and some are induced by human activities. It was hypothesized that rills could be mitigated with cattle trampling. Differences in rilling between impacted and excluded areas were not found for 1995 and 1996.

Conclusions

Total perennial cover seems to have responded more to the level of precipitation than the level of cattle use. Cover evidence indicates that cattle impacts were not excessive nor detrimental to the sustainability of the reclaimed lands. It also suggests that a reclaimed land could sustain cattle impacts within 2 years following reclamation.

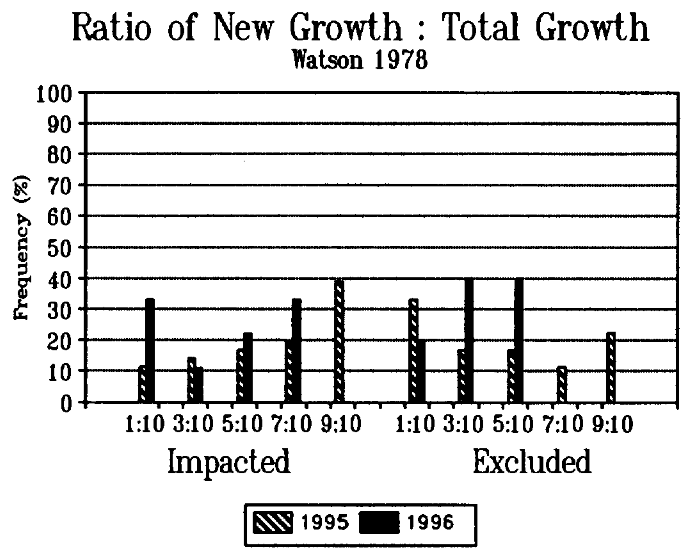
Like total perennial cover, total perennial production, grass density, and shrub density responded more to the level of precipitation than the level of cattle use. This also suggests that the impact level was not abusive nor detrimental to the sustainability of the reclaimed lands.

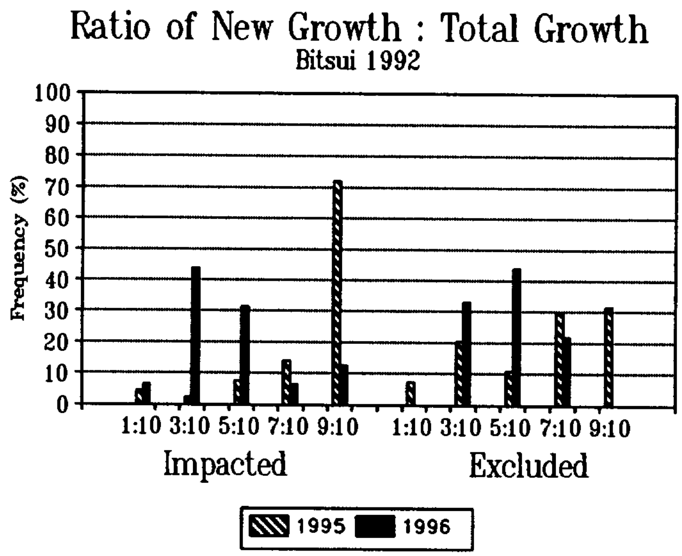
More seedlings were found in impacted than excluded areas in 1995. In 1996, a drought year, seedlings were not common in either area. Most of the plants were of a mature structure in impacted and excluded areas during both years. The increase in decadent plants was greater in impacted areas than excluded areas although the total numbers were quite low.

A greater proportion of present year's growth was found in impacted areas than excluded areas in 1995. Differences during the drought of 1996 were much less notable.

During the more moist year of 1995, more seedheads were found on perennial grass plants in impacted areas than excluded areas in two of the three reclaimed lands. Few or no seedheads were produced on any areas during the drought of 1996.

Animal signs in the impacted and excluded areas were high for insects and rodents and low for birds and large animals. There were more beneficial





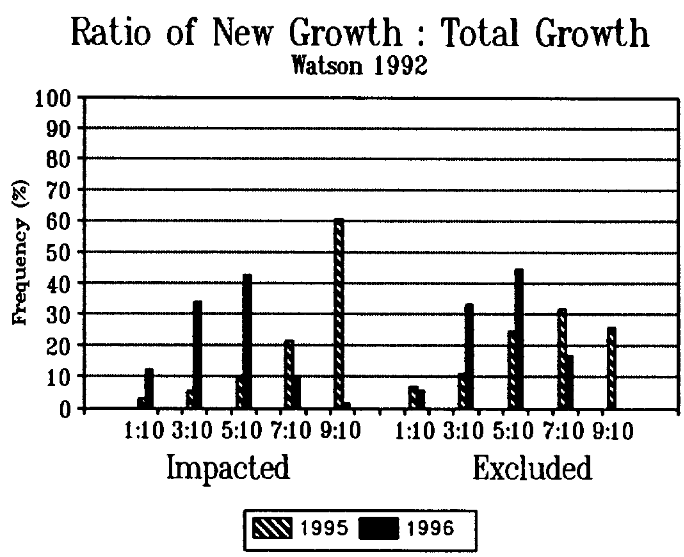


Figure 6. Ratio of new growth to total growth of perennial plants for each reclamation area and each year.

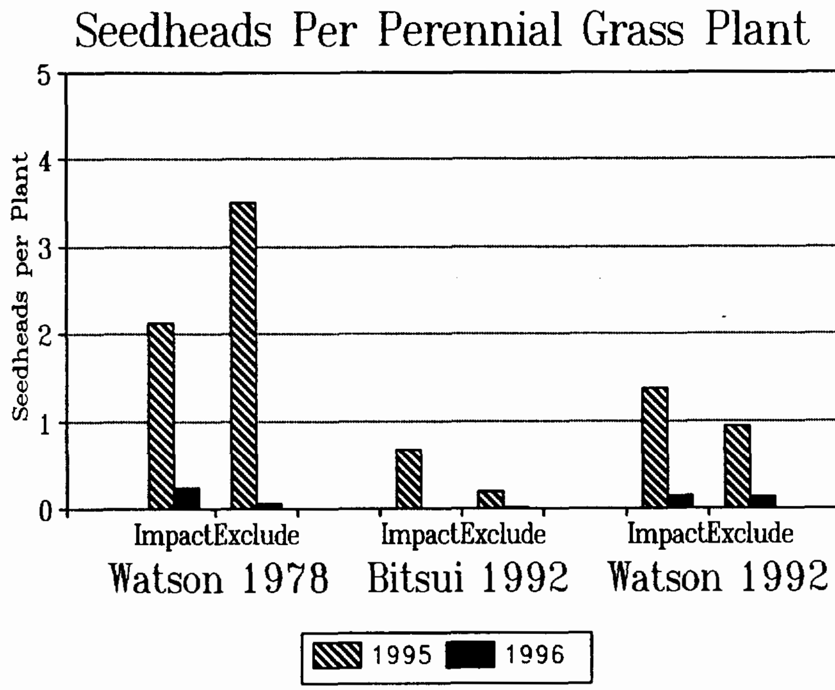


Figure 7. Mean number of seedheads per perennial grass plant for each reclamation land and each year.

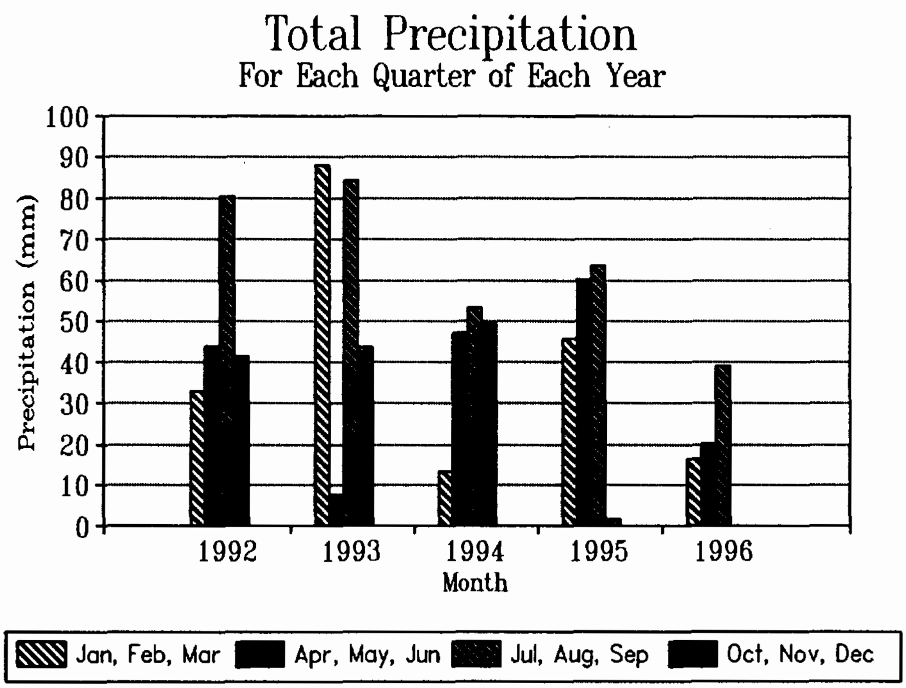


Figure 8. Total precipitation for each quarter of each year.

and harmful insects in the impacted areas than the excluded areas. Most of the insects were beneficial. Plant pedestalling is not considered to have been a problem in either impacted or excluded areas.

Differences in rilling between impacted and excluded areas were not found for 1995 and 1996. Overall, benefits from cattle impacts are not yet fully understood or realized. In 1995, when precipitation during the growing season was average, cattle impacting improved range health, In 1996, when precipitation during the growing season was below average as in a drought, cattle impacting was not found to be excessive or detrimental to the reclaimed sites. To date, it appears to be a sustainable management practice.

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