EFFECTS OF ONE AND TWO SEASONS IRRIGATION ON VEGETAL RESPONSE, NAVAJO MINE, NORTHWEST NEW MEXICO[1]

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Abstract: An irrigation study was established in 1990 to compare the effects of one and two seasons of irrigation on reclamation success. Two study plots were located in the Mason 90 Reclamation Area, Navajo Mine, Northwestern New Mexico. Vegetational data was collected in early 1991, prior to the plot receiving the second season of irrigation. Additional vegetal data has been collected in 1992, 1993, and 1994. Total vegetal cover was generally higher for the plot receiving two seasons of irrigation in 1991 and 1992. However, by 1993 and in 1994, the vegetal responses for the two plots were nearly the same. It appears one season of irrigation may be adequate to establish successful reclamation at Navajo Mine.

Additional Key Words: Semi-arid Mine Land Reclamation, Surface Coal Mines, San Juan Basin, New Mexico.

Introduction

Successful reclamation of mined lands may initially depend on irrigation during the growing season to establish healthy plants. The USDA Forest Service User Guide to Vegetation (1979) states, "the amount and frequency of irrigation depends on the amount and intensity of natural precipitation, mine spoil make-up, density of plant cover desired, the water requirements of the species, applied cultural practices, and the availability of labor and funds". The Guide further points out, "the Vegetation Specialist should keep in mind, however, that the plant community must eventually survive under natural conditions".

Navajo Mine is located in the semi-arid four-corners region of New Mexico. Due to the low annual precipitation occurring at the mine, irrigation has been used to establish reclamation areas since 1970. Irrigation is typically applied for two growing seasons. It is, however, possible that successful reclamation may be accomplished with one year of irrigation and that two years may not be necessary. A study conducted by Powell, et al. (1978) in the semi-arid region of Montana recommended that one year of irrigation was sufficient for reclamation. In contrast, two years of sustained summer irrigation produced a near complete cover of vegetation, but the distribution of species was irregular. Highly irrigation responsive species completely inhibited less responsive species, thus decreasing diversity.

In 1990, the Mason 90 reclamation area was established using sprinkler irrigation to promote plant growth. A study to monitor and evaluate the effects of irrigation treatments on vegetal performance subsequently was initiated in 1991 by Buchanan Consultants, Ltd. (BCL). This report compares four years of vegetal data (1991 - 1994) on plots receiving one year of irrigation (1990) and two years of irrigation (1990 and 1991).

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Methods

In 1991, BCL established a 2,400 m^2 study area within the Mason Reclamation area at Navajo Mine. The area was divided into two plots of equal size, each measuring 60 m long by 20 m wide (Figure 1).

The entire reclamation area was irrigated with overhead sprinklers for one growing season in 1990. In 1991, the western half of the study (one-year irrigation plot) did not receive irrigation, but the eastern half (two-year irrigation plot) was irrigated.

Fifteen permanent 10m vegetation transects were randomly located perpendicular to a 60m west/east reference line centered on the study area (Figure 1). The transects were permanently established by placing rebar at both ends of each transect. Vegetation was evaluated along the transects using the line intercept method. Percent cover of each species was calculated as the total distance of the current years vegetal growth that intercepted the 10m line.

Prior to irrigation in 1991, open ended aluminum cans were placed one meter from one end of each transect within each plot to determine summer precipitation and amount of irrigation. Precipitation and irrigation were recorded to the nearest 0.1 mm. Data were collected after each rain event and each irrigation. Two of the transects, 39 and 40 (Figure 1) in the one-year irrigation plot were located near a break in the irrigation pipe. These transects were not used in the analysis of this study.

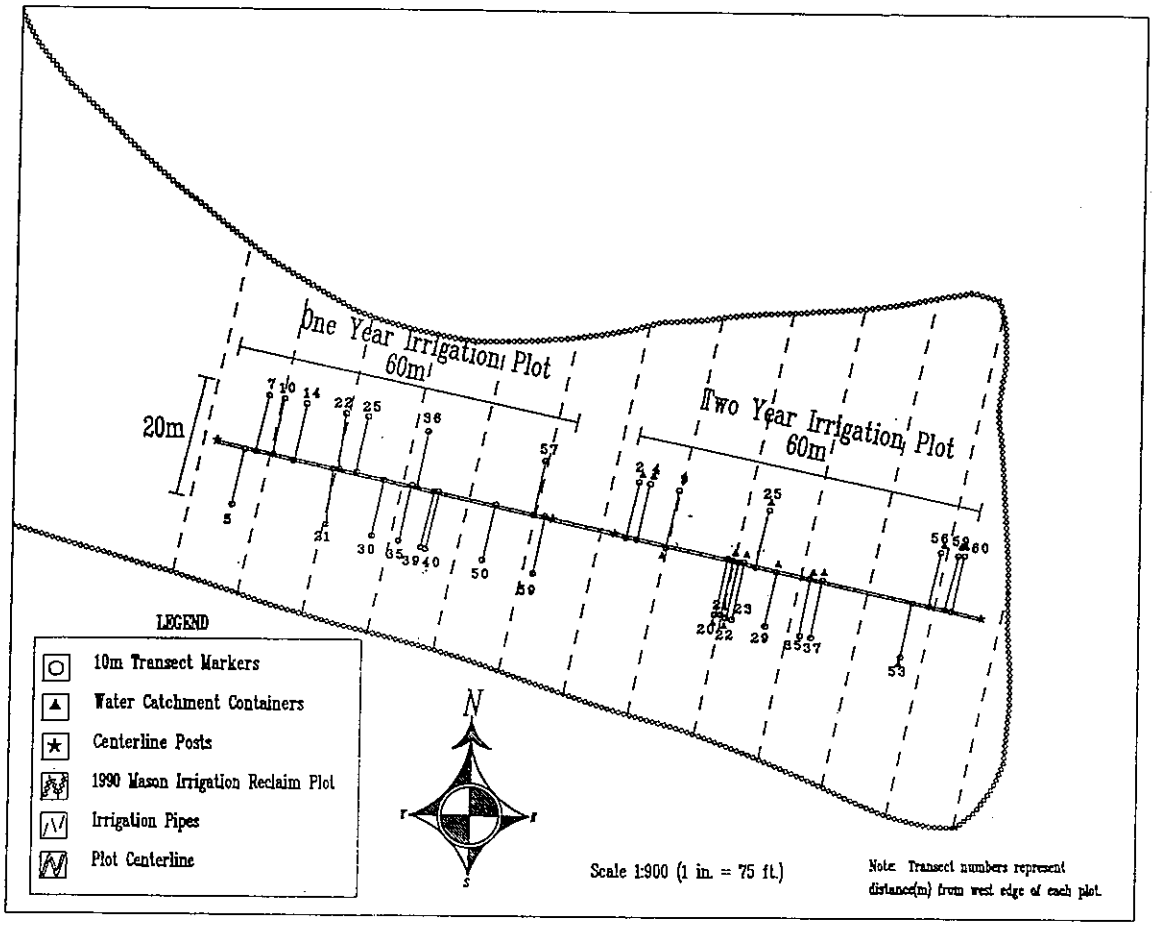

Figure 1: Diagram of the study area located in the Mason 90 reclamation area, Navajo Mine.

Results and Discussion

Irrigation and Precipitation

In 1991, the one-year irrigated plot received a total of 8.1 mm of precipitation and the two- year irrigated plot received 72.5 mm of precipitation and irrigation (Table 1). The two year irrigated plot was irrigated twice a month in July and August for approximately 24 hours. The amounts applied ranged from 7.9 mm to 22.8 mm and averaged 16.1 mm per irrigation (Table 1).

Table 1: Mean amount of precipitation and irrigation on the one-year and two-year irrigation plots, recorded in mm for the 1991 growing season.

	One Year Irrigation Plot		Two Year Irrigation Plot	
Date	Irrigation	Precipitation	Irrigation	Precipitation
		----mm----		
14-Jun	0	0.2	0	0.2
8-Jul	17	0	0	0
18-Jul	16.7	0	0	0
19-Aug	22.8	2.3	0	2.3
19-Aug	7.9	5.6	0	5.6
Total	64.4	8.1	0	8.1

Precipitation totals measured at the New Mexico State University Agricultural Science Center (located a few miles east of Navajo Mine) for January through August of 1990 through 1994 were 139.8, 87.6, 137.0, 212.2, and 148.2 millimeters (mm.) respectively (Table 2). Significant amounts of precipitation occurred in May 1990, 1992, and 1994 and in August 1990, 1992, 1993 and 1994. January of 1993 was singularly significant with 58.6 mm. of precipitation.

Table 2: Precipitation data for March through August, 1990 through 1994, recorded in millimeters. Data recorded at the New Mexico State University Agricultural Experiment Station located a few miles East of Navajo Mine.

	Month								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Year									
1990	13.6	13.6	18.9	21.8	27.4	1.8	8.9	33.8	139.8
1991	15.1	6.7	17.2	0.27	6.9	17.7	8.9	14.8	87.6
1992	3.84	4.61	18.9	6.4	44.8	1.28	25.1	32.0	137.0
1993	58.6	27.1	19.5	20.2	15.4	12.8	9.2	49.4	212.2
1994	6.1	9.2	6.1	12.3	23.3	2.0	19.2	69.9	148.2

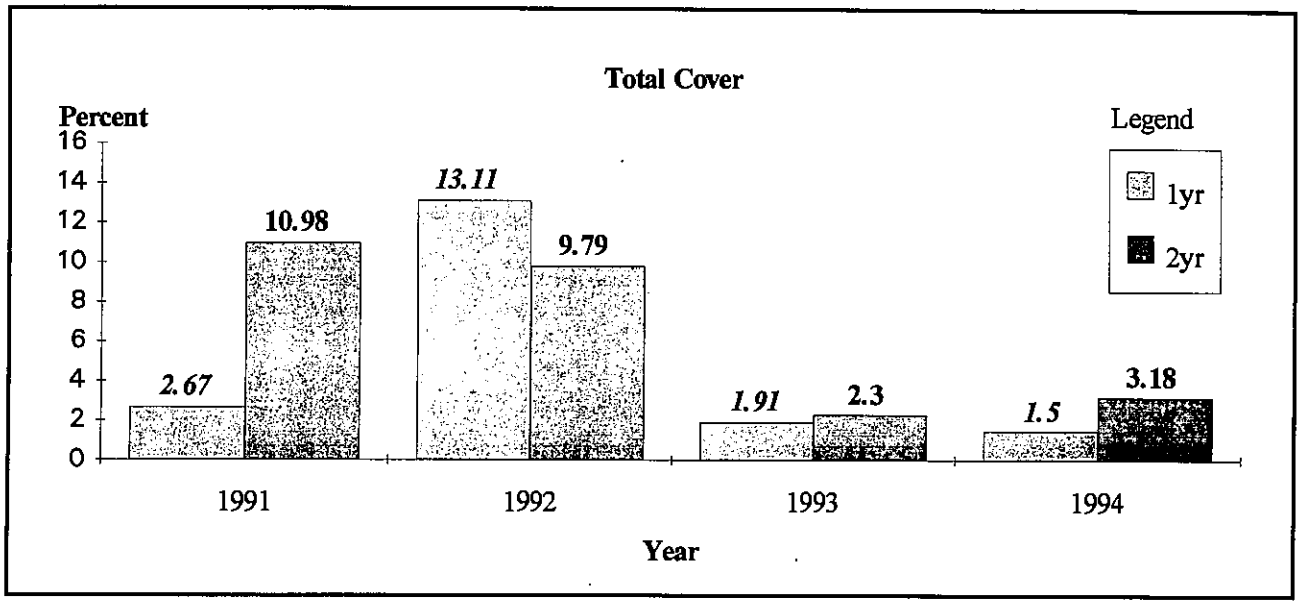

Figure 2: Percent cover of total vegetation on both the one and two-year irrigation plots for the month of August, 1991 through 1994, Mason 90 reclamation area.

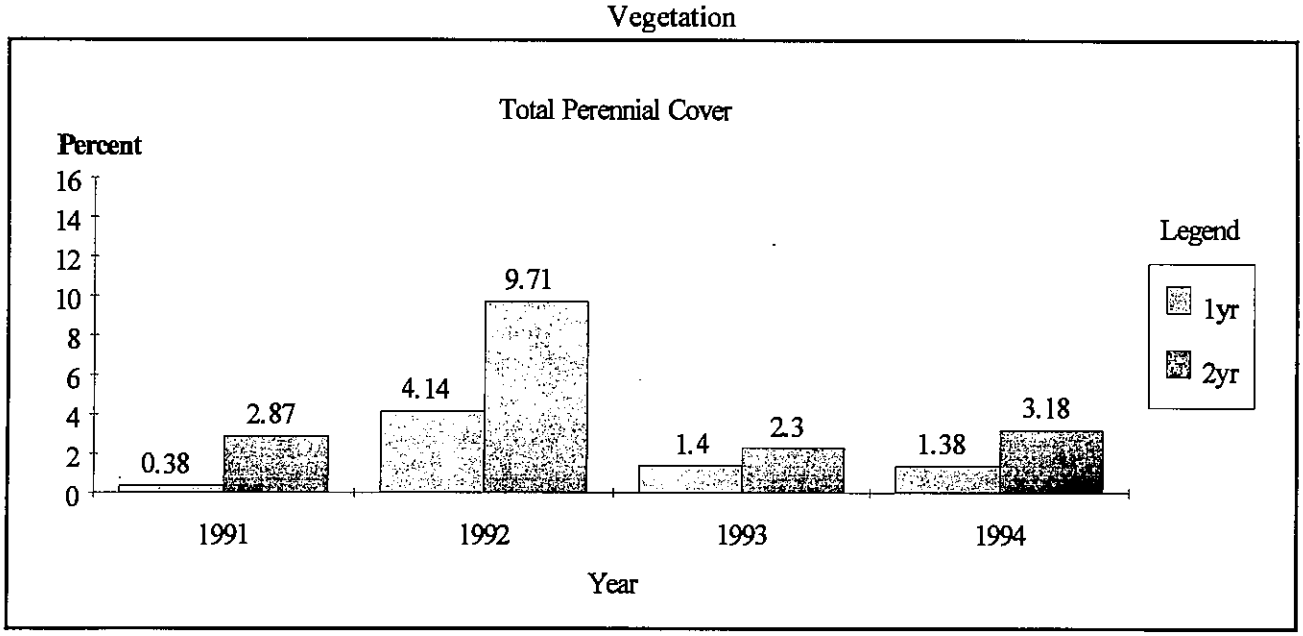

Figure 3: Percent cover of vegetation on both the one and two-year irrigation plots for the month of August, 1991 through 1994, Mason 90 reclamation area.

Vegetal cover, was measured in August of 1991, 1992, 1993 and 1994 to represent end of the growing season vegetal performance. Vegetal data was divided into the following categories: Total Cover, Total Perennial Cover, Annual Grasses, Perennial Grasses, Perennial Forbs, Annual Forbs, and Shrubs. Annual Grasses and Perennial Forbs were present only in small amounts. The contribution of the Annual Grasses to the total annual production was very small and these results are not presented. Figures 2 through 7 show the effects of irrigating the second year versus irrigating for only one year for each the remaining categories.

The one-year irrigation plot exhibited the highest percent total cover (13.1%) of vegetation in August, 1992 (Figure 2). In contrast to this, total cover for August was higher in the two-year irrigation plot in 1991. This can be explained by first considering that annual forbs respond favorably to irrigation and precipitation. Annual forbs, comprised of mainly Russian thistle (*Salsola iberica*) represent the majority of the percent total cover in 1991 and 1992 in both plots. There was some contribution from perennial grasses and shrubs. Annual grasses and perennial forbs existed, but only in small amounts (Figure 5).

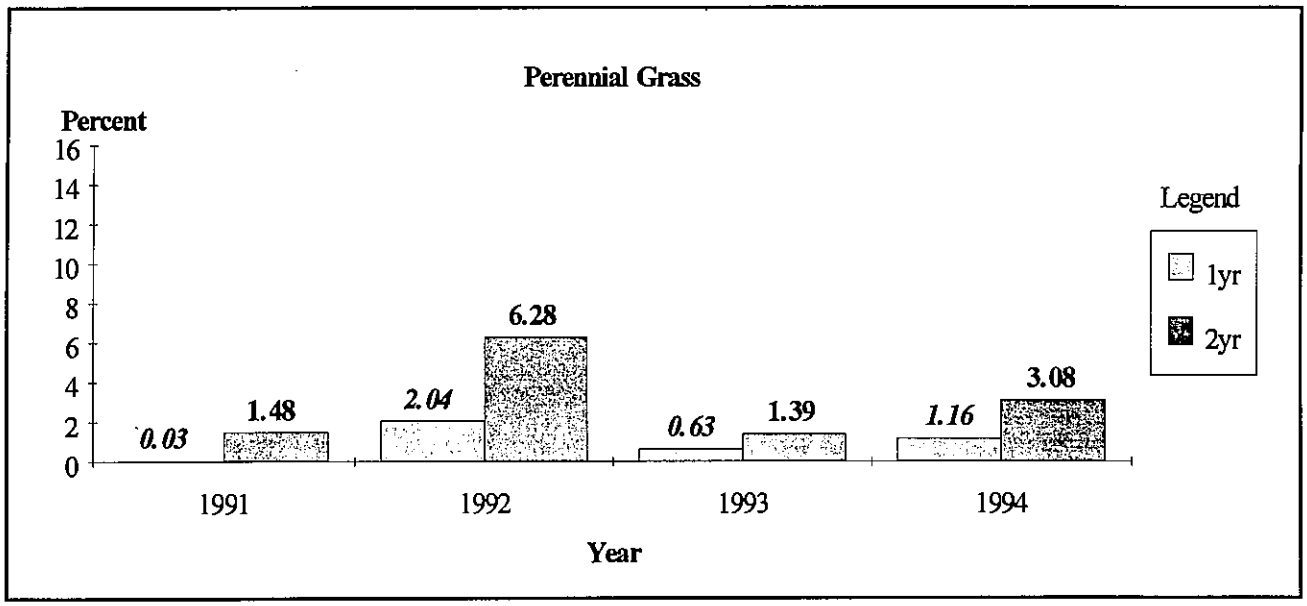

Figure 4: Percent cover of perennial grasses on both the one and two-year irrigation plots for the month of August, 1991 through 1994, Mason 90 reclamation area.

Annual forbs increased from 2.3% in August 1991 to 8.8% in 1992 for the one-year irrigation plot. In contrast, annual forbs for the two-year irrigation plot decreased from 8.0% in August, 1991 to 0.6% in August 1992 (Figure 6). The increase in annual forbs in the one-year irrigation plot was most likely in response to 44.8 mm. of precipitation occurring in May, 1992 (Table 2). The two-year irrigation plot, however, did not respond

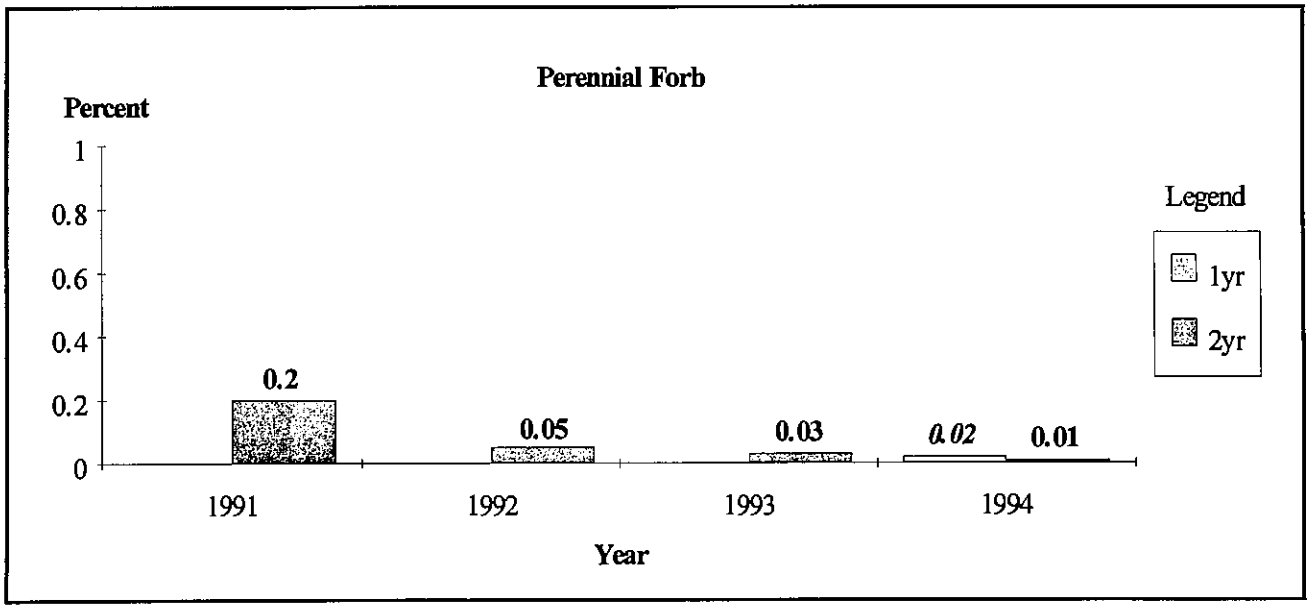

Figure 5: Percent cover of perennial forbs on both the one and two-year irrigation plots for the month of August, 1991 through 1994, Mason 90 reclamation area.

in 1992 to the precipitation. It is suggested that the decrease in annual forbs for the two-year irrigation plot in 1992 and for the one-year irrigation plot in 1993 was primarily due to intra-specific competition among the Russian Thistle. Russian Thistle accounted for approximately 91% of the annual forbs in 1991 and 86% in 1992.

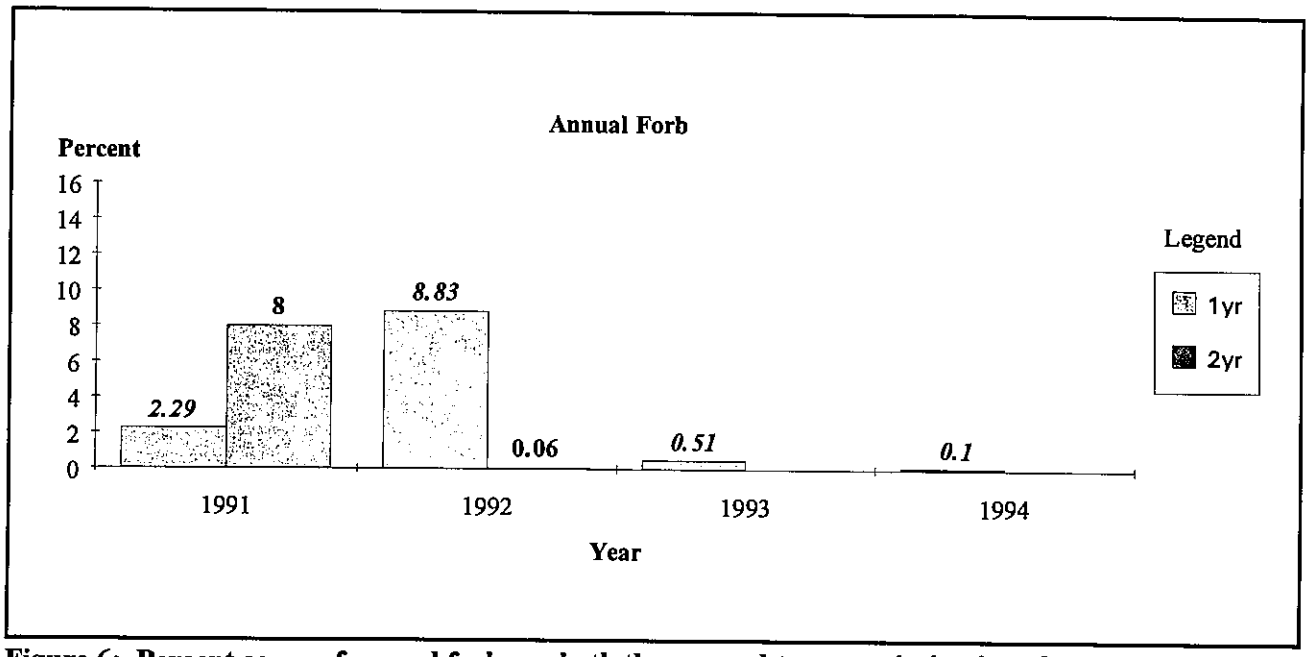

Figure 6: Percent cover of annual forbs on both the one and two-year irrigation plots for the month of August, 1991 through 1994, Mason 90 reclamation area.

Annual forb cover in 1993 and 1994 was 0% for the two-year irrigation plot. The one-year irrigation plot decreased form 0.5% in 1993 to 0.01% in 1994. An increase of total perennial cover, perennial grasses and shrubs in 1992 may have contributed inter-specific competition that was responsible for limiting annual forb cover in both one-year and two-year irrigated plots in 1993 and 1994 (Figures 3, 4 and 7).

Perennial grasses responded favorably to the second year of supplemental irrigation (Figure 4). Perennial grass cover increased in the two-year irrigation plot from 1.5% in August 1991 to 6.3% in August 1992. The one-year irrigation plot also increased from 0.1% in August 1991 to 2.0% in August 1992 (Figure 4).

Perennial grass cover increased in 1993 from 1.39% to 3.08% in the two-year irrigation plot and from 0.63% to 1.16% in the one-year irrigation plot. These results suggest that perennial grass response in 1991 was due to irrigation and to the combined effect of irrigation and seasonal precipitation in 1992. However, in 1993 and 1994, the response is predominately the result of seasonal precipitation , (Table 2, Figure 4). Precipitation in May 1993 was 15.4 mm. compared to 23.3 mm. in May 1994 (Table 2).

Perennial forb cover, is not represented in the 1991, 1992 and 1993 one-year irrigation plot. Perennial forb cover for the two year irrigation plot declined from 0.2% in 1991 to 0.01% in 1994 (Figure 5). Perennial forb cover for the one-year irrigation plot was present in 1994 with 0.02% cover. Perennial forb cover did not demonstrate any response to irrigation after 1991. The decline is probably due to inter-specific competition from perennial grasses. The competition probably masked any effects of precipitation in 1994 but may account for the perennial forb cover in the one-year irrigation plot being higher (0.02%) in 1994 (Figure 6).

Shrubs increased in the two-year irrigation plot from 1.2% in August 1991 to 3.4% in August 1992. Shrubs on the one-year irrigation plot also increased from 0.4% in August 1991 to 2.1% in August 1992 (Figure 7). Shrub cover consistently declined from 1992 to 1994 in both one-year and two-year irrigated plots. Shrub cover in 1993 and 1994 did not show any great differences between one-year and two-year irrigated plots. The decline is once again believed to be due primarily to inter-specific competition with perennial grasses. Shrub cover responded favorably to two years of irrigation in 1991 and to irrigation and seasonal precipitation in 1992. Inter-specific competition probably masked any effects of precipitation in 1993 but may account for the shrub cover in the one year irrigation plot being higher (0.2%) in 1994 (Figure 7).

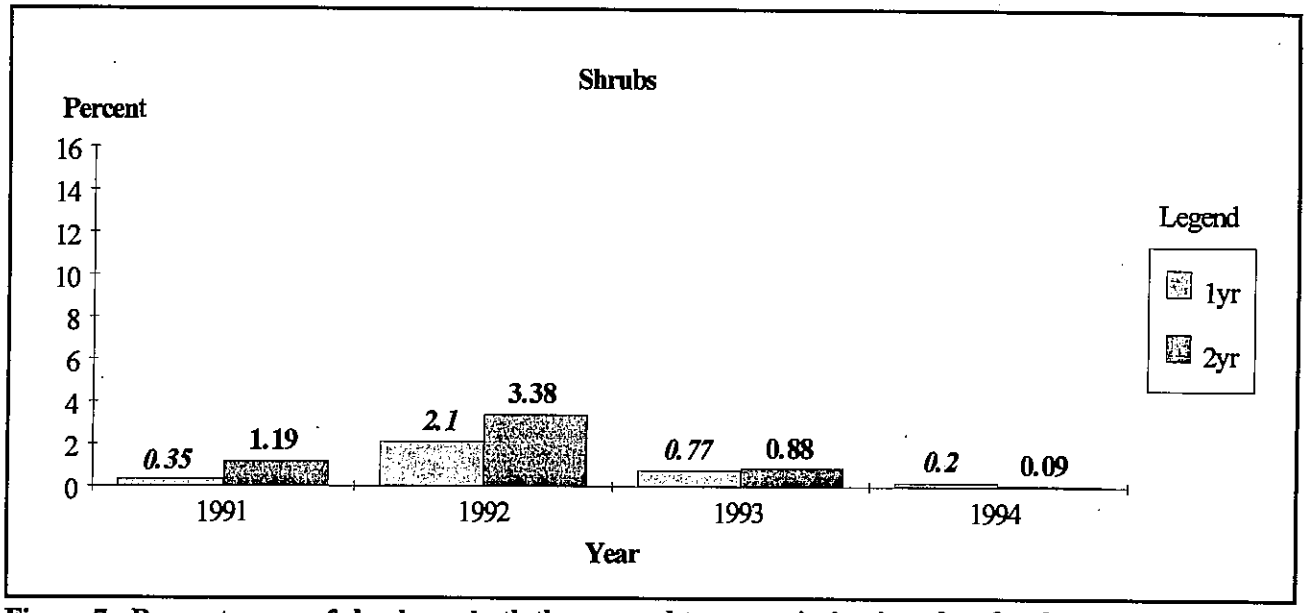

Figure 7: Percent cover of shrubs on both the one and two-year irrigation plots for the month of August, 1991 through 1994, Mason 90 reclamation area.

The one-year irrigation plot generally had lower amounts of vegetal cover from 1991 through 1994 which is believed to be related almost entirely to the amount of irrigation received in 1990 and 1991. Irrigation received by the two-year plot in 1991 resulted in an increase in perennial cover, mainly perennial grasses, over the one-year irrigation plot. An increase in perennial grass cover is indicative of an increase in root growth as well. Root biomass can be viewed as potential in unsuitable years for growth in favorable years. It is therefore not surprising to find total perennial cover for 1993 and 1994 remaining somewhat higher in the two-year irrigation plot, or to observe that there was a slight increase in total cover, total perennial cover, and perennial grass in 1994 in response to the Spring precipitation (Figures 2, 3, and 4). However, over the course of the study, irrigation effects gradually disappeared and seasonal precipitation and inter-specific competition had a pronounced effect. This has resulted in vegetal cover values that do not exhibit any great differences between the one-year and two-year irrigation plots.

Conclusions

The objective of this study was to monitor and evaluate the effects of irrigation treatments on vegetal performance. The results showed vegetal differences between the one year irrigation plot and the two year irrigation plot. The two-year irrigation plot produced higher percentages of vegetation compared to the one-year irrigation plot. There is a trend that shows the percentage of vegetation on the two year irrigation plot beginning to decrease from 1992 to 1994.

Vegetal response was expected to be significantly greater in the plots receiving the second year of irrigation. The data demonstrates that in time the differences in the one year irrigation plot and the two year irrigation plot have decreased, and similar vegetal communities are establishing on both plots. If this trend continues, one year of irrigation appears to be sufficient to achieve successful reclamation.

It is recommended that vegetal data continue to be collected from the Mason 90 study plot. The effect of minimizing irrigation on reclamation areas cannot be fully evaluated until several more years of vegetal data are collected.

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