FIELD TRIP REPORT: NATURAL AND MANAGED RECOVERY OF VEGETATION ON DISTURBED AREAS AT THE NEVADA TEST SITE

E. M. Romney
R. B. Hunter
A. Wallace

ABSTRACT

An all-day field trip to the Nevada Test Site was conducted on April 6, 1989, as part of the Sixth Wildland Shrub Symposium program. Included were visits to aboveground nuclear event sites, nuclear cratering sites, rangeland fire burn sites, and waste management sites in order to observe natural and managed recovery of vegetation on disturbed Mojave Desert land. This report presents conditions observed in terms of the recovery processes involved rather than by route of travel and observation stops.

INTRODUCTION

The 3,500-km^2 region occupied by the Nevada Test Site (NTS), located about 100 km northwest of Las Vegas, NV, is one of extraordinary biological interest because of its geographic location straddling the boundaries of the Great Basin and Mojave Deserts. The NTS was first used to test nuclear weapons in 1951. Since then there have been ecological impacts from both nuclear and nonnuclear testing, as well as impacts from natural events. Such impacts have been the focus of extensive ecological investigation. In fact, the NTS has been one of the most continuously environmentally studied desert areas of the world.

In terms of the total land area disturbed, about 5 percent of the NTS property has been impacted by wildfires and by native fauna, such as the pocket gopher. Earlier grazing on NTS property by domestic livestock was discontinued in the early 1940's when the area began to be used for bombing and gunnery practice by the U.S. Air Force. The sites of land disturbed by aboveground nuclear events during the 1950's equal about 1 percent of the total NTS property, with 0.3 percent currently fenced and maintained as radiation-contaminated exclusion areas. The greatest land area disturbance from ongoing nuclear testing, about 2 percent of the NTS property, has been the development of subsidence craters resulting from underground nuclear events. Another 1 percent of the total NTS area has been disturbed by an extensive roadway network constructed to provide access to various testing sites.

This field trip was held in conjunction with the Symposium on Cheatgrass Invasion, Shrub Die-Off, and Other Aspects of Shrub Biology and Management, Las Vegas, NV, April 5-7, 1989. It was cosponsored by the Environmental Compliance Branch of the U.S. Department of Energy, Nevada Operations Office.

E. M. Romney, R. B. Hunter, and A. Wallace are Research Scientists, Laboratory of Biomedical and Environmental Sciences, University of California, Los Angeles, CA 90024.

NATURAL RECOVERY OF VEGETATION ON SITES DENUDED BY NUCLEAR EVENTS

Aboveground nuclear testing during the 1950's involved detonations from tower and balloon mountings and from air-drops that denuded vegetation around the ground zero and target areas by blast and fire. Some sites were impacted repeatedly from successive series of nuclear events before aboveground testing was discontinued in 1958 (Friesen 1985). Aboveground test areas tended to be circular in shape with impact damage out to distances varying from 1 to 2 km from ground zero.

Within two growing seasons after testing had ceased, the sites began to display species of native or naturalized annual plants. In fact the lack of competitive shrub populations resulted in more available soil moisture, especially during the summer season, which greatly amplified the presence of introduced annuals such as Russian thistle (*Salsola*) and brome grass (*Bromus*). Details on the recovery of annual plant species on disturbed sites will not be addressed in this shrub-oriented report, but interested readers may obtain such information from published sources (Rickard and Shields 1963; Rickard and Sauer 1982; Shields and Wells 1962; Shields and others 1963).

In considering native shrub recovery on disturbed land in the Mojave Desert, one must take into account the two most important factors that limit seed germination and survival—rainfall and jackrabbits. Under normal seasonal rainfall in the Mojave Desert, the total population of germinated shrub seedlings is virtually consumed by grazing jackrabbits. It is only during the unpredictable cyclic periods of 2 or 3 successive years of higher rainfall that sufficient succulent plant biomass is produced so that the needs of the jackrabbit population are satisfied without having to consume all of the new shrub seedlings. The same process also applies to the native perennial grasses (Ackerman 1979; Beatley 1974; Hunter 1987; Romney and others 1989a). Table 1 lists the amounts of annual precipitation at a monitoring station in Yucca Flat that is located within 10 km of each aboveground test area. The precipitation pattern is such that normally from 80 to 100 mm is received during the winter season of November through March. Amounts of precipitation above that level are received from unpredictable rainfall events during the period from April through August (table 2), and it has been following those relatively high summer-season rainfall events that pulse establishment of both perennial

Table 1—Annual precipitation at a station in central Yucca Flat (USWB-BJY)

Year	Precipitation	Year	Precipitation
	mm		*mm*
1962	86.2	1976	201.0
1963	135.9	1977	169.9
1964	62.8	1978	308.1
1965	278.0	1979	102.1
1966	89.7	1980	211.9
1967	65.0	1981	103.1
1968	88.4	1982	211.0
1969	270.1	1983	349.5
1970	128.7	1984	276.1
1971	157.7	1985	103.7
1972	158.5	1986	151.6
1973	208.7	1987	194.1
1974	189.9	1988	114.3
1975	103.4		

The 3 successive years of higher rainfall in 1982, 1983, and 1984, accompanying El Niño weather conditions, resulted in the initiation of extensive new shrub seedling survival on the denuded areas at NTS (Romney and others 1989a; Hunter 1989). Prior to that time there had been noticeable germination of new shrub seedlings that had not survived either subsequent drought or jackrabbit grazing, except along the overland water-flow channels leading from the upslope edges of the impacted areas down across the denuded land. Figures 1, 2, 3, and 4 show views of natural recovery of shrubs and perennial grasses during the 30-year period since the areas were denuded by blast and fire. Natural recovery of grasses and shrubs has been more rapid in terms of increased biomass, cover, and species population on disturbed land located farther away from ground zero. We believe that this primarily reflects the greater degree to which the original soil surface was removed and impacted by blast

Table 2—Precipitation (mm) during the period of April-August in central Yucca Flat (USWB-BJY)

Year	April	May	June	July	Aug.	Period total	Annual total
1967	15.2	5.8	3.0	0	0	24.0	65.0
1968	3.8	0	6.4	16.8	6.1	33.1	88.4
1969	4.8	1.8	22.4	18.3	.8	48.1	270.1
1970	7.1	0	2.3	2.3	30.5	42.2	128.7
1971	10.4	42.9	0	9.9	17.0	80.2	157.7
1972	1.3	2.2	31.0	.5	17.3	52.0	158.5
1973	5.3	5.1	3.6	0	1.3	15.3	208.7
1974	.8	0	0	27.9	10.2	38.1	189.9
1975	15.5	20.8	0	2.0	1.3	39.6	103.4
1976	11.9	9.7	0	18.8	0	40.4	201.0
1977	0	51.3	10.2	1.8	60.5	123.8	169.9
1978	12.4	1.3	0	12.2	0	25.9	308.1
1979	0	2.1	.3	19.3	10.2	31.8	102.1
1980	10.2	5.8	3.8	19.6	3.3	42.7	211.9
1981	10.7	3.8	0	0	2.5	17.0	103.1
1982	10.7	15.5	2.0	11.2	27.4	66.8	211.0
1983	12.2	9.1	0	0	125.2	146.5	349.5
1984	.5	0	19.1	86.9	76.5	183.0	276.1
1985	.3	4.8	8.1	21.3	0	34.2	103.7
1986	4.1	2.5	.5	14.0	8.4	29.5	151.6
1987	16.2	39.6	6.8	35.8	0	98.4	194.1
1988	33.3	7.4	3.3	1.5	18.5	64.0	114.3

grasses and shrubs has occurred. Natural revegetation on sites denuded by nuclear events has exhibited normal patterns of ecological succession comparable to that which has occurred on denuded non-nuclear-disturbed sites during essentially the same period of time.

Within the past 30-year period, the vegetation recovery pattern has been an initial decade dominated by prolific annual plant species production, especially during years of higher rainfall. During that first decade of recovery, we began to see pulse establishment of perennial grasses after the higher summer-season rainfall that occurred in 1965. The second decade of natural recovery was dominated by pulse establishment of perennial grasses, especially following the higher rainfall years of 1969, 1973, 1976, and 1978.

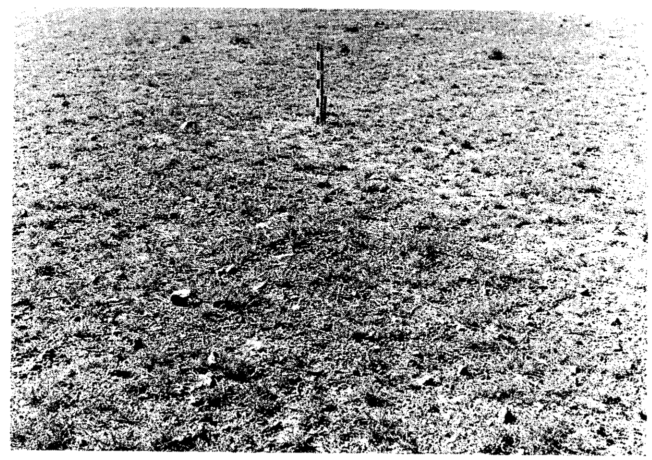

Figure 1—View in 1959 of a denuded study plot located about 400 m from the T-1 aboveground nuclear testing ground zero.

Figure 2—View in 1986 of the same study plot shown in figure 1 experiencing normal succession to perennial grassland.

Figure 3—View in 1964 of the T-1 ground zero area showing the prolific ground cover of the introduced annual Russian thistle species.

Figure 4—View in 1986 of the T-1 ground zero area experiencing normal succession to perennial grassland.

and fire at locations nearer ground zero. However, greater seed pressure also would have been experienced over time around the outer edges of the disturbed areas.

The formation of subsidence craters has had only minimal ecological impact upon each site because sufficient native vegetation survives to provide continuing food and shelter for existing animal populations.

Such was not the case for the Sedan nuclear cratering event in 1962 that resulted in the development of a large crater with blast-shear impact and throwout material deposition upon the surrounding area. Natural revegetation during the first decade after the Sedan event primarily involved introduced summer annuals. There was virtually no evidence of shrub restoration within the throwout pattern, except for some isolated cases where clumps of vegetation somehow escaped total destruction from blast-shear, and regrowth subsequently occurred from root-crown sprouting. Russian thistle species (*Salsola iberica* and *S. paulsensii*) were the primary occupants on the throwout zone (crater lip out to 900 m), during the first 10-year period of recovery, and even they did not grow well where throwout material was deeper than 10 cm. As a result, the zone from the crater lip out to about 900 m remained virtually denuded probably because of the poor moisture-holding capacity and infertile condition of the throwout overburden. Exceptions to this occurred in isolated moisture catchment basins, formed during the throwout deposition process, where prolific populations of Russian thistle and wild buckwheat (*Eriogonum* spp.) species appeared. Winter annual species common to the area begin to appear in significant populations, within the zone from 300 to 900 m from the crater lip, about 15 years after perturbation. Their amount of germination and subsequent growth response has been dependent upon late fall rainfall and winter precipitation, as is common elsewhere in the Mojave Desert. Those populations of winter annuals increased in species complexity with passing time, but the presence of wild buckwheat species has been significant only in the infrequent years of abovenormal precipitation. The introduced annual grass, red brome (*Bromus rubens*), began to appear in dense stands within the disturbed zone only after the higher late-summer rainfall of 1983 and 1984.

During the second decade after the Sedan event, some populations of fourwing saltbush (*Atriplex canescens*) became established from natural seed germination around isolated host plants that either survived the initial blast-shear impact or rejuvenated by resprouting from sheared-off root systems. Specimens of white burrobrush (*Hymenoclea salsola*) and Anderson wolfberry (*Lycium andersonii*) also established themselves along downslope drainage systems leading into the disturbed area near the interface between disturbed and undisturbed land. Aside from this, there has been little evidence of natural shrub restoration on the disturbed land surrounding the Sedan crater. The most significant feature of natural revegetation at Sedan has been the normal succession to grassland during the second and third decade of time on disturbed land that received less than 10 cm of throwout overburden (fig. 5). Table 3 contains example data on the change in perennial grass and shrub populations in study plots located along a transect sampled in 1976 and 1986. Shrubs other than white burrobrush have shown no significant establishment within the blast-shear zone since perturbation. We believe that the appearance of new grasses and shrubs in study plots closer to ground zero is the best evidence of natural revegetation in the disturbed area. Since the abovenormal

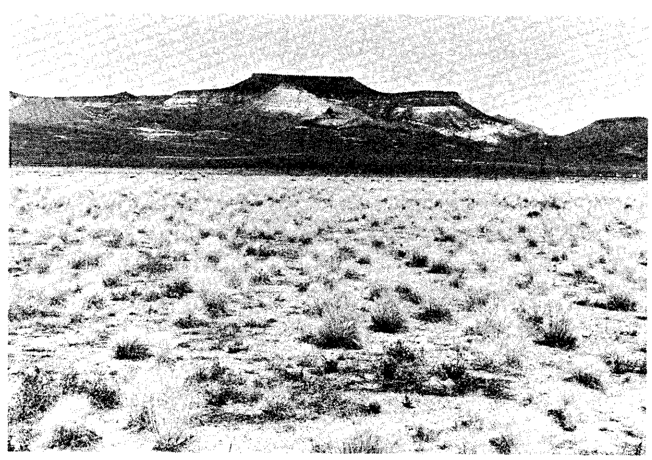

Figure 5—View in 1986 of a study plot located about 900 m from the Sedan throwout crater showing normal succession to mixed perennial grasses.

Table 3—Perennial grasses and shrubs in 1976 and 1986 on study plots located along Sedan transect line 16A[1]

Plant species	Distance from ground zero (meters)							
	305	457	610	762	915	1,067	1,219	1,372
	Number per 100 m^2							
May 1986								
Oryzopsis hymenoides	24	18	16	63	82	118	102	70
Sitanion jubatum	—	3	5	4	17	10	14	22
Stipa speciosa	30	17	19	35	47	59	4	6
Hymenoclea salsola					50	52	19	5
Lycium andersonii					3	8	9	3
Atriplex canescens					1			5
Chrysothamnus viscidiflorus						3	1	
Mendora spinescens							1	
Grayia spinosa							1	
Ambrosia dumosa							1	22
Coleogyne ramosissima							2	45
Lepidium fremontii							2	
Ephedra nevadensis							1	2
April 1976								
Oryzopsis hymenoides				6	102	127	82	88
Sitanion jubatum					13	8	2	7
Stipa speciosa					13	4		2
Hymenoclea salsola					1	4	2	2
Ceratoides lanata					1			
Lycium andersonii					1	7	1	5
Grayia spinosa						1		1
Ephedra nevadensis						1		
Menodora spinescens							3	3
Ambrosia dumosa							3	19
Atriplex canescens							1	
Coleogyne ramosissima								11
Lepidium fremontii								3

[1]Condition of area after Sedan event: **Crater zone**, GZ to 300 m, 1- to 25-m throwout overburden, 100 percent vegetation destroyed; **Blast zone**, 300 to 600 m, 30- to 100-cm overburden, 100 percent vegetation kill; **Shear zone**, 600 to 1,200 m, 3- to 30-cm overburden, 80 to 100 percent vegetation kill.

rainfall years of 1976 and 1978, populations of perennial grass species have increased significantly in the blast-shear zone. Data for Indian ricegrass (*Oryzopsis hymenoides*) are compiled in table 4 to show an example of the preevent population on the study plots and the changes that have occurred through natural recovery processes.

RANGELAND WILDFIRE BURN AREAS

As was pointed out earlier, range fire burn sites account for the greatest impacted area on NTS property. Natural vegetation recovery at these burn sites has followed normal ecological succession patterns. A contributing factor at most sites, and one which causes great concern as potential for future burn events elsewhere at NTS, is the increased invasion and buildup in ground cover biomass from the introduced grass species, red brome and cheatgrass brome (*Bromus tectorum*).

MANAGED RECOVERY OF SHRUBS ON DISTURBED LAND

Transplanting of native shrub species has been done on small sites of land subsequently denuded as the result of waste consolidation and cleanup activities, waste burial, and engineered grading disturbance. We also established some experimental transplantings in areas denuded 30-plus years earlier by pocket gophers, but those shrub specimens all were eventually destroyed by residual gopher populations (Hunter and others 1980). The primary ingredients for successful establishment of transplanted shrubs on denuded Mojave Desert land include individual or group protection from grazing jackrabbits by restrictive fencing and periodic applications of supplemental irrigation water during the posttransplanting period to assure new root establishment (Romney and others 1989b). Figures 6 and 7 show examples of the development of transplanted shrubs growing on earlier denuded land with individual and

Table 4—Change in density of Indian ricegrass on study plots located along Sedan transect lines 16A and 18A from preevent 1962 to 1986

Plot distance from ground zero	Year						
	1962[1]	1964	1965	1975	1976	1983	1986
m	- - - - - - - - - *Number per 100 m^2* - - - - - - - - -						
Transect line 16A							
228	130	0	0	0	0	0	0
305	96	0	0	0	0	16	24
457	69	0	0	0	0	10	18
610	72	0	0	0	0	10	16
762	144	0	0	0	6	38	63
915	75	0	7	24	[2]102	73	82
1,067	10	14	10	[2]130	[2]127	112	118
1,219	0	0	7	89	82	82	102
1,372	3	3	21	55	88	49	70
Transect line 18A							
228	120		0	0		0	0
305	110		0	0		0	0
457	41		0	0		0	0
610	20		0	0		37	61
(Scooter Crater area)							
1,219	14		3	[2]161		68	87
1,372	38		0	[2]322		95	ns
1,524	79		55	[2]147		117	134
1,829	44		52	[2]130		42	84
2,134	41		34	76		58	95
2,439	7		17	10		32	60
2,743	3		0	38		46	49

[1]Preevent.
[2]Included many new seedlings.

group-fenced protection from jackrabbit grazing. Rabbit grazing pressure virtually eliminates any new shrub seedling establishment in the open areas between transplanted specimens protected by individual fences (fig. 6). The individual fencing also permits considerable loss in shrub biomass as illustrated by the condition of shrubs in figure 6 compared to the condition of shrubs that had been protected by perimeter fencing (fig. 7). A long-term advantage of perimeter fences protecting transplanted shrub specimens is that new shrub seedlings developing around the host shrubs are not as easily destroyed by grazing jackrabbits.

One lesson that was learned early on in shrub transplanting work was the esthetic impact of planting specimens in spaced rows instead of at random spacing (fig. 8). Where possible, we recommend random-spaced transplanting in order to give the denuded area a more natural appearance upon recovery. Another problem that can be improved upon at sites where significant topsoil has been removed during the denuding process is to chisel or plow the land surface on contour to permit increased seasonal moisture penetration for use of transplanted shrub specimens.

It has been our experience at NTS that the best success with managed revegetation is to transplant native shrub specimens during the mid-spring months of March and April in order that the specimens may take advantage of previous winter season recharge soil moistures for developing an adequate new root system. Transplanting at later times during early and mid-summer months can be successful, but that success is dependent upon supplemental irrigation as needed. It is important that transplanting of deciduous shrubs be done early enough in the year to allow time for new root establishment before the transplanted specimens undergo normal fall and winter dormancy.

Given protection from grazing jackrabbits and the abovementioned procedural applications, we have consistently experienced better than 80 percent survival of transplantings on disturbed Mojave Desert land at NTS. The transplanting effort and followon maintenance necessary for the success of managed shrub revegetation is less of a problem than that of procurement and production of native shrub transplant specimens, which must be resolved at least 1 year before any field transplanting can be done.

Figure 6—View in 1986 of native shrubs transplanted in 1981 with an individual wire mesh fence protecting each specimen. Note the loss of biomass around the base of shrubs to grazing jackrabbits.

Figure 7—View in 1986 of native shrubs transplanted in 1981 within a perimeter-fenced area to provide protection from grazing jackrabbits. Density of transplanting was the same as on the nearby study plot shown in figure 6.

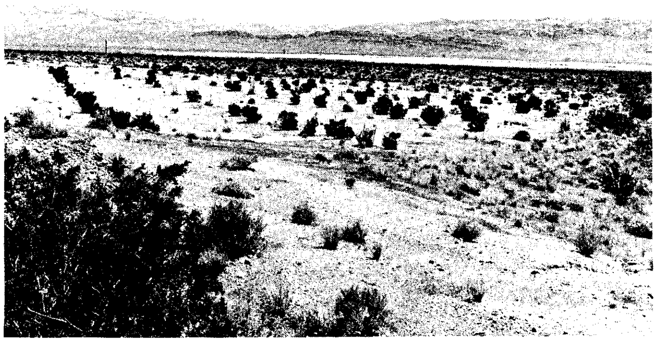

Figure 8—View in 1986 of creosote bushes (*Larrea tridentata*) transplanted at spaced-row intervals in 1976 on land deeply scraped to borrow material for roadway construction.

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