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Self-Revegetation of Disturbed Ground in the Deserts of Nevada and Washington

Abstract

Plant cover established without purposeful soil preparation or seeding was measured on ground disturbed by plowing in Washington and by aboveground nuclear explosions in Nevada. After a time lapse of three decades in Washington and two decades in Nevada, fewer species were self-established on the disturbed ground than the nearby undisturbed ground. Alien annual plants were the dominants on the disturbed ground. Cheatgrass (*Bromus tectorum*) dominated abandoned fields in Washington, and filaree (*Erodium cicutarium*) dominated disturbed ground in Nevada. Perennial grasses and shrubs appeared to be more successful as invaders in Nevada than in Washington. This distinction is attributed to the superior competitive ability of cheatgrass in Washington.

Introduction

The orderly predictable process of self-revegetation of disturbed ground is termed ecological succession. Characteristically, the succession process is initiated by invasion of bared ground by annual plants having the capacity for copious seed production and efficient seed dispersal. Gradually, these annual plants are either suppressed or replaced by larger sized perennial plants until the next ground baring disturbance. In theory these perennials are the permanent members of the site, but they can be destroyed by sudden events such as fire, or diseases, or by man's activities such as mechanically disturbing the soil, or by the damage caused by domestic livestock. Although fire and disease have relatively little impact on the physical features of the rooting substrate, plowing or mechanical scraping not only destroys the plants but also disrupts the upper few decimeters of soil. Plowing itself is not generally considered to be a destructive process because it is conducted on the best soils which are promptly seeded to economically valuable crop plants. Because plowed ground in southeastern Washington is seldom allowed to become self-vegetated due to the economic value of cropping, there is little information on the rate or the terminal product of the self-revegetation process.

This study describes the species composition and canopy cover provided by plants on an abandoned cultivated field in the semi-arid shrub-steppe region of south-central Washington for comparison with land disturbed by nuclear explosions in the arid desert region of southern Nevada. Both sites have been essentially free from additional man-induced disturbances following the cessation of plowing and nuclear weapons testing which occurred 30 years ago in Washington and 20 years ago in Nevada.

Study Site

The Washington study site is located on the U.S. Department of Energy's Hanford Site in Benton County, Washington. Here, productive dryland wheat fields were aban-

doned in 1943 when the land was incorporated into the Hanford Site. The study field is located at an elevation of about 500 m above sea level and has a history of ecological study (Rickard *et al.*, 1973; Cline and Rickard, 1973; Hinds, 1973). The soil is at least one meter deep layered over basalt rock and is classified as Ritzville silt loam. The average annual precipitation over an eight year time span (1968-1975) averaged 25 cm (Hinds and Thorp, 1977). Precipitation falls mostly in fall and winter; snowfall is an annual event. The habitat-type is classified as *Artemisia tridentata/Agropyron spicatum* (Daubenmire, 1970). Since abandonment, the field has been occupied by a more or less closed sward of annual plants, especially cheatgrass (*Bromus tectorum*).

The Nevada site is located in Yucca Flat on the U.S. Department of Energy's Nevada Test Site in Nye County, Nevada. Many aboveground test explosions were conducted in Yucca Flat in the years 1950-1957; plant studies on the devegetated ground have been reported by Shields and Wells (1961), Rickard and Shields (1963), and Shields *et al.* (1963). The study site, Area T-2C, is located on a gentle slope along the western side of the valley. The elevation is approximately 1000 m above sea level. The soil substrate is of alluvial origin and is a heterogeneous mixture of rock and fine particles. The vegetation before nuclear testing was probably comprised of shrubs, mostly *Grayia spinosa* and *Lycium andersonii*, and a rich variety of small herbaceous species as described by Rickard and Beatley (1965). The study site was last used as a test area in the summer of 1957. In the early 1960s, some close-in mechanical blading was done at the site to scrape some persistent residual radioactive contaminants from the soil surface. The climate of Yucca Flat is arid: annual precipitation amounts to only 15 cm and on the average is equitably distributed throughout the year. Cattle grazed Yucca Flat in the years before it was incorporated as part of the Nevada Test Site, but grazing has been prohibited since the early 1950s.

Methods

Canopy cover was estimated using the method developed by Daubenmire (1959). In 1957, study lines consisting of 100 ft lines with 50 plots each (0.1 m^2) at two foot intervals were established in Yucca Flat by using marker stakes at 0.1-mile intervals eastward from ground zero of nuclear test "Shasta" to a distance of one mile (Rickard and Shields, 1963). It was hoped that these same study lines could be relocated after a time span of 20 years, but this operation was not possible. In the spring of 1978, 100 ft lines were established at 0.2, 0.3, 0.4, and 0.5 mi from ground zero and at 0.7, 0.8, 0.9, and 1.0 mi from ground zero. The first four lines were in the most heavily damaged zone (i.e., no vegetation remained after the explosion); the second four lines were in a zone with little visible damage. The ground slope is very gradual, with a drop in elevation of perhaps 5 m in 2000 m eastward into the central basin of Yucca Flat.

Four study lines were established on the Hartford Site Arid Lands Ecology Reserve. Two lines were located 20 m inside the boundaries of a 35-year-old abandoned cultivated field, and two lines were located in the relatively undisturbed vegetation *Artemisia/Agropyron* habitat type outside the old field boundaries. The field boundaries are still identifiable by a line of standing wooden fence posts. Plant names for Washington plant species follow Hitchcock and Cronquist (1973), and plant names for Nevada follow Beatley (1976).

Results and Discussion

Cheatgrass (*Bromus tectorum*) clearly dominated the canopy cover of longtime abandoned plowed ground in south-central Washington (Table 1). The adjacent relatively undisturbed vegetation in contrast was dominated by perennial grasses, especially bluebunch wheatgrass (*Agropyron spicatum*). Cheatgrass provided 24 percent of the total canopy cover in one undisturbed stand and only 1 percent in another. These two stands, however, probably have had different land use histories. Fire has been a factor in both stands, as evidenced by the presence of burned stumps of sagebrush. The year of the last fire was 1957 during a large burn that covered an estimated 50-60 mi^2. However, grazing use of the two sites was probably different. The stands are on opposing sides of a fence line that at one time separated wheat fields from rangeland. It is likely that the rangeland side of the fence was grazed much more heavily than the wheat side, resulting in an invasion by cheatgrass that has persisted for 30 years. More species were encountered on the two undisturbed (unplowed) sites than on the plowed field sites, but total canopy cover was greater on the plowed ground (Table 1).

Filaree (*Erodium cicutarium*) and red brome (*Bromus rubens*) dominated the canopy cover of severely disturbed ground at Yucca Flat (Table 2). The undisturbed ground supported twice as many plant species as the disturbed ground. There were also more plant species in Nevada than in Washington. Russian thistle (*Salsola* sp.) was more abundant in Nevada than in Washington.

As in Washington, fewer species occupy the disturbed than the undisturbed ground. Annuals are not an important component of vegetation of undisturbed ground in Washington, but they are an important part of the understory in Nevada (Rickard and Beatley, 1956). In Washington, undisturbed ground was dominated by perennial grasses, 67 percent canopy cover as compared to only 12 percent in Nevada (Table 3). Disturbed ground was dominated by annual grass, 88 percent canopy cover in Washington as compared to only 14 percent annual grass in Nevada. In both states, annual species of European origin were the most important invaders of disturbed ground. Cheatgrass and tumble mustard (*Sisymbrium altissimum*) were most important species in Washington; filaree, red brome, and Russian thistle were important in Nevada.

Although the process of secondary plant succession has often been described for moist, temperate forest communities, there is little information concerning the process in more arid regions (Drury and Nisbet, 1974). In recent years, surface mining for coal and uranium in the more arid grassland and desert regions of the western United States has created a need to revegetate severely disturbed ground promptly. The guidance for revegetation has been largely derived from agriculture and range management practices with little reference to the expected successional pattern. This procedure is not unexpected, as there are relatively few places in the West that are available for the long term observation of the self-revegetation process without concomitant man-induced land use interferences. The findings of this investigation are useful because lands that have been severely disturbed by man are studied. In our studies, there have not been any judgments made to predetermine what the end point use of revegetation should be—i.e., livestock grazing, wildlife habitat, or crops. This practice differs from conventional range management practices which aim to provide improved livestock forage, and it differs from agricultural practices which normally seek to increase yields of crop species. Our data indicate that self-establishment to dominance by perennial species can be a

TABLE 1. Canopy cover (%) covered by plants on ployed and unplowed grount in South Central Washington.

	Unplowed ground		Plowed ground	
	A	B	A	B
Annual Grasses				
Bromus tectorum[2]	0.7	24	95	97
Festuca spp.	0.4	1.6	0	0
Total annual grass	1.1	26	95	97
Average	14		96	
Annual Forbs				
Sisymbrium altissimum[2]	0	2.9	11	0.4
Plantago patagonica	0	2.6	0	0
Draba verna[2]	0.5	0.3	0	0
Descurainia pinnata	0	0.8	1.0	0.1
Holosteum umbellatum[2]	0	0	1.0	0.1
Amsinckia lycopsoides	0	0	0	0.1
Total annual forbs	0.5	6.6	13	0.7
Average	3.6		6.3	
Perennial Grasses				
Agropyron spicatum	33	31	0	0
Poa sandbergii	13	18	0.8	1.3
Stipa thurberiana	1.8	3.4	0	0
Stipa comata	1.6	0	0	0
Poa Cusickii	16	0	0	0
Total perennial grasses	64	52	0.8	1.3
Average	58		1.0	
Perennial Forbs				
Phlox longifolia	4.1	0.3	0	0
Astragalus sp.	0	3.4	0	0
Achillea millifolium	0.2	2.8	0	0
Lomatium macrocarpum	0	0.3	0	0
Lupinus sp.[3]	0	0	1.4	0
Microseris lanciniata	0.1	0	3.8	1.7
Antennaria dimorpha	0.1	0	0	0
Erigeron filifolius	0.7	0	0	0
Calochortus macrocarpus	0.6	0	0	0
Crepis atrabarba	1.1	0	0	0.9
Lupinus sp.	0.1	0	0	0
Tragopogon dubius[2]	0.2	1.0	2.8	1.1
Total perennial forbs	7.1	7.8	8.0	3.7
Average	7.4		5.8	
Shrubs				
Artemisia tridentata	7.2	0.1	0	0
Chrysothamnus viscidiflorus var. lanceolata	2.0	0	0	0
Total shrubs	9.2	0.1	0	0
Average	4.6		0	
Total Canopy Cover	82	92	116	103
Average	87		114	
Number of Taxa	19	15	7	9
Average	17		8	

[1]Burned, 1957; [2]Introduced species; [3]Seedlings only.

TABLE 2. Canopy cover % of plants on disturbed and undisturbed ground—Yucca Flat, Nevada.

	One-tenth mile intervals from ground zero T2c							
	Disturbed				Undisturbed			
Taxa	0.2	0.3	0.4	0.5	0.7	0.8	0.9	1.0
Annual Grasses								
Bromus rubens[1]	15	15	14	14	35	18	18	20
Total Annual Grasses	15	15	14	14	35	18	18	20
Average	14				23			
Perennial Grasses								
Stipa speciosa	3.6	0	0	0	5.0	2.8	0.4	2.9
Tridens pulchellus	4.0	2.8	2.8	8.6	0.3	0.3	0.4	0
Aristida longiseta	0.4	9.5	2.1	0	0	0	0	0
Oryzopsis hymenoides	0	0	0	5.9	0.5	8.1	0.7	1.1
Hilaria jamesii	0	0	0	0	1.4	0	2.6	9
Total Perennial Grasses	8.0	12	4.9	14	7.2	11	4.1	4.0
Average	9.7				6.6			
Annual Forbs								
Erodium cicutarium[1]	37	43	46	34	4.1	1.6	0.1	0.5
Salsola sp.[1,2]	2.6	1.7	2.3	2.3	6.0	1.7	2.0	1.0
Eriogonum nidularium	2.0	1.1	0.9	1.1	1.9	1.1	0.6	0.5
Cryptantha circumscissa	0.9	0.8	0.7	0.2	0.2	0.3	0.4	0.6
Sisymbrium altissimum[3]	0.1	0	0	0	0.5	0.4	0	0
Chaenactis steviodes	0.1	0.1	0	0	0	0	0.1	0.5
Mentzelia albicaulis	0.7	1.7	0.1	0.7	1.2	0.2	0.2	0.3
Camissonia kernensis	0	0.1	0	0.1	0	0	0.4	0.1
Euphorbia polycarpa (?)	0	0	0	0.7	0.5	0.6	0	0.1
Gilia sp.	0	0	0	0.1	0	0	0	0.4
Rafinesquia neomexicana	0	0	0	0	0.6	0	0.4	0
Oxytheca perfoliata	0	0	0	0	0.1	0	0.6	0
Syntrichopappus fremontii	0	0	0	0	0.8	0	0	0
Lupinus sp.	0	0	0	0	0.3	0	0.1	1.1
Lepidium lasiocarpum	0	0	0	0	0	0	0.6	0
Phacelia vallis-mortae	0	0	0	0	0	0	0.1	0.2
Compositae sp.	0	0	0	0	0	0	0.1	0.2
Eriophyllum pringlei	0	0	0	0	0	0	0	0.1
Oenothera sp.	0	0	0	0	0	0	0.1	0.2
Total Annual Forbs	43	48	50	39	16	6.9	6.7	7.6
Average	45				9.3			
Perennial Forbs								
Macheranthera sp.	0.3	0.1	0.5	0.1	0	0.1	0	0
Sphaeralcea ambigua	0	0	0.1	0.8	1.0	5.8	3.1	2.0
Dichelostemma puchellum	0	0	0	0	0.1	0	0	0.2
Astragalus lentiginosus	0	0	0	0	0	0	0	0.8
Total Perennial Forbs	0.3	0.1	0.6	0.9	1.1	5.9	3.1	3.0
Average	0.5				2.3			
Shrubs								
Hymenoclea salsola	0	0.3	1.9	0	2.9	5.4	4.5	0.6
Artemisia spinescens	0	0	0	0	0	0	0	0.3
Atriplex canescens	0	0	0	0	0.8	0.88	2.1	1.9
Grayia spinosa	0	0	0	0	0.7	0.1	0.6	0.7
Lycium andersonii	0	0	0	0	2.0	1.1	5.7	5.2
Ephedra nevadensis	0	0	0	0	0	0.3	1.1	5.5
Eurotia lanata	0	0	0	0	0	0	0.3	0
Haplopappus sp.	0	0	0	0	0	0	0	1.6

TABLE 2—(Continued)

Chrysothamnus viscidiflorus	0	0	0	0	0	0	0	1.6
Chrysothamnus nauseosus	0	0.9	0	0	0	0	0	0
Total Shrubs	0	1.2	1.9	0	6.4	7.7	15	16
Average			0.8				11	
Total Canopy Cover	67	77	71	69	66	50	47	50
Average			71				53	
Total number of taxa	12	12	11	13	22	19	26	27
Average			12				27	

[1]Introduced (alien) species, [2]Seedlings.

TABLE 3. Canopy cover % by plant categories on disturbed and undisturbed ground in Washington and Nevada and the percent of total canopy cover (%) provided by each plant category.

	Canopy Cover, %			
	Washington		Nevada	
Category	Undist.	Dist.	Undist.	Dist.
Annual grass	14 (16)	96 (88)	28 (47)	14 (20)
Annual forb	3 (>1)	6.3 (6)	10 (17)	45 (64)
Perennial grass	58 (67)	1 (<1)	7 (12)	10 (14)
Perennial forb	7.4 (11)	5.8 (5.3)	3 (5.0)	<1 (1)
Shrub	4.6 (5)	0 (0)	11 (19)	<1 (1)
Total	87 (100)	109 (100)	59 (100)	70 (100)

very slow process. It may not be possible to re-establish plant communities to pristine status in terms of species composition because of the ubiquitous presence of alien annuals that have successfully blended in with the native flora and seem to have altered the expected successional pattern of perennial grass and sagebrush dominance in Washington and desert shrub and annual forbs dominance in Nevada.

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