REVEGETATION FOLLOWING ARTIFICIAL DISTURBANCE

Progress Report
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REVEGETATION FOLLOWING ARTIFICIAL DISTURBANCE

L. Fraley, Jr.

Abstract: Seedbeds were prepared and seedings made in May, August and September of 1976 using 5 different seed mixtures at Rocky Flats. Early observations indicate very poor results.

The vegetation receiving chronic exposure to irradiation at the Grasslands Irradiation Site appears to be at equilibrium as measured by diversity or coefficient of community with a 50% response value of approximately 15 R/h.

Recovery patterns in the short-term seasonally exposed vegetation and those non-irradiated plots that were burned, scraped or rototilled were essentially the same as last year. Diversity values had returned to normal in all plots. Cover by Bouteloua gracilis had returned to normal in the burn plots and those partially damaged by ionizing radiation. B. gracilis cover in the plots heavily damaged by ionizing radiation and those plots scraped or rototilled was essentially zero although there were some B. gracilis seedlings present in those plots.

Experiments to relate chromosome damage in plants by alpha emitters were initiated. No results have been obtained to date.

SUBPROJECT 1. THE POTENTIAL FOR RECLAMATION AT ROCKY FLATS FOLLOWING TOPSOIL REMOVAL OR DISTURBANCE

Methods: Three seedings were made during the 1976 growing season; on 17 May, 9 August, and 30 September. The seed mixtures used are given in Table 1.

It was impossible to prepare the seedbed using conventional tillage methods because of the number and size of rocks in the soil. A standard moldboard plow was tried but it would not penetrate the soil-rock combination. A disc plow was not tried but they are not recommended for rocky soil. A scarifying tool, one normally used in landscape work, was used and successfully destroyed the existing vegetation and a seedbed was prepared.

Because of the number and size of the rocks, it was not possible to seed with a normal seeder. Instead, the seeding rate was doubled and the seed was broadcast by hand. The seeding rates used were those recommended by Hull, et al.

Results: As of December 1976, there was no evidence of any seed germination of those species seeded. There was a low density (approximately 2 plants/m²) of cheatgrass (Bromus sp.) that had germinated on the plots.

It is obvious that the above methods were not adequate, at least in 1976, for establishing vegetative cover following disturbance or topsoil removal. Modifications of the methods for 1977 are outlined in the accompanying proposal.

Table 1. Species in seed mixtures and seeding rates* used at Rocky Flats revegetation trials in 1976.

Mix Number	Species in Mix	Seeding Rate	
		g/m ²	lb/acre
1	Crested wheatgrass	1.4	12
	Western wheatgrass	1.1	10
	Sand dropseed	0.22	2
2	Crested wheatgrass	1.4	12
	Buffalograss	2.2	20
	Sand dropseed	0.22	2
3	Western wheatgrass	1.1	10
	Sideoats grama	0.68	6
4	Crested wheatgrass	1.4	12
	Western wheatgrass	1.1	10
	Sand dropseed	0.22	2
5	Western wheatgrass	1.1	10
	Sand dropseed	0.22	2
	Buffalograss	2.2	20
	Sideoats grama	0.68	6

*Above seeding rates gave approximately 450 seed/m².

SUBPROJECT 2. EFFECTS OF RADIATION ON A SHORTGRASS PLAINS ECOSYSTEM

Density or cover data were collected in June 1976, on all plots including control, those chronically irradiated, those that had received the spring, summer or late fall (1969) irradiation treatment, and those that had been disturbed by artificial methods; burning, scraping or rototilling. These data were analyzed and converted to coefficient of community (CC), diversity (D), and plant density.

Chronic irradiation: There appeared to be little or no change in the CC50 (exposure rate which resulted in a CC of 50% of the no effects average) since 1975. The CC50, as a result of non-linear, least squares fit of the data was 14 R/h. When the data in the straight line portion of the curve (see Fraley and Whicker, 1973) were fit to a linear regression model, the CC50 was 13 R/h (9 to 19, ± 2 s). The D50 (exposure rate which resulted in a D of 50% of the no effects average) did not show a change. The non-linear fit D50 was 17 R/h and the linear fit D50 was 17 R/h (13 to 22, ± 2 s).

Thus it appears that, as determined by CC or D, no further changes are taking place in the vegetation that is being chronically irradiated.

Short-term, seasonal irradiation: The emphasis in these sectors has been to measure recovery (modified secondary succession) per se and to compare recovery in the seasonally irradiated sectors to recovery in the artificially disturbed plots. Two indices of recovery were used. One was diversity (D) and the other was percent cover of Bouteloua gracilis (blue grama).

As measured by diversity (D), all sectors which were given the short-term, seasonal irradiation treatment have recovered. The mean value for D in those plots affected by the irradiation treatment was not different than the mean value for D in the

no effects zone. The actual vegetation community, however, was different and was in the second or so seral stage of succession. (Since not all of the vegetation was eliminated in this zone, the successional pattern has not been the same as for secondary succession.)

As measured by coefficient of community (CC), there was a decrease in CC values in the plots affected by the radiation when compared to the no effects zone. This implied recovery but some different species. In general, the species present in the affected zone were those typical of the 1st and 2nd seral stages of secondary succession.

Cover by Bouteloua gracilis gave a good indication of effects and recovery. The same general pattern for recovery held for all 3 seasons of treatment. In those plots where B. gracilis was eliminated, there was no evidence of recovery (see exception below). In those plots where B. gracilis was damaged and cover decreased, the cover has returned to pre-treatment values. This was done by growth and filling in of plants that did not die out rather than new plants coming in.

There is an exception to the above statement on recovery in the highest radiation zones. In 1976, for the first time, seedlings which have tentatively been identified as B. gracilis were found in plots where all of the B. gracilis had been killed. These seedlings were marked and will be followed for positive identification and development. This is significant because the germination conditions (soil temperature and moisture) for B. gracilis are very exacting and the return of this species will probably be the key factor in reaching climax vegetation.

Artificially damaged plots: Diversity (D) values in 1976 for all treatments were the same and the same as for 1975 (Fig. 1). The D values started converging the year after the treatments and had fully converged by 1972, 3 years after

Fig. 1. Diversity of shortgrass plains vegetation, expressed as percent of control, as a function of time for plots burned, scraped and rototilled.

treatment. B. gracilis recovered only in the burn plots and this took longer; until 1975. Cover in the scraped and rototilled plots has been essentially zero (Fig. 2). There have been, in a few plots, seedlings tentatively identified as B. gracilis. The seedlings will be carefully followed so that a positive identification can be made.

Chromosome aberration studies: Studies were initiated to correlate chromosome damage, as measured by chromosome aberrations, with alpha emitter concentrations in selected plant species. Tradescantia occidentalis (spiderwort) plants have been brought into the lab for study. A preliminary LD 50 study was started. Efforts have been directed towards developing techniques to get good cell smears of T. occidentalis root meristems.

REPORTS, PUBLICATIONS AND MEETINGS

The following abstracts have been submitted for oral presentations:

Iodine-129 in rabbit thyroids on the INEL Site. G. C. Bowman, O. D. Markham, and L. Fraley, Jr. Submitted and accepted for the Health Physics Society 22nd Annual Meeting, Atlanta, GA, 3-8 July 1977. To be presented by G. C. Bowman. Contract E(10-1)-1526 (IDO).

Submicron radioactive aerosol deposition and retention by vegetation in a cool desert biome. G. C. Millard, L. Fraley, Jr. and O. D. Markham. To be submitted for the regional AAAS meetings in San Francisco, July 1977. To be presented by G. C. Millard. Contract E(10-1)-1526 (IDO).

Radioactive aerosol deposition and retention by vegetation in a cool desert biome. G. C. Millard, L. Fraley, Jr., and O. D. Markham. Submitted for the ESA section of the AIBS meetings, MSU, East Lansing, MI, 21-26 August 1977. To be presented

by L. Fraley, Jr. Contract E(10-1)-1526 (IDO).

Fig. 2. Cover of *Bouteloua gracilis* (BOGR), expressed as percent of control, as a function of time for plots burned, scraped and rototilled.

Iodine-129 in rabbit thyroids on the INEL Site. G. C. Bowman, O. D. Markham, and L. Fraley, Jr. Submitted for the ESA section of the AIBS meetings, MSU, East Lansing, MI, 21-26 August 1977. To be presented by L. Fraley, Jr. Contract E(10-1)-1526 (ID0).

Effect of ionizing radiation on the production and germination of Lepidium densiflorum seed. L. Fraley, Jr. Submitted for the ESA section of the AIBS meetings, MSU, East Lansing, MI, 21-26 August 1977. To be presented by L. Fraley, Jr. This contract. Abstract attached.

A comparison of early recovery patterns of shortgrass plains vegetation damaged by ionizing radiation, fire, scraping or rototilling. L. Fraley, Jr. Submitted for the ESA section of the AIBS meetings, MSU, East Lansing, MI, 21-26 August 1977. To be presented by L. Fraley, Jr. This contract. Abstract attached.

No manuscripts were submitted for publication during the period covered by this report. A manuscript in rough draft form tentatively entitled, "The Effect of Ionizing Radiation on the Production and Viability of Lepidium densiflorum, Schrad. Seed" (copy attached) has been prepared and will soon be submitted to Environmental and Experimental Botany (formerly Radiation Botany).

Another manuscript on the recovery pattern of shortgrass plains vegetation after disturbance by ionizing radiation, fire, scraping or rototilling is in preparation.

I attended the AIBS meetings in New Orleans, LA, in June 1976. I did not present any papers and paid for cost of attending the meetings myself.

OTHER WORK

At the present time I am working in 2 other areas of research, which includes partial support, plus teaching duties in the Department.

I have a research contract through the Idaho Operations Office, Idaho Falls, ID, contract #E(10-1)-1526. This involves radioecology research on the INEL Site. Four graduate students are involved in this research. I serve as advisor to 3 of them and as a committee member to the other. This research work is in cooperation with Dr. O. D. Markham, ERDA staff member at the Health Services Laboratory. During the past year I did not receive any support on this contract and have requested 1 month's support for the next fiscal year.

I am on partial support of Contract E(11-1)-1156 (Dr. F. W. Whicker, PI) and am assisting with the development of a Rocky Flats grasslands ecosystem Pu model.

LITERATURE CITED

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- Hull, A. C., Jr., D. F. Hervey, C. W. Doran and W. J. McFinnies. 1958. Seeding Colorado range lands. Colorado State University Experiment Station Bulletin 498-S. Ft. Collins, CO 80523. 46 pp.

Appendix 1

Fraley, Leslie Jr., Colorado State University, Effect of ionizing radiation on the production and germination of Lepidium densiflorum seed.

During an experiment on the response of native shortgrass vegetation to ionizing radiation, an influx of Lepidium densiflorum (pepperweed) occurred at exposure rates of 15 to 35 R/h. The plants were observed through maturity and seed was collected. Seed viability was determined using germination and tetrazolium tests. Total exposures to the plants ranged from 32 to 76 kR during their life cycle. Seed production and viability decreased with increasing exposures. Controls and plants receiving 35 R/h produced 94 and 26 viable seed per 50 silicles, respectively. The germination and tetrazolium tests gave similar results.

Equipment: 5 X 5 cm (2 X 2 in) slide projector

Time requested: 10 m

Mailing address: Leslie Fraley, Jr.
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Poster session: optional

Fraley, Leslie Jr., Colorado State University, A comparison of early recovery patterns of shortgrass plains vegetation damaged by ionizing radiation, fire, scraping or rototilling.

Native shortgrass plains vegetation was damaged by radiation, burning, scraping and rototilling. Recovery patterns were observed using diversity and Bouteloua gracilis cover. Scraping and rototilling were comparable to exposures greater than 50 (winter irradiation) or 240 kR (spring, summer) which eliminated all vegetation. Burning was comparable to intermediate levels of exposures; 14 to 34 (winter) or 34 to 140 kR (spring, summer) where B. gracilis was severely weakened. Diversity returned to pretreatment values within two years. Burn and irradiation cover of B. gracilis returned to pretreatment values within six years with almost no recovery for the scrape or rototill treatments.

Equipment: 5 X 5 cm (2 X 2 in) slide projector

Time requested: 15 m

Mailing address: Leslie Fraley, Jr.
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Poster session: optional (would be somewhat difficult to convey results via posters)

Appendix 3

Effect of Ionizing Radiation on the Production and
Viability of Lepidium densiflorum, Schrad. Seed

L. Fraley, Jr.

The effects of ionizing radiation on growth lethality and reproduction on many species of plants have been previously reported. Apparently, reproduction is more sensitive than growth which is more sensitive than viability. Reproduction should be one of the first measurable quantities that might affect ecological parameters of a given species.

I was conducting a study of the radiosensitivity of a native short-grass plant community and during the course of the study, there was an incursion of Lepidium densiflorum (prairie pepperweed) in a zone which had suffered near complete to approximately 50 percent mortality of species that were present prior to the initiation of radiation. The Lepidium plants were growing vigorously and I collected seed pods (silicles) from the plants and studied the viability of the seed using two different techniques.

Materials and Methods

An 8750 Ci ^{137}Cs source was used to establish a chronic radiation field in native shortgrass vegetation. Exposure rates ranged from a high value of 650 R/h to 10 mR/h with effects ranging from complete lethality to no observable effects on the vegetation. The vegetation was irradiated continuously except for up to 4 h/d when the source could be lowered if necessary to record data. A more complete description of the radiation field is given elsewhere (2, 3).

Three years after the initiation of the irradiation treatment, most of the vegetation had been eliminated from the source out to an exposure

rate of approximately 20 R/h. The vegetation receiving exposure rates of 10 to 20 R/h was effected as measured by coefficient of community (3). During the third year of treatment, there was a strong influx of a pioneer species, Lepidium densiflorum in the region receiving exposure rates in the range of 7 to 45 R/h. The plants were observed visually during the growing and reproduction stages and when the seeds were mature, stem portions of plants were collected for the seed. The seed pods, silicles, were removed from the stems and held for viability tests.

Two methods were used to determine seed viability, germination in petri dishes and the tetrazolium test.

Preliminary trials indicated that the seeds were dormant and that some method must be employed to break dormancy. Groups of 50 silicles were opened and the seeds present were removed, the number recorded, and they were placed in a petri dish that had a wet filter paper in the bottom. The number of petri dishes prepared for the 0, 15, 25 and 35 R/h treatment, respectively, was 4, 8, 8 and 7. There was a potential for 100 seeds in each petri dish. The petri dishes were placed in a refrigerator at 3-5 C for 12 d and then moved to a seed germination chamber (25-15 C temperature and 9-15 h light-dark, 100% RH) in the National Seed Storage Laboratory on the Colorado State University campus where they were checked periodically for germination. Any seed that had germinated was removed from the petri dish. Gibberelic acid was added to the seeds 14 d after they were moved to the germination chamber to further enhance germination. The germination trial was terminated after 60 d.

To determine seed viability using tetrazolium, 20 seeds were cut in half through the embryo and placed in a petri dish. A 0.5 percent solution

of 2,3,5-triphenyl tetrazolium chloride was added (1,4). After 20 h the embryos were checked for color and those that were stained a deep red were scored as viable. Four petri dishes for each exposure rate were used.

Results and Discussion

Germination test: There was a reduction in the percent germination of the seed produced by Lepidium between the control and those plants exposed to any of the three listed exposure rates (Table 1). There was no difference at the 5% significance level between the means of the three exposure groups. There was a significant difference at the 5% level for all between mean comparisons for the number of seeds germinated per 50 silicles except for the 25 R/h and 35 R/h exposure rate comparison. The reduction in the number of seeds germinated per 50 silicles with increasing exposure rates was exponential and the data were fit to the following equation.

$$y = 93 \exp(-0.035 x)$$

where y was the number of seeds germinated per 50 silicles and x was the exposure rate in R/h. R^2 for the fit was 0.999.

Tetrazolium test: The effect of ionizing radiation of seed viability followed the same pattern of significance when viability was determined using the tetrazolium test as when using the germination test. The number of seed per 50 silicles was assumed to be the same as for the germination test and the viable seed per 50 silicles was calculated. The resulting data were fit to the exponential equation.

$$y = 94 \exp(-0.038 x)$$

where y was the number of viable seed per 50 silicles and x was the exposure rate in R/h. R^2 was 0.991.

Table 1. Percent germination and number of seeds germinated per 50 silicles and percent seeds viable and viable seeds per 50 silicles (tetrazolium test) for seed produced by Lepidium densiflorum plants completing their life cycle exposed to selected levels of ionizing radiation.

Germination test	Exposure rate (R/h)			
	0	15	25	35
Seeds per 50 silicles	96 $\pm$ 0.96	74 $\pm$ 11	54 $\pm$ 8.1	39 $\pm$ 19
Percent germination	98 $\pm$ 0.64	73 $\pm$ 19	71 $\pm$ 14	70 $\pm$ 15
Seeds germinated per 50 silicles	94 $\pm$ 0.96	54 $\pm$ 16	38 $\pm$ 10	27 $\pm$ 14
n	4	8	8	7
Tetrazolium test				
Percent viable	98 $\pm$ 2.9	75 $\pm$ 11	62 $\pm$ 9.6	65 $\pm$ 11
Viable seed per 50 silicles	93 $\pm$ 2.9	55 $\pm$ 12	34 $\pm$ 7.2	25 $\pm$ 13
n	4	4	4	4

The almost identical results between the two methods of testing for seed viability indicated that the tetrazolium test was the preferred test. It was thought that some differences might occur because of the injury to the embryo from the ionizing radiation that would not affect the tetrazolium test but would affect germination. This did not seem to be the case. The tetrazolium test was much faster, required fewer total hours of labor, less laboratory space and equipment, yet gave comparable results.

The decreases in seed production and viability by plants exposed to ionizing radiation has been reported previously. What was surprising in this experiment was the amount of radiation to which the plants were exposed yet viable seed were produced. Lepidium is a winter or spring annual, depending on soil temperature and moisture conditions. When the plants in this study germinated was not known but germination would have taken place by 1 April. Plant growth and seed production take place rapidly after 1 May and the plants were dormant by mid-July. Assuming an active growth period of critical meristem tissues from 1 May thru June this means that this species produced viable seed while being chronically exposed to 50 kR. Even when considering the large chromosome number of L. densiflorum this is incredible.

It should be emphasized that the viability of the seed in this experiment was determined in petri dishes and with chemicals and not under more adverse conditions as might occur in the field. Germinability or at least survival under field conditions might indeed be considerably less and plant density was determined in the plots the following year. The average plant density for L. densiflorum in these plots the next two years was 31 plants/m².

Some of the seed may have come from outside the radiation area but I believe

that a significant portion of the seed came from plants growing in the radiation zone. L. densiflorum is normally present at low densities in shortgrass

vegetation. It is an invader species during secondary succession. When growing and reproducing at relatively large exposure rate (up to 35 R/h) it was successful at producing large numbers of viable seed.

LITERATURE CITED

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4. Porter, R.H., Durrell, M. and Romm, H. A. (1947). The use of 2,3,5-triphenyl tetrazolium chloride as a measure of seed germinability. Plant Physiol. 22, 149-159.