STOLLER-ESER-83

A Survey of Vegetation Recovery on Wildfire Containment Lines and an Ecological Evaluation of Pre-suppression Firebreak Construction on the INEEL

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Environmental Surveillance, Education and Research Program

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INTRODUCTION

Containment lines are created to separate fuel from a fire to stop its spread and to create a "safe strip" from which to start burning out fuel between the fireline and the fire (Teie 2001). Teie (2001) recommends firelines in heavy brush have a cleared area width of 9 feet (3 m) with 1 to 2 feet (0.3 to 0.6 m) of mineral soil exposed. Firelines in grass fuels need to be 2 to 3 feet (0.6 to 0.9 m) wide cleared to mineral soil (Teie 2001).

Firebreaks or fuelbreaks are constructed as part of a fuels management program to break up large areas of fuel or to isolate a specific resource from fuel. They are strategically located areas where fuel loads have been permanently reduced (Green 1977). To be effective they require long-term maintenance.

There has been data collected on the INEEL on the recovery of vegetation following wildfire (Anderson, Patrick, Blew, Horman etc.). Most sites show recovery of native perennial species, with the exception of big sagebrush (*Artemisia tridentata*) within the first three years. The general conclusion has been that if a healthy plant community existed before the fire, it will likely recover.

Soil disturbance associated with a fire can reduce the potential for successful recovery. Ratzlaff and Anderson (1995) reported that the soil disturbance associated with drilling seed into a recently burned area near Pocatello, ID slowed recovery. Blew (1997, 1998, 1999) reported similar results for soil disturbances associated with reseeding burns on the INEEL. No data on the direct effects of constructing containment lines or firebreaks without follow-up vegetation management have been reported for eastern Idaho.

This study was conducted to provide site-specific information on the impact of pre-suppression and suppression activities on ecological resources of the INEEL. Specific objectives included:

- Determining the effect of containment line construction on recovery of native vegetation following fire. Both the effect of blading the containment line and the effect of not re-contouring the soil ricks was addressed.
- Evaluate the ecological effects of the construction of pre-suppression firebreaks.

METHODS

Containment Lines

Containment lines around fires were surveyed for species density, frequency, and cover. Four fires were selected for surveys. In each fire, five sampling sites were established. At each site, 50-m long transects were established in the center of the containment line, both soil ricks on the margins of the containment line and nearby in the burned area. Both soil ricks were sampled in case there were differences between the rick on the windward side and the one on the lee side.

It was hypothesized that the ricks would be suitable sites for windblown seed to be deposited and that more seed might be deposited on the windward rick. Rick height was measured at 5-m intervals along the transect.

Ten 0.5-m^2 quadrats were read for density and frequency. Density is the number of individuals in a 1.0 m^2 area. Frequency is the proportion of plots in which a particular species was found. The ten quadrats were placed at 5-m intervals along the transect.

Cover was determined by line intercept along the 50-m transect. Cover was determined for perennials only, because most of the annual species had senesced before the sample was completed. Including them would have provided an inaccurate estimate of their cover. Density and frequency are suitable measures of their presence in the plant community. Cover is not reported for the soil ricks because of interferences from individuals not located on the ricks. There was significant overlap of especially shrubs from off of the rick, because the ricks are relatively narrow. This made interpreting this data problematic. Density and frequency calculated from the quadrat data adequately describes the plant community directly affected by deposition of the soil rick.

Data analysis was by paired analysis. Most analyses were by paired t-test. Some data required log or acrsin transformations to meet assumptions for normality and equal variances. One comparison (cheatgrass in the leeward rick vs. the burn) required the non-parametric Wilcoxon Sign-Rank test because the data did not meet normality assumptions. Transformations did not correct the deficiencies.

Interpretations of traditional statistical approaches require the data supply evidence that a treatment mean is significantly different from the control mean. The determination of suitable statistical evidence is usually based on an acceptable error rate of 5 percent. In other words, only 5 percent of the time will the means be found to be different when in fact they are the same. This kind of error is referred to as a Type I error, or a false change error. The acceptable error rate (usually less than 5 percent) is called α and is designated as $\alpha < 0.05$. If the data do not supply that evidence, the means are considered to be equivalent.

The precautionary principle is often used to determine if a disturbed area has returned to a pre-disturbance condition (Elzinga, et.al 1998, Manly, 2000). Using the precautionary principle, the data must not only be able to demonstrate a difference between the treatment mean and the control mean (based on α), it must also be able to supply direct evidence that the two means are equivalent. This evidence is also based on an acceptable error rate. In this case, however, the error of concern is determining that no difference between means exists when in fact the means are different. This is called a Type II error, or a missed change error. This error rate is called β. The usually accepted Type II error rate is less than 20 percent, designated as $\beta < 0.20$. When the statistical results show that $\beta < 0.20$, it provides greater confidence that the test has sufficient power to conclude that the two means are, in fact, the same.

The rule-set used to interpret the statistical results is based on interpreting both Type I and Type II error rates. If the results of a test show that $\alpha < 0.05$, then it can be concluded that the treatment mean (containment line or soil ricks) is significantly different from the control mean (burn transect). If the results of a test show that $\alpha > 0.05$, but $\beta < 0.20$, then we can conclude that the treatment mean is equal to the control mean. However, if the results of a test show that $\alpha > 0.05$ and $\beta > 0.20$, then we do not have sufficient evidence to conclude that the treatment mean and control mean are equal, nor can we conclude that they are they different. In this case, the precautionary principle recommends that we cannot consider the two to be equal. See Green (1994) for additional discussion on this approach.

Firebreaks

Recently constructed firebreaks and other fuel management areas were mapped using GPS. The mapping was done by driving or walking down the center of the firebreak. As the features were being mapped, observations on the condition of the fuelbreak, the cover on the firebreak, the length and width of the firebreak, etc. were also noted. This information was used to recommend management needs for maintaining the firebreaks and fuel management areas, and evaluate their potential impact to ecological resources.

RESULTS AND DISCUSSION

Containment Lines

The containment lines surveyed ranged in width 3.25 to 9.3 m (10.5 to 30.5 ft). Figures 1 and 2 show containment lines constructed in 1999 (Figure 1) and 1995 (Figure 2) that illustrates their typical structure. Note in Figure 1 the relatively large soil rick on the right-hand side, relatively deep cut on the left-hand side, and the generally poor recovery of native grasses and shrubs. Figure 2 shows a containment line built in 1995 that burned over again in 1999. Note the generally inconspicuous soil ricks (suggesting only shallow soil disturbance) and strong recovery of native perennial grasses. These two figures demonstrate the range of conditions found on containment lines during this survey.

Figure 1. Containment line showing larger soil ricks and little recovery of native perennial vegetation.

Figure 2. Containment line showing good recovery of native perennial grasses. Note soil ricks are inconspicuous.

Cheatgrass density was generally lower on the burn transects than on the containment line or on the soil ricks (Table 1). The Butte City fire is a notable exception. Interpreting the statistical results using the precautionary principle leads to a conclusion that the cheatgrass densities on the containment lines and the soil ricks was not the same as on the burn and were likely higher. The frequency that cheatgrass occurred was also generally lower in the burn than on the containment line than on the undisturbed, burned area (Table 1). Because $\alpha < 0.05$, we can conclude that the frequency of cheatgrass on the containment line and soil ricks is significantly higher than on the undisturbed burned area (Table 1).

It is generally considered that soil disturbance is one of the key factors allowing cheatgrass invasion and dominance on a site. Cheatgrass invasion is likely the single most important factor in loss of sagebrush steppe habitat. Cheatgrass provides an important "flash fuel" that provides both an important ignition fuel and a rapid rate of spread. Fire tends to re-enforce the dominance of cheatgrass on a site by altering the fire return interval. Instead of areas burning once every 50 to 100 years or more, with cheatgrass dominance they will burn every 3 to 5 years. This provides too little time for most native species, especially sagebrush to recover. The results of this study suggest that cheatgrass may find the containment lines and the soil ricks a more favorable place to gain dominance than the undisturbed burned areas.

Table 1. Mean density and frequency of cheatgrass on each transect type for each fire sampled. Statistical results are for paired t-tests comparing disturbed transects to the burn.

		Density (plants/m^2)				Frequency		
Fire	Burn	Containment Line	Leeward Soil Rick	Windward Soil Rick	Burn	Containment Line	Leeward Soil Rick	Windward Soil Rick
Butte City	34.3	25.0	58.8	32.9	0.32	0.42	0.44	0.44
1995/1999	27.8	38.7	32.2	60.1	0.50	0.66	0.64	0.72
1999	8.9	5.4	6.7	31.6	0.22	0.28	0.28	0.62
Tin cup	19.5	52.0	137.2	22.4	0.42	0.52	0.52	0.56
Overall Mean	22.6	30.3	58.7	36.7	0.36	0.47	0.47	0.585
Statistical Results	α	0.189	0.182	0.015		0.004	0.012	<0.0001
	β	0.911	0.818	0.348		0.353	NA	0.020

The presence and dominance of perennial grasses is an important indicator of the recovery status of vegetation following fire or other disturbances. Perennial grass density (Table 2) on the burned transects (62.7) was more than double that found on the containment line (26.4) or either soil rick (21.1 and 17.5). Because $\alpha < 0.05$ for all of the pairwise comparisons, we can conclude that the density of perennial grasses is significantly higher on the burned area than on the containment lines or soil ricks. Cover by perennial grasses was also twice as high on the burned area as on the containment lines (Table 2).

Table 2. Mean density and cover of native perennial grasses and sedges on each transect type for each fire sampled. Cover reported only for the burn and the containment line. Statistical results are for paired t-tests comparing disturbed transects to the burn.

	Density (plants/m^2)				Cover (%)	
Fire	Burn	Containment Line	Leeward Soil Rick	Windward Soil Rick	Burn	Containment Line
Butte City	80.3	34.6	12.2	21.1	3.8	3.0
1995/1999	99.5	30.6	36.5	17.7	4.2	1.8
1999	49.5	30.3	19.5	18.8	4.4	0.6
Tin cup	21.3	9.9	16.0	12.5	2.7	0.8
Overall Mean	62.7	26.4	21.1	17.5	3.8	1.6
Statistical Results	α	0.016	<0.001	0.003		<0.001
	β	0.353	0.040	0.114		0.004

The perennial grasses are generally the first native species to recover following a fire. Along with the shrubs capable of re-sprouting following fire, the grasses provide the primary means of minimizing soil erosion. There is usually sufficient cover by perennial grasses to limit blowing dust the first year after a wildfire. The successful recovery of the grasses is also important for competing against invasive species like cheatgrass and limits their spread into, and dominance of, the burned area.

The results for density of non-native forbs showed means for the containment lines and the soil ricks were higher than that in the burned area (Table 3). Using the precautionary principle, we conclude that non-native forb density on the containment line and the soil ricks is not the same as the burn and may be higher. This group of plants includes desert alyssum, Russian thistle, kochia, and tumble mustard. These species are typical invaders of disturbed areas. They re-enforce the process of increased fire frequency typical of areas invaded by the annual, non-native grass, cheatgrass.

Table 3. Mean density of non-native forbs on each transect type for each fire sampled. Statistical results are for paired t-tests comparing disturbed transects to the burn.

	Density (plants/m^2)			
Fire	Burn	Containment Line	Leeward Soil Rick	Windward Soil Rick
Butte City	26.9	36.9	16.6	28.3
1995/1999	9.56	24.1	24.0	35.4
1999	2.02	13.9	5.64	9.2
Tin cup	5.1	47.6	60.6	27.3
Overall Mean	10.9	30.6	26.7	25.1
Statistical Results	α	0.071	0.102	0.086
	β	0.674	0.750	0.715

The results for density of native forbs were not as expected. The statistical results suggest that the means from the containment lines and the soil ricks are not equal to that in the burned areas (Table 4). Mean densities for the containment line and soil ricks were generally higher than that found on the burned area.

The native forbs, or wildflowers, are important to the biodiversity of the sagebrush steppe. This group includes many leguminous species that may provide an important input of nitrogen to this ecosystem. Many of these forbs are also an important food source for some sagebrush steppe wildlife. Significant among them is sage grouse. Sage grouse chicks require forbs as an important part of their summer diet.

Table 4. Mean density of native forbs on each transect type for each fire sampled. Statistical results are for paired t-tests comparing disturbed transects to the burn.

	Density (plants/m²)			
Fire	Burn	Containment Line	Leeward Soil Rick	Windward Soil Rick
Butte City	3.4	3.6	4.5	10.4
1995/1999	2.0	4.3	4.0	4.3
1999	4.4	11.1	8.0	5.4
Tin cup	8.0	10.1	3.0	5.0
Overall Mean	4.4	7.3	4.9	6.3
Statistical Results	α	0.100	0.793	0.266
	β	0.746	0.950	0.921

Another invasive species of concern on portions of the INEEL is halogeton (*Halogeton glomeratus)*. Halogeton is commonly found on areas that have been severely disturbed and is generally isolated to those habitats. It was found at six of the twenty sampling sites in this study (Table 5). The containment line in Figure 1 was one of those sites. It was found on the burned transect at only two sites. Because halogeton was not likely to be found at all sampling sites, statistical analysis only included those sites where it was found in this study.

Halogeton densities and frequencies were generally higher on the containment lines and soil ricks than on the burned areas (Table 6). The interpretation of the statistical results suggest the disturbed transects are not equivalent to the burned transects. Halogeton is an invasive species that has historically been an important concern for range managers in the sagebrush steppe ecosystem. Halogeton is poisonous to sheep and it is difficult to control once it gets started.

Because of the range of conditions the containment lines were found in, it will likely be necessary to inventory most of the length of each line to determine which parts of, and to what extent, the containment lines need rehabilitation. As shown in this study, there are areas at risk to invasion and domination by cheatgrass, halogeton and other non-native plants. These areas should be identified and a weed management plan developed and implemented. Those areas found to have inadequate recovery of native perennial species should have revegetation plans developed and implemented. These plans should include re-contouring the soil ricks.

Table 5. Mean density and frequency of halogeton on each transect type for each site sampled. Statistical results* are for paired t-tests comparing disturbed transects to the burn.

		Density (plants/m^2)				Frequency			
Fire	**Site**	**Burn**	**Containment Line**	**Leeward Soil Rick**	**Windward Soil Rick**	**Burn**	**Containment Line**	**Leeward Soil Rick**	**Windward Soil Rick**
Butte City	old highway	0	0	0	0	0	0	0	0
Butte City	t11	0	0	0	0	0	0	0	0
Butte City	t3	0	0	0	0	0	0	0	0
Butte City	t5	0	0	0	0	0	0	0	0
Butte City	tower road	0	0	0	0	0	0	0	0
1995/1999	t22 bottom	0	0	0	0	0	0	0	0
1995/1999	t22 hilltop	0	0	0	0	0	0	0	0
1995/1999	t22 north	0	0	0	0	0	0	0	0
1995/1999	t22 south	0.2	2.6	4.4	7.6	0.1	0.2	0.3	0.7
1995/1999	t23	0	43.6	19	0	0	0.3	0.7	0
1999	t20	0	0	0.2	0	0	0	0.1	0
1999	t22	0	60.6	14.6	14.8	0	0.7	0.5	0.4
1999	t25	0	0	0	0	0	0	0	0
1999	t4	0	0	0	0	0	0	0	0
1999	t7	3.4	1.4	3.2	0	0.6	0.5	0.3	0
Tin cup	old highway	0	0	0	0	0	0	0	0
Tin cup	t12	0	0	0	0	0	0	0	0
Tin cup	t2	0	0	0	0	0	0	0	0
Tin cup	t3	0	0	0	0	0	0	0	0
Tin cup	TRA	0	1.2	0.6	0	0	0.2	0.1	0
Means *		0.6	18.2	7.0	3.7	0.12	0.32	0.33	0.18
Statistical Results*	α		0.174	0.118	0.306		0.145	0.189	0.709
	β		0.834	0.751	0.928		0.795	0.849	0.950

* Means and statistical analysis included only those sites with recorded occurrence of halogeton. See text for details.

In order to reduce the expense of restoration on containment lines constructed in the future, guidelines should be developed to control the methods used to construct containment lines including their width and the depth of soil removed. Some of the expense of restoration could be eliminated by developing guidelines for where containment lines should, or should not, be constructed. For example, a containment line was constructed that parallels a wide gravel road, T-12 (Figure 3) for several miles rather than using the road as an anchor point (Teie 2001).

Figure 3. Containment line paralleling graveled road, T-12.

Firebreaks

Twenty-four firebreaks were surveyed as part of this study (Table 6). The locations of the surveyed firebreaks are shown in Figure 4. The total length of pre-suppression firebreaks constructed during 2000 and 2001 was approximately 63,000 m (39 miles)(Table 6). The firebreaks ranged from 4 to 17 meters (13 to 56 feet in width)(Table 6). Some of the firebreaks were covered by gravel as part of the construction. Others were left as bare soil.

Table 6. Attributes of recently constructed firebreaks constructed on the INEEL.

Firebreak Location	Width (m)	Ground Cover	Length (m)	Vegetation Type
WRRTF	7	bare soil	1,524	Sagebrush/Rabbitbrush and Salt Desert Shrub both sides
CFA 689	5	bare soil	210	Sagebrush Steppe outside Facility inside
EBR-I Perimeter Fence	17	gravel	1.098	Sagebrush Steppe outside Replanted Sagebrush Steppe Inside
EBR-I T-road	6	bare soil	1,812	Sagebrush Steppe both sides
RWMC Flood Control Channel	5	bare soil	2,559	Sagebrush Steppe both sides
Experimental Field Station (road to precipitation sampling station)	5	bare soil	345	Crested Wheatgrass both sides
Experimental Field Station (road to caissons)	4	bare soil	87	Sagebrush Steppe both sides
Experimental Field Station (lawn around storage shed)	11	bare soil	121	Crested Wheatgrass outside Facility inside
Experimental Field Station (entrance road)	13	bare soil	139	Sagebrush Steppe/Crested Wheatgrass outside Gravel Road inside
PBF Perimeter Fence	6	bare soil	6,933	Sagebrush Steppe both sides
CFA Fire Station Propane Tank	12	gravel	120	Sagebrush Steppe outside Facility inside
Mercury Retort Area Perimeter Fence	12	bare soil	564	Sagebrush Steppe outside Facility Fence inside
RESL to Medical Center (road)	10	gravel	265	Sagebrush Steppe both sides
East Side of Railroad	5	gravel	13,875	Sagebrush Steppe outside Railroad inside
West Side of Railroad	5	gravel	14,697	Sagebrush Steppe outside Railroad inside
T-4, U.S. 26 to Middle Butte Fire	5	bare soil	3,244	Sagebrush Steppe both sides
TAN (NE corner to T-28)	10	bare soil	3,118	Salt Desert Shrub and Grassland both sides
SMC North Perimeter Fence	7	bare soil	866	Playa outside Facility inside
TAN North Perimeter Fence	6	bare soil	390	Sagebrush/Rabbitbrush and Salt Desert Shrub outside Facility inside
SL-1.Perimeter, Inside	8	bare soil	1,842	Sagebrush Steppe both sides
SL-1.Perimeter, Outside	6	bare soil	2,377	Sagebrush Steppe both sides
SL-1 Entrance Road	6	bare soil	202	Sagebrush Steppe both sides
NRF to TRA	6	bare soil	4,604	Sagebrush Steppe both sides
TRA to CFA	12	bare soil	1,883	Sagebrush Steppe both sides
	Total Length		**62,875**	

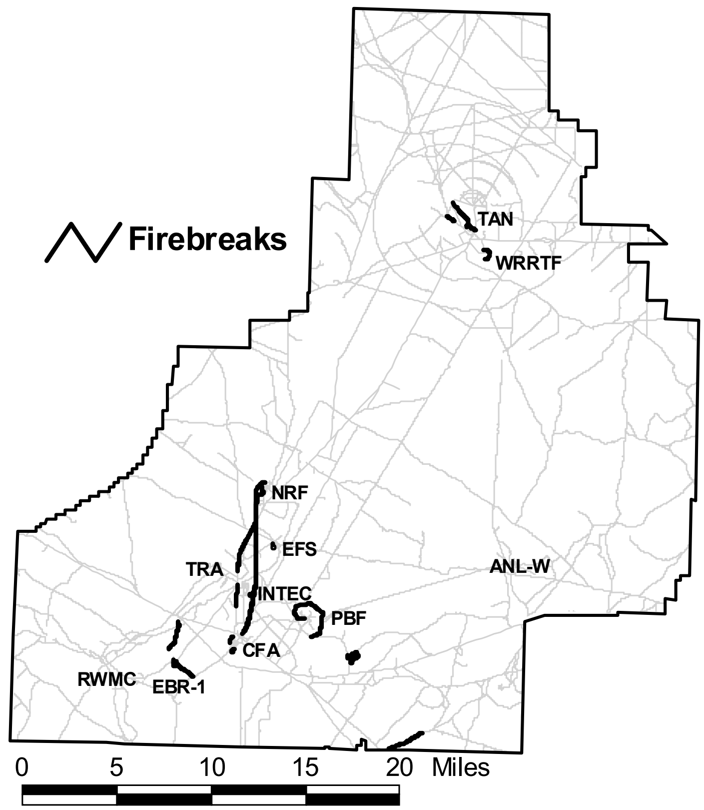

Figure 4. Locations of recently constructed firebreaks on the INEEL.

The firebreaks surveyed ranged from 5 to 17 m (16 to 56 feet) in width. One criticism of pre-suppression firebreaks is that they generally cannot stop a headfire under extreme conditions (Countryman 1974 and Green 1977). Countryman (1974) noted this to be true of firebreaks even 100 to 400 feet wide in chaparral vegetation.

Fourteen of the firebreaks surveyed had burnable vegetation, primarily sagebrush, on both sides of the firebreak. Some of these firebreaks are a considerable distance from the nearest facility. For example, the individual facilities that make up PBF are an average of 500 m (1650 ft) from the firebreak constructed outside of the perimeter fence.

At some facilities, firebreaks were constructed in areas with minimal burnable vegetation. Examples include the SMC North Perimeter Fence and TAN (NE corner to T-28), which are in playa, salt desert shrub or grassland. In at least one case, the Experimental Field Station, firebreak construction destroyed crested wheatgrass greenstrips.

As mentioned previously, soil disturbance is one of the key factors allowing cheatgrass invasion and dominance on a site. Because cheatgrass plays such an important role in loss of sagebrush habitat, developing long-term maintenance plans for these firebreaks is critical. Each firebreak should be re-evaluated for its strategic role in a broader fire management plan. Those that are deemed useful should have a long-term maintenance plan developed and a commitment for funding the plan obtained. If the firebreak is determined to not have a place in the strategic plan or if long-term funding cannot be secured, the firebreaks should be restored to the pre-existing vegetation type.

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