

Post-Fire Revegetation at Hanford

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728



P.O. Box 650
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

Post-Fire Revegetation at Hanford

R. C. Roos
Mission Support Alliance

A. R. Johnson
J. G. Caudill
J. M. Rodriguez
J. W. Wilde
Mission Support Alliance

Date Published
December 2009

To Be Presented at
Waste Management 2010

Waste Management Symposia
Phoenix, Arizona

March 6-11, 2010

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-09RL14728



P.O. Box 650
Richland, Washington 99352

Copyright License

By acceptance of this article, the publisher and/or recipient acknowledges the U.S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper.

J. R. Caudill 01/05/2010
Release Approval Date

**Approved for Public Release;
Further Dissemination Unlimited**

LEGAL DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This document is available to the U.S. Department of Energy and its contractors, in paper from the Office of Scientific and Technical Information (OSTI). It is available for sale to the public from the National Technical Information Service (NTIS).

This report has been reproduced from the best available copy.
Available in paper copy.

Printed in the United States of America

Post-Fire Revegetation at Hanford – 10434

Richard Roos, A. Ray Johnson, Joe Caudill, Juan Rodriguez, Justin Wilde
Mission Support Alliance (MSA), Richland, Washington 99352

ABSTRACT

Range fires on the Hanford Site can have a long lasting effect on native plant communities. Wind erosion following removal of protective vegetation from fragile soils compound the damaging effect of fires. Dust storms caused by erosion create health and safety hazards to personnel, and damage facilities and equipment.

The Integrated Biological Control Program (IBC) revegetates burned areas to control erosion and consequent dust. Use of native, perennial vegetation in revegetation moves the resulting plant community away from fire-prone annual weeds, and toward the native shrub-steppe that is much less likely to burn in the future. Over the past 10 years, IBC has revegetated major fire areas with good success. IBC staff is monitoring the success of these efforts, and using lessons learned to improve future efforts.

INTRODUCTION

The Hanford Site is located in a semiarid area of south-central Washington state. With less than 18 cm annual precipitation [1], the native vegetation is shrub-steppe. The soils are generally highly erodible. However, when undisturbed, mature shrub-steppe plant communities effectively protect the soil from erosion, and are resistant to invasion by annual weeds.

Past agricultural and/or industrial activities have removed native vegetation over large areas of the Hanford Site. Annual weeds often dominate disturbed areas, predominantly cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola sp.*). Both species are highly flammable when dry. Particularly, cheatgrass promotes range fire by forming a continuous cover of vegetation that dries in the summer to fine kindling.

EFFECT OF RANGE FIRE ON HANFORD OPERATIONS

In areas dominated by annual weeds, fire removes vegetation and exposes the soil to wind erosion. Following the 24 Command Fire in 2000, it was common to find areas with 25 cm of soil eroded from the surface. Eroding soil created severe dust storms. Often personnel were withdrawn from activities in the field due to blowing dust. Blowing dust and sand also damaged filters and equipment. Loss of visibility caused by blowing dust closed roads and highways both on and off the Hanford Site.

Erosion killed perennial vegetation (grass, forbs) over many acres, allowing annual weeds, primarily cheatgrass and Russian thistle to increase. Proliferation of cheatgrass causes two undesirable conditions at Hanford. Cheatgrass has been identified as a significant factor in increasing frequency of range fire. Once cheatgrass is established, it displaces native species and reduces habitat quality. Past agricultural or industrial practices disturbed thousands of acres at Hanford allowing cheatgrass to dominate the Site for over 60 years.

POST-FIRE RESPONSE BY HANFORD'S BIOLOGICAL CONTROL PROGRAM

Hanford's IBC Program has been tasked with two primary responsibilities regarding burned areas: 1) Reduce impact of blowing sand and dust to personnel and operations; and 2) Prevent spread of noxious weeds on the Hanford Site. The approach IBC selected as the most permanent and cost effective method of accomplishing the objectives is to establish perennial, native vegetation in burned areas that lack adequate perennial cover.

IBC is actively working with the Hanford Fire Department to reduce the future threat of range fire at Hanford by revegetating fields of fire prone annual weeds dominated by cheatgrass, and replacing the annual weeds with perennial, native vegetation.

The ideal end condition for a revegetation project by IBC is a multi-story and multi-species community composed of:

- ◆ Shrubs at a density sufficient to disrupt surface winds, and to compete with deep rooted invasive species. Shrubs protect the soil from erosion, and are often effective at excluding non-native weeds.
- ◆ Tall-statured grass in the interspaces between shrubs. Tall grasses further disrupt surface winds, providing additional protection against erosion.
- ◆ Short-statured grass in the interspaces between tall grasses.
- ◆ Cryptogams or micro biotic crust colonized on the soil between vascular plants.

A multi-species community stabilizes the soil and allows colonization of bare areas by micro biota, forming a protective crust on the soil. Once established, a community comprised of the four elements is resistant to invasion by weedy species. The perennial plants produce little standing, dead vegetation to propagate fire through the community.

Sometimes, one or more components of the ideal plant community are not appropriate or practical on a given site. Although the ability of a plant community to resist invasion by weeds is reduced when community components are absent, good results can be achieved if only one community component is missing. Perennial plants are competitive for resources and tend to exclude competing plants from their rooting area. Sagebrush (*Artemisia tridentata*) often has a "halo" around the shrub that is free of annual weeds, but is occupied by native perennials that have evolved with the sagebrush. When growing in a group, the sagebrush community can be nearly free of weeds, while supporting a vigorous community of native plants. Under some circumstances, communities of mixed perennial grass also can exclude weeds.

24 COMAND FIRE – JUNE 2000

From late June to early July 2000, the 24 Command Fire burned approximately 65,600 hectares on and around the Hanford Site in Washington state. The fire burned tens of thousands of hectares of mature sagebrush steppe. As a result of the fire removing protective vegetation from the soil, a great amount of wind erosion of the soil took place resulting in dust storms in the months following the fire.

Erosion created conditions ideal for establishment of invasive and noxious weeds. To discourage weed infestation, U.S. Fish and Wildlife Service (USFWS) seeded thousands of hectares to perennial grass on Arid Land Ecology, land owned by U. S. Department of Energy (DOE) and actively managed by USFWS. IBC seeded approximately 400 hectares with perennial grass and planted with shrub seedlings on land actively managed by DOE.

“Competent Islands”

Prior to the fire, mature sagebrush dominated the land revegetated by DOE. Sagebrush seed and other resources were insufficient to restore the revegetated area to pre-fire density of sagebrush. Consequently, shrubs were planted in islands, discrete clumps of shrubs. Native grass was planted over the entire revegetated area. Forbs also were seeded when seeds were available. The expectation was that as the shrubs matured, they would begin to exclude weedy species from the root zone. Closely spaced sagebrush within the groups would form a weed-free “island” colonized by native species. As the sagebrush propagate, establishing plants outside the original island, components of a healthy native community (perennial grasses, shrubs, and forbs) will be present within the island, and will expand as the shrubs expand.

By planting in islands, shrubs were reintroduced through the entire revegetated area; however, only 15 percent of the area was actually planted. After the shrubs matured, the as-planted density was expected to be great enough to break up the surface winds that cause soil erosion.

The bulk of both seed (grass and forb) and seedling (shrub) planting occurred in 2001. Over the past several years, the revegetated area has generated very little dust, even during severe wind storms. Shrubs are propagating and expanding the footprint of the original islands, and it is common to find weed-free areas within the islands, despite heavy presence of invasive species on the perimeter of the islands.

WAUTOMA FIRE – AUGUST 2007

In August 2007, the Wautoma Fire burned on the Hanford Site over an area very similar to that which burned in the 24 Command Fire in 2000. DOE and site contractors were anxious to prevent the dust and damage that occurred following the 2000 fire. Resources were made available to plant grass and establish shrubs on nearly 3,200 hectares that were burned on DOE-managed land.

In spring 2008, several areas were identified showing dramatic “fence line contrast” between areas planted with perennial grass following the 2000 fire, and adjacent areas not planted. Planted areas had dense stands of grass vigorously growing. Following the 2007 fire, having enough grass crowns on the surface and roots binding soil near the surface minimized erosion. Spring growth provided the necessary above ground structure to further moderate surface winds and to protect the soil. In contrast, adjacent areas not planted following the 2000 fire had poor grass stands and severe erosion that further damaged what grass was present.

We prepared a seeding mix of perennial grasses. The mix included species adapted to a variety of soils. It was expected that a subset of the planting mix would establish regardless of the soil characteristics in any given area. With a large area to plant, highly variable soils, and changes in soil occurring suddenly, and often subtly, it was impractical to prepare several seeding mixes and plant separate seed mixes on each soil type.

Spring barley (*Hordeum vulgare*) was included in the seed mix at a low rate to provide early structure above the ground and therefore serve as a windbreak for the slower establishing native grass seedlings. The hope was that the barley would germinate with early fall rains, grow quickly, then die with cold winter temperatures, leaving standing, dead plant material to disrupt wind near the ground surface.

We chose spring barley for this project for several characteristics. Spring barley germinates and grows quickly. It is not tolerant of frost. It cannot persist under the droughty conditions on the Hanford Site. With this combination, we hoped to establish quickly the above ground structure to protect the soil and seedlings from erosion, but not risk a non-native plant persisting in the environment.

A dry and cold fall 2007 resulted in the seeds not germinating. In February 2008, the seeds germinated, and as expected, frost killed the spring barley. The few barley seedlings that survived frost succumbed to the summer drought and did not produce viable seed.

Following the Wautoma Fire, approximately 2,830 hectares were planted, using 60,000 kg native grass seed and 31,500 kg spring barley. In spring 2008, we set up transects to assess early establishment of grass seedlings. Transects ranged from 0 seedlings/m² (one of twelve transects) to 30 seedlings/m² with a mean of 10 seedlings/m².

The mean of 10 seedlings/m² leaves room for expected decline in population density as plants mature and begin competing for resources. Although the number is highly variable, it is estimated that a high density of tall-statured grasses at Hanford is 1-3 plants/m².

Following the initial planting of grass seed in 2007, we also planted shrub seedlings in early December 2008. We collected sagebrush seed during fall 2007, and grew them in a commercial greenhouse. The shrub seedlings were planted using an agricultural seedling planter, modified for use in rangeland conditions.

Shrubs were planted in double rows with approximately 1.8 m between rows and 1.8 m between plants within rows. Approximately 18,000 shrub plants were planted along 12.4 kilometers.

At the time of planting (December 3-5, 2008), weather was mild with daytime highs near 7 degrees Celsius and nighttime lows near minus 7 degrees Celsius. However, on December 16 an early cold front hit driving temperatures down to minus 19 degrees Celsius. There was concern that plants so recently out of the greenhouse would not be able to survive the extreme

temperature. Fortunately, a light snow accompanied the cold temperatures that provided ground insulation reducing the depth of frost. The snow also helped keep relative humidity high.

A major risk of planting seedlings late in the fall is desiccation due to frost. Seedlings planted late in the fall often have insufficient time to establish roots deep in the soil. If the soil freezes below the level of the roots, moisture is locked up as ice and unavailable to the roots. However, leaves and stems continue to lose moisture to the atmosphere. If the moisture lost through the leaves is not replaced, it can result in death of the plant.

In spring 2009, we evaluated shrub survival. We estimated the survival rate to be 70 percent, which is considered excellent. Additional loss occurred during the extremely dry summer of 2009. Plans are to evaluate shrub survival in spring 2010. Quick estimates of shrub survival in fall 2009 indicate approximately a 40 percent survival rate. The number of shrubs planted in 2008 and remaining alive in spring 2010 is expected to remain relatively stable, with minimal additional mortality.

NATIVE SEED

The IBC Program on the Hanford Site maintains a policy of using native plants to revegetate sites that are away from industrial areas and likely to remain undisturbed in the future. IBC strives to use plant materials with genetic origin near the Hanford Site and from similar climate conditions.

The availability of seed with genetic origins near the Hanford Site is somewhat limited. To improve the availability of local seed, IBC contracted with local seed growers. The growers collected seed from the Hanford Site to propagate on their commercial fields. Most of the major grass species used in revegetation were collected, along with several forb species. The first commercial crop will be available in 2010. Species collected include:

Grass: Sandberg's Bluegrass	<i>Poa secunda</i>
Needle & Threadgrass	<i>Hesperostipa comata</i>
Indian Ricegrass	<i>Achantherum hymenoides</i>
Bottlebrush Squirreltail	<i>Elymus elymoides</i>
Prairie Junegrass	<i>Koeleria macrantha</i>
Bluebunch Wheatgrass	<i>Pseudoroegnaria spicata</i>
Big Bluegrass	<i>Poa ampla</i>

Forbs: Yarrow	<i>Achillea millefolium</i>
Munro's Globemallow	<i>Sphaeralcea munroana</i>
Penstemon	<i>Penstemon acuminatus</i>
Balsamroot	<i>Balsamorhiza careyana</i>

TRIAL PLOTS

Sandberg's bluegrass (*Poa secunda*) is very important to long-term success of revegetation efforts undertaken by IBC at Hanford. Sandberg's bluegrass is a low-statured grass that fills the interspaces between more robust grasses that tend to be widely spaced. In the absence of Sandberg's bluegrass, the interspaces between plants are subject to erosion that weakens existing plants and ultimately leads toward failure of the grass stand.

Sandberg's bluegrass in association with taller species stabilizes the soil. Stabilizing the soil allows colonization of bare soil by crust forming micro biota. The micro biotic crust further stabilizes the soil and discourages weed invasion.

Although Sandberg's bluegrass plays a critical role in stabilization plantings, establishment of the grass in plantings has been unreliable. Furthermore, in most cases, establishment is either very good or very poor, with little intermediate results. Some observations of successful and unsuccessful projects relating to Sandberg's bluegrass suggest a possible connection with planting date as a key to success.

IBC has initiated a five-year seeding trial. If planting date plays a significant role in determining success of Sandberg's bluegrass, it is expected that the trial will identify the significance and isolate high and poor success planting windows.

COMMUNICATION AND COORDINATION

Before operations begin in the field, a plan is prepared and reviewed by ecologists and managers from Hanford Site contractors and DOE. Archaeologists assigned with Hanford contractors review the plan and present it to affected Native American tribes. Often the plan is presented to stakeholders, including tribes, federal, state, county, city and private organizations.

During major field activities, media is often invited to observe and report on activities. Stakeholders and other interested public and private parties are welcome to observe field activities consistent with safety and security protocol.

During revegetation following the fire in 2007, local seed growers expressed an interest in the operations. This interest resulted in a contract, bringing the growers onto the Hanford Site to collect native seed for propagation on their commercial fields. As a result, we will make native seeds from the Hanford Site available for revegetation projects beginning in 2010.

Post-fire revegetation and other work performed by IBC are often presented at management, technical, and stakeholder meetings on the Hanford Site, and formally and informally at meetings in the community.

SUMMARY

Range fire is an unavoidable part of the ecology in a shrub-steppe environment. Invasion of annual weeds, primarily cheatgrass, has greatly increased the frequency of fire. After a fire removes the protective vegetation, Hanford's erodible soils blow in the frequent high winds. This causes environmental damage, unsafe work conditions, disruption of activities, and damage to equipment at Hanford.

IBC stabilizes soils following fire by planting native, perennial grass and shrubs. This approach to stabilization accomplishes a number of objectives including:

Minimize Erosion and Dust – After perennial plants establish, they form an effective windbreak, disrupting wind near the soil surface, and protecting the soil from erosion.

Protection Following Future Fires – Vigorous grass stands are effective in preventing major wind erosion following fire. Although fire consumes leaves of grass, the crowns, or base of the grass plant, generally survive. These crowns provide some structure above the ground surface to help disrupt erosive winds. Additionally, near-surface roots help to stabilize soil. Micro biotic crusts that grow in grass stands provide additional protection from erosion. Grass sprouting from burned crowns quickly reestablish above ground structure to protect the soil.

Exclusion of Noxious and Invasive Weeds – Established communities of mixed, perennial vegetation are effective in preventing invasion and establishment of invasive species.

Reduce Risk of Future Fire – Established communities of mixed, perennial vegetation do not form continuous mats of standing, dead vegetation (fuel). Standing dead vegetation is a characteristic of annual cheatgrass communities. The dead vegetation in cheatgrass communities often forms continuous fields of dry vegetation that is extremely flammable. Perennial plant communities have much lower risk of fire ignition and propagation.

IBC has had the opportunity to perform stabilization over thousands of acres on the Hanford Site, and we continually strive to learn and improve our materials and techniques. IBC is anxious to share its information and experience with others both on and off the Hanford Site.

REFERENCE

1. D. J. Hoitink, K. W. Burk, J. V. Ramsdell, Jr., W, J, Shaw, "Hanford Site Climatological Summary 2004 with Historical Data" Pacific Northwest National Laboratory (2005)