Semi-Annual Progress Report, 1

27 December, 2007

"Restoring Natural Fire Regimes at Golden Spike National Historic Site by Developing a Healthy Sagebrush/Grassland Vegetation Community to Prevent the Cheatgrass-Wildfire Cycle"

RM-CESU Cooperative Agreement Number: H1200040001

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1. Progress To Date

The project was initiated on 1 September 2007. To date we have begun one research project, have thoroughly developed the broad experimental plan for a second project relevant to the goals of the cooperative agreement, and have a first draft of a design for a third study. In addition, we interviewed two potential graduate students for the project and have selected on. We are attempting to find additional funding to add a second student to the project.

1.1. Seeding by seed-caching rodents

This Fall we developed a proposal for a preliminary study on the potential use of seed caching rodents to help increase the density and diversity of native perennial herbaceous species in the understory of intact sagebrush (*Artemisia tridentata*) communities. The proposal (attached as Appendix 1) was approved by the National Park Service and the first rodent live-trapping session has been conducted in order to assess the rodent community at Golden Spike National Historic Site. Trapping success in Fall was relatively low, which has been typical in 2007 of other sites in which we and colleagues have worked in the northern Great Basin. Nonetheless, kangaroo rats (*Dipodomys* sp.) were trapped at our experimental sites and signs of their activity (e.g., recently active burrow systems, seedlings emerging from characteristic seed caches, etc.) suggest that there should be sufficient animals for our experimental work in the coming year.

1.2. Seeding into existing sagebrush stands

We have completed the major experimental design for our experiment to assess the impacts of vegetation management treatments and seeding treatments on the success of seeding desirable native herbaceous species into existing sagebrush stands. The full proposal is not yet complete in terms of all sampling details, but the outline of the experimental design is attached as Appendix 2.

The core of the design involves four Vegetation Management Treatments (Control; Burn, 100%; Hand thin, 100%; Hand thin, 50%) factorially crossed with two Pre-Emergent Treatments (With vs. without Plateau pre-emergent herbicide) for a total of 8 treatment plots, each of which will be replicated four times. Within each plot we will apply five Seed Sowing Treatments using a native seed mix approved by GOSP (Aerial seeding; Aerial seeding on top of snow; Aerial seeding with activated carbon; Aerial seeding with sucrose; Aerial seeding, then raked into soil). All aerial seeding will be simulated by hand sowing. See Appendix 2 for further details on treatments and brief justification.

1.3. Restoration of cheatgrass stands

Although not part of the original proposal, we will take advantage of our on-going work at GOSP to attempt to help the Historic Site develop methods for restoring areas that have burned and converted to stands of cheatgrass. In this line, we are in the early stages of developing a research design involving seedbed treatments (e.g., burned or not) and seeding treatments to determine the best approach to establishing native perennial plants with minimal surface disturbance. This outline is too preliminary to include as an appendix.

2. Plans For Second Reporting Period, 1 Jan – 30 June 2008

2.1. Seeding by seed-caching rodents

Experimental sites will be live-trapped again in Spring 2008 to continue assessing the rodent community.

2.2. Seeding into existing sagebrush stands

The proposal will be completed and submitted on-line to NPS for approval by the end of January 2008. NPS fire crews will use this proposal for submitting information for NFPORS in order to be able to apply the treatments in the Fall. In early May 2008, experimental plots will be marked out on site and pre-treatment vegetation measurements will be made.

2.3. Restoration of cheatgrass stands

The proposal will be completed and submitted on-line to NPS for approval by the end of February 2008. NPS fire crews will use this proposal for submitting information for NFPORS in order to be able to apply the treatments in the Fall. In early May 2008, experimental plots will be marked out on site and pre-treatment vegetation measurements will be made.

Appendix 1: Seeding by seed-caching rodents

INTRODUCTION

Title: The Potential of Seed-Caching Rodents to Help Restore the Herbaceous Understory of Sagebrush Communities

Date: 4 December 2007

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Table of Contents: N/A

Abstract: Much of the Intermountain Region, including many National Park Service Units, can be characterized as having sagebrush communities with relatively healthy shrubs but with a depleted native herbaceous understory. Such stands have reduced ecological value and are prone to conversion to persistent stands of exotic annual weeds following fire. In order to prevent this it is desirable to develop methods for increasing the density and diversity of desirable native herbaceous species in the understory without severely damaging the shrub component. Seed-caching rodents might be useful in this context in that they can cache very large quantities of seeds and fail to recover all of them, leaving the remaining seeds buried in appropriate microsites for establishment. We propose to conduct a preliminary set of studies to begin to assess the potential for using rodents as a restoration tool.

OVERVIEW

Statement of Issue: Much of the Intermountain Region can be characterized as having

sagebrush communities with relatively healthy shrubs but with a depleted native herbaceous understory. This is true of many National Park Service Units such as Golden Spike National Historic Site, as well as of other federal, state and private lands. Such stands have inherently reduced ecological value due to the lack of a healthy, functioning native herbaceous component. In addition, they are prone to conversion to persistent stands of exotic annual weeds following fire. In order to increase the ecological value of existing stands and to prevent their conversion to annual weeds following disturbance it is desirable to develop methods for increasing the density and diversity of native herbaceous species in the understory. In particular, it is desirable to develop methods that do not damage the existing shrub component when it is healthy and functioning. Seed-caching rodents might be useful in this context. These rodents can cache very large quantities of seeds and then fail to recover all of them. Remaining seeds are scattered throughout the rodent home range and are buried in appropriate microsites for establishment. We propose to conduct a preliminary set of studies to begin to assess the potential for using rodents as a restoration tool.

Literature Summary: The loss of healthy understory and the threat of conversion of sagebrush rangelands to cheatgrass-dominated communities is widely known (West 1983). Once abundant, cheatgrass promotes increased fire frequency which promotes further cheatgrass domination and the development of a cheatgrass-wildife cycle that is difficult to break. Although sagebrush die following fire, most of the native herbaceous component is at least to some degree fire tolerant. Thus, if a healthy understory is present fire can be used as a vegetation management tool and the landscape can recover from wildfires with minimal inputs.

Although there has been extensive research in the western USA on post-fire restoration/reclamation, little effort has focused on the establishment of native perennials in the understory of existing sagebrush stands (Huber-Sannwald & Pyke 2005). Even less is known about the potential for using seed-caching rodents such as the kangaroo rats for establishing natives in the understory. We do know that such rodents can cache extraordinarily large numbers of seeds in small groups scattered throughout their home ranges and that not all seeds are recovered and eaten (Vander Wall 1990). Further, it has been demonstrated that kangaroo rats can be extremely important for the successful establishment of Indian ricegrass seedlings (Longland et al. 2001). Thus, there is the potential for using these native rodents to help augment a depleted sagebrush understory.

Fluorescent powder has been used frequently to track rodents and seeds dispersed by rodents with no apparent ill effects on rodents (Longland & Clements 1995).

Scope of Study: Scientifically, this study will provide a baseline for developing more detailed research in the future. Geographically, the results will be relevant to federal lands not only in the Great Basin, where the study will occur, but also through the Colorado Plateau, the southern Rocky Mountains, the desert southwest, and beyond.

Intended Use of Results: The primary use of these results will be in the development of more detailed research on the topic. Nonetheless, this preliminary study might yield results that can be applied in an ‘experimental’ land management context.

OBJECTIVES/HYPOTHESES TO BE TESTED

Because this is a preliminary study no formal hypotheses will be tested. Our objective is to conduct two preliminary field assessments: (1) rodent live trapping using Shearman live trapping methods in order to assess the granivorous rodent community, and (2) fluorescent dye seed tracking in order to assess the seed caching patterns of rodents using artificial depots of restoration seeds.

METHODS

Description of Study Area: This study will be conducted at Golden Spike National Historic Site. In particular, it will be conducted along the railroad grade west of the Visitor's Center (West Auto Tour).

Procedures: The initial research plan has been designed to explore various aspects of rodent granivory in an ecological restoration context. Initially, we are proposing two field assessments in order to evaluate the potential for using rodents as seed cachers in order to increase native species density and diversity in the understory of sagebrush communities at Gold Spike National Historic Site (GOSP), Utah. We propose the following two field assessments: (1) live trapping using Shearman live trapping methods, and (2) fluorescent dye seed tracking. The potential to use rodent as seed cachers is largely dependent on the presence of heteromyid rodents at GOSP, which is not known at this point.

We will evaluate rodent communities at up to five 0.25 hectare plots, each separated from the next by > 200 m. In each plot the rodent community will be sampled using Sherman live traps placed in a 7 x 7 trap grid arrangement with approximately 10 m between adjacent traps (n = 49 traps/plot). Trapping will be conducted for five consecutive nights in all cases and traps will be checked and re-set each day. All animals trapped will be field identified to species using standard morphological characteristics, weighed, sexed, marked, and released. Marking will be either with small aluminum interlocking button tags or an ear punching system for individual identification using a metal ear puncher. Traps will be baited with a combination of peanut butter and mixed bird seed. In addition, extra bait and two standard cotton balls will be placed in each trap during cooler trapping periods. This research plan has been approved by Utah State Universities Institutional Animal Care and Use Committee (IACUC – see attached).

If we determine that the rodent community consists of a suitable proportion of heteromyid species (>10% total community composition) fluorescent powder-coated Indian ricegrass (*Achnatherum hymenoides*) seeds will be placed at the corner of each plot in a dish that also contains fluorescent powder. Each corner will have 10 g of seed placed before sunset, each with a unique color (e.g. corner 1 = blue, corner 2 = green, corner 3 = yellow, and corner 4 = red powder). Before sunrise the following morning, we will locate any caches using black lights and mark them with pin flags for evaluation and/or excavation the following day. This will allow us to make the general assessment of (1) proportion of seeds cached, (2) spatial distribution of caches including distance from original source, (3) number of seeds/cache, and (4) depth of caches.

The data gained from this preliminary field assessment will allow us to better design experiments that specifically address relations between increasing native species understory diversity in sagebrush communities and aspects of rodent seed moving behaviors that could not be done without this background information.

Collections: Our IACUC proposal requested the following numbers of animals by species to be live-trapped. These are the maximum numbers – actual numbers trapped will of course depend on the rodent community but will likely be very much less than these. All animals will be released; none will be collected as vouchers.

Species	Number Requested
Deer mouse (*Peromyscus maninulatus*)	500
Western harvest mouse (*Reithrodontomys megalotis*)	100
Great Basin Pocket mouse (*Peroganathus parvus*)	500
Pinyon mouse (*Peromyscus trueii*)	100
White-tailed antelope squirrel (*Ammospermophilus leucurus*)	100
Ord's Kangaroo Rat (*Dipodomys ordii)*	500
Desert Woodrat (*Neotoma lepida)*	100
Chisel tooth Kangaroo rat (*Dipodomys microps)*	100
Rock squirrel (*Spemophilus variegates*)	100
Least chipmunk (*Tamias minimus*)	500

Analysis: The objectives of this preliminary study will be met primarily with descriptive statistics: mean proportion cached, mean distance of caches from source, mean number of seeds per cache, depth of caches, etc. In addition, spatial statistics might be used to evaluate the distribution of caches in the plot.

Schedule:

Start – immediately
Trapping of rodents – Winter 2007; Spring, Summer, and Fall 2008
Tracking seed caches – Fall 2008, immediately following last trapping session
Completion of this Phase and Reporting – Fall 2009

Budget:

Flagging, miscellaneous supplies	$200
Travel	$2000

This research is supported by the National Park Service (IMR Fire Management Fuels Funding) and the Utah Agricultural Experiment Station.

PRODUCTS

Publications and Reports: A report will be submitted to NPS on our preliminary results. The primary use of the results will be to design further studies. No peer-reviewed publications are expected yet.

Collections: N/A

Data and Other Materials: No other products are expected to be generated.

LITERATURE CITED

Huber-Sannwald, E. & D.A. Pyke. 2005. Establishing native grasses in a big sagebrush-dominated site: an intermediate restoration step. Restoration Ecology 13: 292-301.

Longland, W.S. and C. Clements. 1995. Use of Fluorescent Pigments in Studies of Seed Caching by Rodents. Journal of Mammalogy 76:1260-1266.

Longland, W.S., S.H. Jenkins, S.B. Vander Wall, J.A. Veech, and S. Pyare. 2001. Seedling recruitment in *Oryzopsis hymenoides*: are desert granivores mutualists or predators? Ecology 82: 3131-3148.

West, N.E. 1983. Western Intermountain sagebrush steppe. Pp. 351-354 *in* N.E. West, ed., Temperate deserts and semi-deserts. Elsevier Scientific, Amsterdam, Netherlands.

Vander Wall, S.B. 1990. Food hoarding in animals. University of Chicago Press.

QUALIFICATIONS

Eugene W. Schupp is a Plant Population Ecologist with over 30 years of field experience in a diversity of environments including seasonally flooded forests, tropical forests, and semi-arid woodlands and shrublands. For the past 15 years he has mostly worked in the Great Basin and Colorado Plateau of Utah. His research focuses on seed and seedling ecology, primarily from the perspective of limits to plant establishment. In this context, he studies seed dispersal, seed predation, germination ecology, and early seedling growth and survival.

Steven M. Ostoja is a Plant Ecologist who has studied seed dispersal and seed predation by granivorous rodents in the Great Basin for the past five years. In addition, he has worked with plant ecology and with rodents in California and Belize.

Matt Brooks is a Research Botanist with expertise in the ecological responses to fire in arid and semiarid regions of the western USA.

Kelly Fuhrmann is the Fire Ecologist at Zion National Park

SUPPORTING DOCUMENTATION

Safety: Minimal threat of diseases and bites from handled rodents.

Access to Study Site: Access is easy from Park Service roads – the sites are directly adjacent to the railroad grade west auto tour road.

Use of Mechanized and Other Equipment: Sites will be marked with plastic flagging which will be removed at the end of the study.

Chemical Use: N/A

Ground Disturbance: each potential seed cache will be marked with a 1.5 mm diameter stake-wire flag pushed a few cm deep into the soil. These potential caches will be gently excavated to recover seeds. It is expected that these disturbances will be no more than 5 cm diameter and 5 cm deep, probably less. The number can not be known in advance.

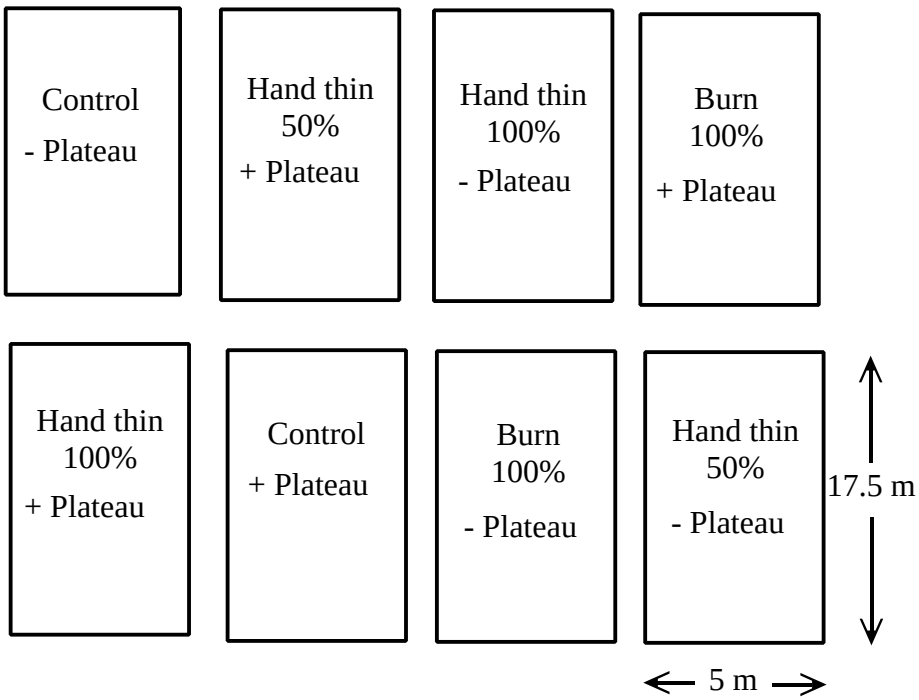
Animal Welfare: See attached copy of the IACUC proposal and the memorandum documenting it has been approed.

NPS Assistance: Occasional use of a trailer at the Golden Spike National Historic Site office complex for sleeping and access to sites.

Wilderness "Minimum Requirement" Protocols: N/A

Appendix 2: Seeding into existing sagebrush stands

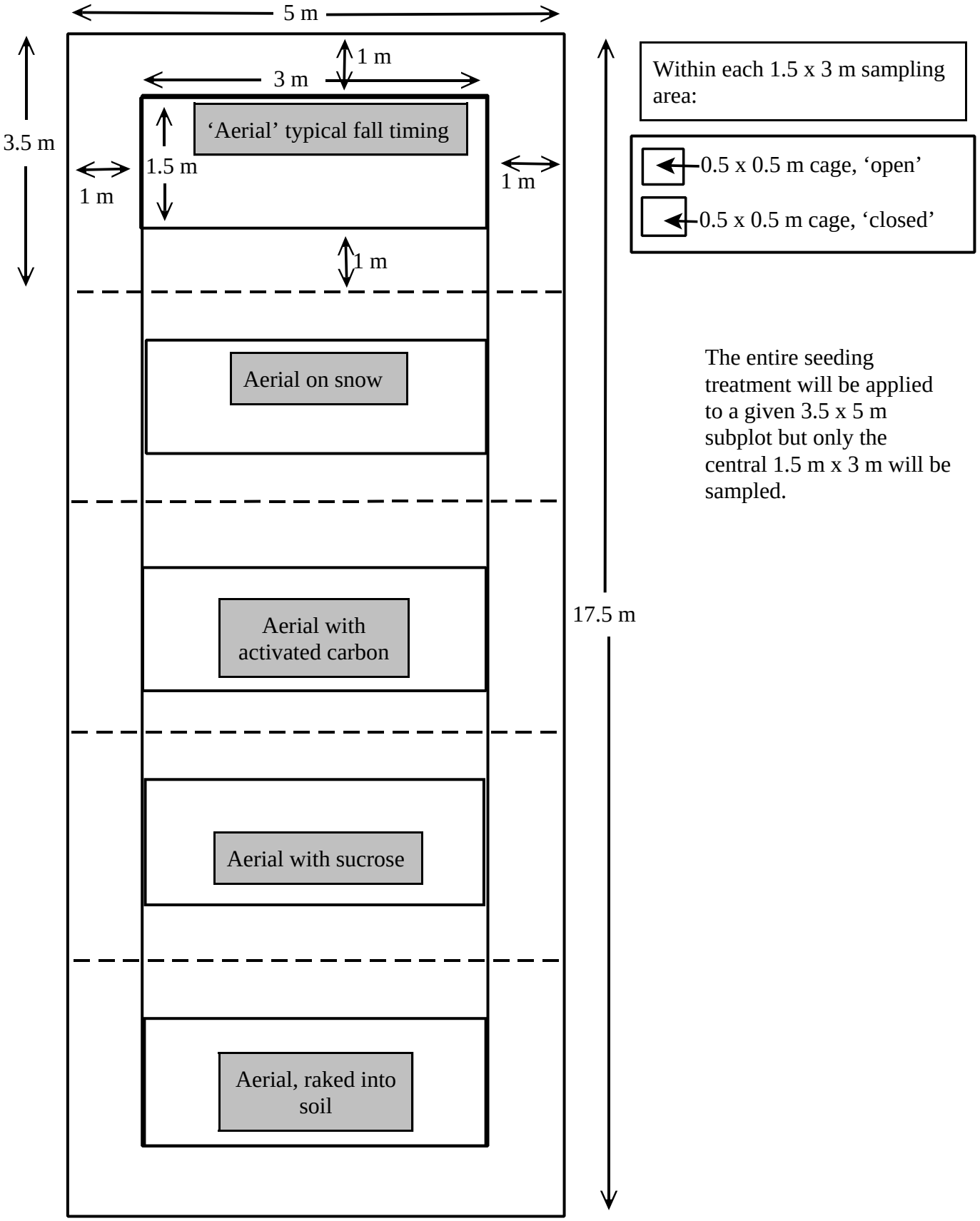
Overall Layout of a Single Replicate – 4 Replicates (see page 3) – hypothetical arrangement of treatment combinations.



This is the plot layout. More detailed view of the individual plots is found on the next page. Note that the individual 17.5 m x 5 m plots are independent but within a relatively small general area – also, the external buffers around individual plots can be larger than I have on the next page (1-m buffers) if there is enough room within an area to fit it all in – and they do not have to be laid out so regularly. This design gives flexibility with respect to rocky outcrops on the hill. Also, note that we need 'relatively' flat areas for these plots so there is not too much downhill movement of seeds and 'treatments' at this small scale.

On page three I describe in more detail the treatments and their justifications.

NOTE PLOT DETAIL ON NEXT PAGE IS NOT EXACTLY DRAWN TO SCALE (DIMENSIONS)



The entire seeding treatment will be applied to a given 3.5 x 5 m subplot but only the central 1.5 m x 3 m will be sampled.

Replicates: Four, 2 on deeper soils near the Visitors Center and 2 on shallower soils on hill in eastern part of Site (East Auto Tour area).

Vegetation management treatments: four

- Control – sagebrush unmanipulated
- Burn, 100% – attempt to completely blacken plot – mimic what happens in burned areas of a patchy, mosaic burn.
- Hand thin, 100% – same as above, only creating patchiness mechanically.
- Hand thin, 50% – effects of thinning sagebrush to free up resources for understory without eliminating sagebrush.

Pre-emergent treatments: two

- with Plateau pre-emergent herbicide
- without Plateau – evidence that plateau can reduce cheatgrass emergence and that it can release established perennials. Although less clear-cut, there is some evidence that it can control emerging annual grasses while allowing 'some' level of establishment of desirable perennial grasses from seed – interspecific differences in sensitivity of perennials to Plateau during emergence is fairly high, but there is potential...

Note that vegetation management treatments (4) and pre-emergent treatments (2) are factorially crossed yielding 8 combinations = 8 plots.

Sowing treatments: five – the seed mix is the desired mix established by GOSP

- aerial – traditional 'aerial' sowing in fall – by hand, seeds mixed with rice hulls.
- aerial on snow – hand sowing on snow cover during the winter – has been suggested as a way to reduce seed predation earlier in fall and to help incorporate seeds into the soil with snow melt – but virtually no data on the technique.
- aerial with activated carbon – there is evidence that activated carbon (charcoal as in water filters, basically) can improve establishment of desirable perennials in weed-infested communities but the study was done by incorporating 1% by volume C into the top 10 cm of soil. This is not feasible as a restoration strategy, but activated C on the surface might still help – activated C absorbs or adsorbs organic compounds so it can tie up both allelopathic compounds and nutrients (see below).
- aerial with sucrose – easily consumed energy sources (such as table sugar, often used experimentally) can stimulate heterotrophic microbial population growth and immobilize, or tie up, soil available N, P, etc. It is thought that annuals (our weeds) are more sensitive to resource availability than are slower growing perennials – they depend on rapid growth for their success. In addition, there is some experimental evidence that nutrient immobilization can be a useful tool in restoration of perennials – no magic bullet, but a tool.
- aerial, raked into soil – we are primarily seeking ways to establish the understory without using heavy equipment such as a rangeland drill or dragging a harrow. This is a very difficult challenge, but it is a problem that needs to be experimentally addressed in our view. And it certainly seems appropriate for

GOSP where there are potentially important artifacts everywhere. Nonetheless, this treatment can help give an idea of establishment under what is typically considered 'ideal' seeding conditions – when you insure seeds are incorporated into the soil.

One last point – in light of this challenge, a side aspect that needs to be addressed in this overall project is, basically, a screening trial of potential native species to elucidate in a sense a ranking of ability to work into the soil and establish without being 'drilled.' There is evidence that seed traits will be important (e.g., size, shape, etc.), but we are far from knowing.

<u>Rodent exclusion:</u> two

Preliminary evidence is that rodent populations at GOSP are not very large, at least at the moment; nonetheless, at the small spatial scale of seeding desirable species in this study they might have a very strong impact on our results – especially for surface sown seeds. Therefore, this treatment, added into the end of each sampling area, is intended to quantify the impact of rodents on our results.

- cage, 'open' – hardware cloth cage that has openings in all 4 sides to allow rodents to enter – a control of altered physical environment by cages.
- cage, 'closed' – cage to exclude rodents.