C Amendment Protocol

1. Study design

The addition of C to sequester soil N (encourage microbial uptake of inorganic N and reduce the N available to plants) is the main treatment to be applied in experiment 2. The core experiment (NV&OR low precip; UT high precip) consists of 6 treatment blocks measuring 15.5m x 23m in each study area, each block comprised of 18 plots measuring 1.5m x 2.5m. Experiment 2.b, testing the effect of seed densities in addition to the core experiment (NV high precip), consists of 6 treatment blocks each measuring 26.5m x 29m, each block comprised of 37 plots measuring 1.5m x 2.5m. Experiment 2.c, testing the interactions with secondary weeds in addition to the core experiment (ID both precip, OR high precip, UT low precip) consists of 6 treatment blocks each measuring 20m x 23 m, each block comprised of 24 plots measuring 1.5m x 2.5m. C in the form of sucrose (i.e. sugar) will be added to all of the plots in three of the six blocks in all sites prior to seeding of accessions.

The total area requiring C addition calculated from additions on a plot-by-plot basis (plot area = 3.75 m^2) is as follows for each study site:

Nevada:

a) Low precip: 202.50 m^2
b) High precip: 416.25 m^2

Oregon:

a) Low precip: 202.5 m^2
b) High precip: 270.0 m^2

Idaho:

a) Low precip: 270.0 m^2
b) High precip: 270.0 m^2

Utah:

a) Low precip: 270.0 m^2
b) High precip: 202.5 m^2

2. Application of C

a) Application rate

Young et al. (1997) applied 580 kg/ha C per year in antelope bitterbrush communities, and Paschke et al. (2000) applied 1600 kg/ha C per year in shortgrass prairie. Other researchers have applied as much as 1 kg/m^2 sucrose (Reever Morghan and Seastedt 1999) or have applied more recalcitrant C (sawdust, mulch, cellulose) with or without sucrose (Zink and Allen 1998, Torok et al. 2000, Baer et al. 2003).

We wish to see a quick response with minimal complication caused by mulching effects, we wish to ensure that C addition is adequate to cause substantial reduction in N availability, and we wish the timing of N reduction to coincide with high N requirement for cheatgrass . Therefore we will use an addition of about 1500 kg/ha C in the form of sucrose (exceeding the amount used by Young et al. 1997 and slightly below that of Paschke et al. 2000). Because C in the form of sucrose is readily available, the effect is rapid but not long-lasting. Changes in soil respiration and available N have been observed as little as 3 days after application, and may continue for 1-2 months after application (Torok et al. 2000, Reever Morghan and Seastedt 1999). Applications will be made twice annually.

b) Application timing

Sucrose will be added twice annually over the course of the experiment: in October (immediately prior to seeding of experimental plots and coinciding with fall germination) and in late winter/early spring (January-March), coinciding with a typical winter thaw. Sucrose will be broadcast across the treatment plots and initially will be incorporated into the soil by raking; this will also provide scarification for broadcast seeding. In subsequent applications sucrose will be broadcast on the soil surface but will not be raked in since seeding will have already occurred.

c) Application procedure

At each application, 675g of sugar per treatment plot (180g per square meter) will be broadcast by hand (as evenly as possible) on the treated plots at each study location. In October 2003, sugar application will be followed by raking of the plots to scarify soil and incorporate sugar into the soil surface. In subsequent applications, sugar will be broadcast by hand as evenly as possible but plots will not be raked.

This application rate will require the following amounts of sugar per application for each of the study areas:

Nevada:
Low precip (18 plots x 3 blocks): 36.45 kg, (total needed per year: 72.9 kg)
High precip (37 plots x 3 blocks): 74.93 kg (total needed per year: 149.86 kg)

Oregon:
Low precip (18 plots x 3 blocks): 36.45 kg (total needed per year: 72.9 kg)
High precip (24 plots x 3 blocks): 48.60 kg (total needed per year: 97.20 kg)

Idaho:
Low precip: (24 plots x 3 blocks): 48.60 kg (total needed per year: 97.20 kg)
High precip: (24 plots x 3 blocks): 48.60 kg (total needed per year: 97.20 kg)

Utah:
Low precip: (24 plots x 3 blocks): 48.60 kg (total needed per year: 97.20 kg)
High precip (18 plots x 3 blocks): 36.45 kg (total needed per year: 72.9 kg)

3. REFERENCES

Baer, S. G., Blair, J. M., Collins, S. L., and Knapp, A. K. (2003). Soil resources regulate productivity and diversity in newly established tallgrass prairie. Ecology 84:724-735.

Paschke, M. W., McLendon, T., and Redente, E. F. (2000) Nitrogen availability and old field succession in a shortgrass steppe. Ecosystems 3:144-158.

Reever Morghan, K. J., and Seastedt, T. R. (1999) Effects of soil nitrogen reduction on nonnative plants in restored grasslands. Rest. Ecol. 7:51-55.

Torok, K., Szili-Kovacs, T., Halassy, M., Toth, T., Hayek, Zs., Paschke, M. W., and Wardell, L. J. (2000). Immobilization of soil nitrogen as a possible method for the restoration of sandy grassland. Appl. Veg. Sci. 3:7-14.

Young, J. A., Clements, C. D., and Blank, R. R. (1997) influence on nitrogen on antelope bitterbrush seedling establishment. J. Range Manage. 50:536-540.

Zink, T. A., and Allen, M. F. (1998) The effects of organic amendments on the restoration of a disturbed coastal sage scrub habitat. Rest. Ecol. 6:52-58.

Experiment 2: Competitive Interactions

2.a. Core experiment (low precipitation study areas in NV and OR, high precipitation study area in UT)

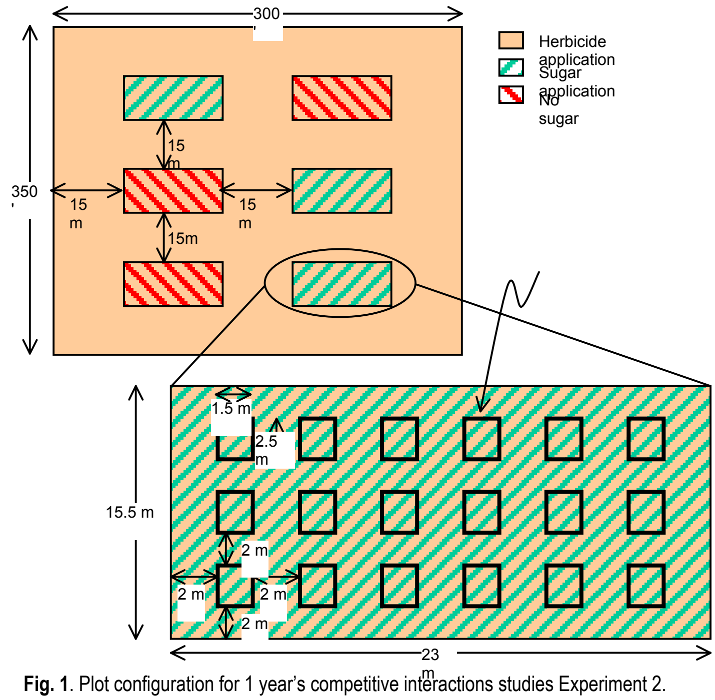

Fig. 1. Plot configuration for 1 year's competitive interactions studies Experiment 2.

2.b. Effects of seed densities (high precipitation study area in Nevada)

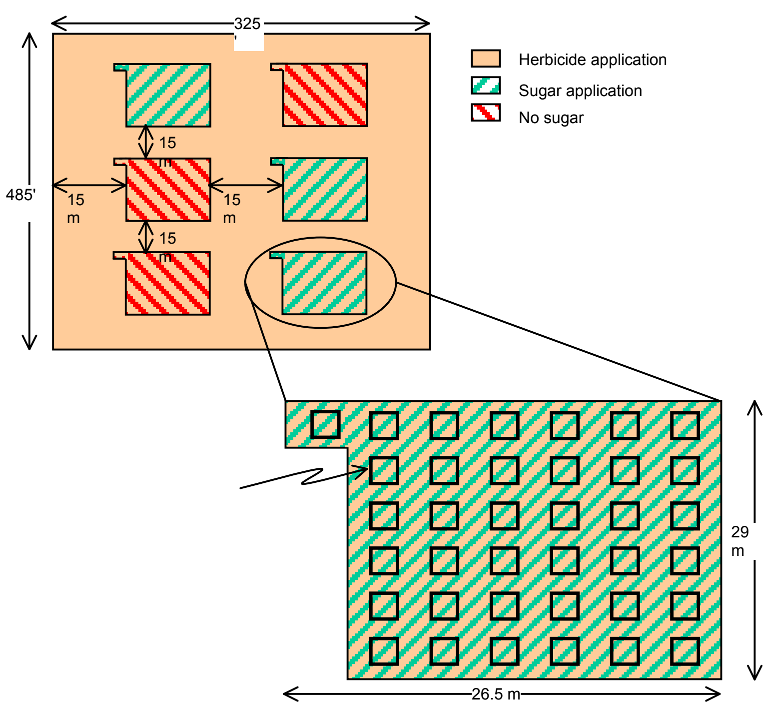

Fig. 2. Plot configuration for 1 year's competitive interactions that also investigates seeding density in Experiment 2

2.c. Effects of secondary weeds (both study areas in Idaho, high precipitation study area in Oregon and low precipitation study area in UT)

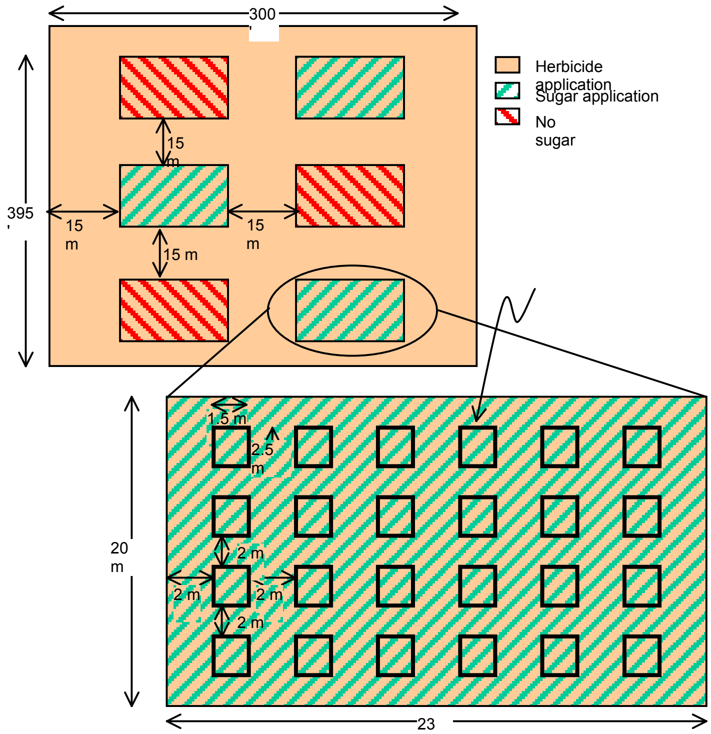

Fig. 3. Plot configuration for 1 year's competitive interactions studies that also investigates secondary weeds in Experiment 2.