1. Title of Demonstration Project TO BURN OR NOT TO BURN: WHAT IS THE QUESTION?
School name and school address Big Sky High School
ECOS Team Names (Alphabetical order): Frank Janes, Kathleen Kennedy, Dave Oberbillig, Andrew Whiteley, and Jennifer Woolf

2. 100 word abstract of the nature of the project including the ecology theme and major accomplishments.

As a demonstration project, we conducted an experimental prescribed burn in a field dominated by invasive weeds. The project focused on two primary ecological themes: disturbance and invasive organisms, both of which are extremely relevant locally because residents often burn fields to reduce invasive weed population numbers. This project successfully taught students about the scientific process and about ecology as science by having them develop and participate in a field experiment. We also designed and implemented other outdoor exercises throughout the school year to ensure the students fully participated in the experiment, including lessons on sampling methods, population biology, and data collection.

3. Introduction – please describe what you had proposed to do as described in your Demonstration Project Grant

This demonstration project will introduce students to the scientific process in a hands-on manner, using a subject that is extremely locally relevant. We will conduct prescribed burns of field plots with varying levels of fuel augmentation, and observe the subsequent succession of plants and insects. We will perform this experiment on DNRC land adjacent to Big Sky High School, Missoula, Montana. There will be a total of nine plots, each one 20 meters X 20 meters. There will be 10 meters of buffer in between adjacent plots. The area around the plots will be thoroughly cleared of plant matter to prevent the spread of fire. Three of the plots will serve as controls, and the remaining six plots will be divided into two groups, one of which will received a moderate amount of fuel augmentation, and the other will received heavy augmentation with light fuels such as grass. Before the burn, transects will be performed to determine which plants are present as well as their abundance. Insects will also be captured by pit fall traps and sweep nets. The burns themselves will be conducted by trained firefighters handling drip torches with a fire engine present. Temperature sticks (Tempil©) will be used to determine the heat of the fire and how deep the heat penetrates the ground. Afterwards we will partially seed the ground with native plant species. The students will return to the site periodically during the year to observe how plant and insect succession differs depending on the treatment.

4. Schoolyard Demonstration Project Description – Please describe what you actually did.

a. What was the science theme?

We had three main goals in conducting our experiment: 1) teach the process of science using hands-on learning, 2) teach field ecology as science and 3) use locally relevant issues to engage students. The project focused on two primary ecological

themes: disturbance and invasive organisms, both of which are extremely relevant locally because residents often burn fields to reduce invasive weeds.

b. Was there a target grade level, several grade levels, or whole school?

We directly interacted with eight sophomore ($10^{th}$ grade) biology classes.

c. What was purchased and built?

We purchased a sign made for DNRC to designate a voluntary trail closure through the study site. We also purchased sampling materials and Tempil© temperature sticks that measure the heat and intensity of fire. The time spent by DNRC firefighters was kindly donated by the DNRC. We bought other materials that were used to implement the before and after data collection with the students. We plotted out 9 - 20m x 20m plots and mowed the grass around them to serve as a firebreak. We added weed seed free straw (donated kindly by Kathy Knudsen) to three treatment plots and dried leaves to three treatment plots to augment fuel levels.

d. Describe the demonstration project – what is it, how was it set up, who helped set it up, who has used it and how?

The first step in our experiment was to introduce the idea of fire research in relation to invasive weeds to the students. After interacting with the students throughout the year, we knew they had been previously exposed to concepts regarding invasive weeds and prescribed fire. We spent about 20 minutes in the classroom tying the two topics together using examples of real current research taking place in the Missoula Valley. We then took the students to the field site to make observations. The field site is a 15-acre field adjacent to the high school that is owned and managed by the Montana Department of Natural Resources. We developed a memorandum of understanding among Big Sky High School, the University of Montana, and Montana Department of Natural Resources to use the land for this experiment.

The students were divided into groups of three to work together for the spring semester on this project. Each group was required to record five observations and develop three good scientific questions based on field observations. We then compiled a list of questions that were repeatedly suggested and then slightly adjusted them to be answerable in the context of our experiment (see box 1 for questions). Each class had approximately 24 students, and we selected eight questions to serve as the foundation of student data collection. Students worked in groups of three within classes and each class worked on only one of the nine 20m x 20m plots. Data from multiple classes were pooled in the end to compare treatments and controls.

*Experiment*

We designed the experiment without direct input from the students because we did not have enough time to teach about the principles of experimental design necessary for the students to actively participate in this process. We worked directly with Mick Harrington, a fire scientist at the USFS Fire Science Laboratory in Missoula, MT to design this experiment. He has a great deal of experience conducting experiments just like this in the local area and was essential to the process. We used a Before-After Control-Impact (BACI) design with three replicates of each treatment. Dr. Harrington

recommended we test two different types of fuel augmentation, as the fuel loading on our sites was naturally quite low. We tested the effect of dried leaves as a fuel augmentation compared to weed-free straw. We also had three replicate control plots for a total of nine plots. Dr. Harrington also had very helpful advice on the important aspects of fire behavior to measure during the experiment such as fuel moisture and fire temperature.

The sampling design for all of the questions was based directly on the sampling safari exercise we conducted earlier in the year and therefore was familiar to the students (see Sampling Safari Inquiry). That is, we used the same 10m x 10m cell grid and had the students choose random numbers from within the grid to locate subsamples. The specific methodology for each question was developed either by an ECOS fellow or with the assistance of a local expert at the University of Montana (see Box 1 for an overview of methodology).

In early spring, we set aside a day to collect pre-treatment data for each question. We wanted each group to have personal attention while collecting this data, so we solicited volunteers from the University to come to the High School for a 90-minute commitment and assist the students in following a detailed protocol. The volunteers did not need to have any experience in the field of the question they were addressing, but simply were present to assist the students in following directions of this type. We spent ~ 10 minutes in the classroom prior to sending the students outside to go over the grid design. Many groups were required to revisit the site or take additional measurements again later in the week to complete pre-treatment data collection (insects, bacteria, soil moisture). Again, each class collected data from only one of the research plots to avoid trampling of the sites.

We coordinated the prescribed burn with the Montana Department of Natural Resources Fire Department. They graciously volunteered their equipment and professional fire fighters to conduct the burn. In our local area, prescribed burning is dependent on various local conditions such as green-up, rain, wind, and airshed quality (Missoula Valley suffers from severe inversions). Therefore, we planned 6 tentative dates with the fire crew and teachers to conduct the burn. The week before these tentative dates, we passed out fliers to neighbors to warn them about smoke on one of the six days. Immediately prior to the burn, we took samples of fuel moisture and placed temperature sticks designed to melt at certain temperatures in the plots to determine how hot it burned. We placed two of each temperature (109, 113, 250, 500°C) haphazardly throughout the plot. Each burn took place on March 31 and all 6 plots were completed in one day. The fire crew staggered the burns as different classes came out to observe.

The students collected post-treatment data by following the same protocols as before. Because the students had previous experience with the protocol, we did not enlist the help of any volunteers.

The final activity we conducted as part of the demonstration project dealt with interpretation of data. We synthesized results of data into graphical form and presented examples of questions that had a clear interpretation in light of the treatment, as well as questions that did not have a clear interpretation. We then gave the students a one page "quiz" that had them interpret results of the biomass question. We wanted the students to think about the results in relation to our experiment and in a broader context of application of the research to local problems. This final day with the students served as an excellent wrap-up for this large-scale field experiment.

e. What is its current status of the demonstration project (completed and ready for next year; still needs work to finish it, etc…)?

The demonstration project is completed and the site can be used for scientific inquiry for years to come. We have a three-year agreement with the DNRC for use of the land.

f. If what you eventually did was different than what you proposed, please describe the changes.

Overall, we performed what we proposed. One minor change occurred with the experimental design related to fuel augmentation. Due to logistical constraints we used hay and leaves as the two fuel augmentation treatments, instead of two different amounts of hay that we proposed. We also did not reseed any plots with native plants.

5. Please list the names and addresses of all the community members and businesses that helped with the project, and describe their contribution.

- Mick Harrington, Fire Ecologist, RMRS Fire Sciences Lab, Missoula, MT: helped in the design of the experiment
- Sue Clark, MT DNRC, Missoula, MT, developed MOU with UM and BSHS and ordered sign for trail closure.
- Rob Gustafson and Ken Parks: MT DNRC, Missoula, MT, firefighters donated time and equipment to plan and conduct the prescribed burn
- The following people donated time during the pre-treatment data collection session: P. Alaback, S. Amish, Greg Guscio, S. Keller, J. Marangelo (ECOS Staff), T. Mildenstein (ECOS Fellow), L. Neraas, P. Spruell, A. Trillo, and D. Ucitel.

6. Sustainability - What is needed for this project to be sustained at the school in the coming years? What would be the ideal way for the next cohort of fellows to integrate with this project next year (please answer this regardless of if the school was selected to be an ECOS school next year)

Dave Oberbillig has mentioned that he will continue to use the experimental plots with his Ecology students in years to come. This is the best and most obvious way that this demonstration project could be continued and that future ECOS fellows could contribute to this project. Dave mentioned wanting to perhaps burn some plots and leave others (both control and treatment) untouched, to create a mosaic of burned and unburned plots. Continued contact with Dave would provide logistical support to make this more likely to occur. It is unlikely that freshman or sophomore classes will continue using these plots without the involvement of a full ECOS team. If a full team were at Big Sky in two years, they could easily pick up where we left off.

7. Summary – please summarize what was accomplished through the demo project this year.

We successfully completed our three primary goals with this demonstration project. We showed the students how science works through by exposing them to all the parts of a large-scale research project. We taught students that ecology is science as much as other, perhaps more commonly, discussed fields of biology. We also engaged students by focusing our demonstration project on locally relevant issues. We

successfully set up a large-scale burn experiment, despite the logistical challenges. Students collected the data before and after the experiment so felt like they were a part of the whole process. Through comments from students, we believe that we exposed students to a scientific experience that they will remember in the future.

Appendix 1 - Curricula: Please attach all of the curriculum pieces developed for your school this year.

See Curriculum pieces.

Appendix 2 - Photos: Please attach photos to illustrate your report. We need jpeg files that have informative names.

See word file with embedded pictures.

## Box 1: Questions and Methods

1) *How will different levels of fuel augmentation followed by prescribed fire affect insect composition and density?*
Method: randomly choose 10 cells per plot and install 20 oz. cups with 1" of soapy water as pitfall traps, return 48 hours later and collect insects

2) *How will different levels of fuel augmentation followed by prescribed fire affect biotic soil factors (bacteria)?*
Method: collect 1g of soil and dilute 1:10 five times, culture the fifth dilution and count colonies the next day

3) *How will different levels of fuel augmentation followed by prescribed fire affect abiotic soil factors (moisture, nutrients)?*
Method: choose three random cells per plot, remove organic layer, collect three composite subsamples from each random cell. To measure moisture, we took a wet weight, put the soil sample in a drying oven and then recorded a dry weight and used the difference to measure moisture. We focused on ammonia for nutrients as it was most likely to change immediately after a fire. We added 30g of soil to 50ml of KCl, shook for 30 minutes and put it through a buchner funnel. We then had a soil scientist at UM test for ammonia levels.

4) *How will different levels of fuel augmentation followed by prescribed fire affect cheatgrass and bunchgrass density?*
The students selected 20 random cells per plot and used a daubenmire frame to estimate % cover of each species. The students placed painted nails in the corners while collecting pretreatment data to ensure measuring the same spot post-treatment.

5) *How will different levels of fuel augmentation followed by prescribed fire affect plant growth rates (biomass)?*
The students selected three random cells per plot and removed vegetation

6) *How will different levels of fuel augmentation followed by prescribed fire affect individual plant vigor and growth?*
The students followed 3 individual plants of knapweed, bunchgrass, and quackgrass within three randomly chosen cells by measuring length of leaves and stems before and after the burn. Colored nails were used to locate the same individual plants later.

7) *How will different levels of fuel augmentation followed by prescribed fire affect plant species composition*?
The students selected 20 random cells per plot and used a daubenmire frame to estimate % cover of each species. The students placed painted nails in the corners while collecting pretreatment data to ensure measuring the same spot post-treatment.

8) *How will different levels of fuel augmentation followed by prescribed fire affect moss density?*
The students selected 20 random cells per plot and used a daubenmire frame to estimate % cover of each species. The students placed painted nails in the corners while collecting pretreatment data to ensure measuring the same spot post-treatment.


Big Sky High School students make observations and think about interesting questions in February, before we burned the field.


Big Sky High School students make observations and think about interesting questions in February, before we burned the field


Two Big Sky High School Students show the size of the 20m x 20m plots (middle right and middle left, with one leg on stake marking corner of plot).


Knapweed in DNRC field in February.


ECOS Fellow Jennifer Woolf (black shirt, right) and UM Professor Paul Spruell (back jacket, middle) help students collect pre-burn data. Jennifer is working on collecting soil cores to determine soil nutrient and moisture levels. Paul is helping a student determine the percent composition of cheatgrass in a white PVC sampling square (March 2005).


ECOS Fellow Jennifer Woolf helps students vacuum samples for soil nutrient analysis.


UM Professor Paul Alaback helps students dig holes for pit fall traps, which were used to collect insects.


Dave Oberbillig (Big Sky Teacher) helps his students identify plants before the experimental burn.

Two Big Sky High School students collect plant material and put it into plastic backs to determine the biomass on the plots before burning.

Geared up and ready to go.  Sampling kits were prepared for each question and each class period.


ECOS Fellow Andrew Whiteley mows a buffer strip around future burn plots.


ECOS Staff Member Jen Marangelo, ECOS Fellow Frank Janes, UM Graduate Student Dalit Ucitel, and ECOS Fellow Jennifer Woolf prepare to take students outside to collect pre-burn data.

ECOS Fellow Tammy Mildenstein helps students identify plants during pre-burn data collection.

ECOS Staff Member Jen Marangelo helps students dig hole for pit fall traps.


DNRC fire fighters, Rob Gustafson and Ken Parks, use a drip torch to light a prescribed fire.


Big Sky High School students watch as the prescribed fire puts up smoke.


DNRC fire fighter Rob Gustafson controls the prescribed burn.


DNRC fire fighters, Rob Gustafson and Ken Parks, monitor the prescribed burn.

ECOS Fellow Jennifer Woolf, Big Sky Teacher Dave Oberbillig, Big Sky Teacher Kathleen Kennedy, and UM Professor Carol Brewer discuss the prescribed burn.

Kathleen Kennedy, Dave Oberbillig, and Ken Parks recover temperature sticks immediately after the prescribed burn.

Big Sky students offer advice to Rob Gustafson as he monitors a prescribed burn.

ECOS Fellows Frank Janes and Jennifer Woolf observe four of the burn plots the day of the prescribed fires.