Appendix A. Research Questions

Study Project 1: Prescribed fire effects on vegetation

Management Questions: Is late summer/fall burning an efficient method for controlling juniper encroachment? What effect does prescribed fire have on vegetation diversity and productivity, forage values for livestock, and wildlife habitat? What is the impact of prescribed fire on invasive weeds?

Existing spatial databases and field monitoring will be used to stratify the study areas by slope, aspect, soils, and vegetation cover type. Plant production, canopy and basal cover, Leaf Area Index (LAI), species composition, and frequency will be measured within each strata before prescribed fire is applied, during the first 3 years following fire, and at 5-year intervals throughout the recovery period . Pre- and post-fire data will be compared to evaluate the response of herbaceous, shrub, and tree species (including juniper, bitterbrush, mountain mahogany and invasive weeds) to prescribed fire. Species diversity, abundance, productivity, and forage-availability indices will be used for statistical comparison. Multispectral digital aerial photography and ground measurements will be used to classify habitat types, and delineate habitat-type boundaries, before and after prescribed fire. Habitat patch size, connectivity, edge length and other habitat parameters will be compared between sampling periods using GIS techniques. The following hypotheses/questions will be evaluated statistically with the sampled data:

1. Was the density of juvenile and mature juniper reduced significantly and was the reduction correlated with fire severity patterns?

2. How was diversity, abundance and productivity of herbaceous species; sprouting and non-sprouting shrubs; and invasive weeds affected by prescribed fire?

3. How did prescribed fire affect the seedbed microclimate and seedbank of both native and invasive-weed species?

4. How do spatial and temporal patterns of forage availability for livestock, and wildlife habitat change subsequent to prescribed fire?

<u>Study Project 2</u>: Prescribed fire effects on soil properties, infiltration, runoff, surface erosion and down-stream water quality

Management Questions: What is the impact of prescribed fire on soil properties, infiltration, runoff, erosion and water quality? How are these impacts distributed over space and for how long do the effects persist?

The impact of prescribed fire on infiltration and erosion rates will be studied using simulated rainfall techniques. Plant communities and soil surface characteristics within the proposed fire boundaries will be studied immediately before, after, and for 2-3 years following fire with 0.5m^2 replicated plots. Simulated rainfall will be applied to each plot at a rate of 75 mm/hr (3 in/hr) for a 60-minute duration. Sub-samples of runoff and sediment concentration will be collected throughout the rain event. Rill erosion will be measured before and after the fire using simulated rilling techniques. Flowing water will be released at a single point at rates of 3, 7, 12, 15 and 21 l/min for 12 minutes at each rate. Sub-samples of runoff and sediment concentration will be collected throughout the duration of each flow rate. Flow velocity, flow width and flow depth will also be measured for each flow rate. Surface soil and vegetation parameters such as hydrophobicity, infiltration rates, bulk density, particle size, aggregate stability, root content, ground cover, canopy cover and vegetative biomass will be sampled for each plot. Suspended sediment and stream temperature will be monitored at the Dobson Creek, Tollgate, Upper Sheep, Johnston Draw and Outlet weirs. The following hypotheses/questions will be evaluated statistically with the sampled data:

1. How does prescribed fire affect the spatial and temporal distribution of soil properties such as organic carbon, bulk density, aggregate stability and hydrophobicity?

2. How do changes in soil properties affect infiltration capacity, overland flow dynamics and sediment yields?

3. How are these soil impacts affected by fire severity?

4. Can fire impacts on overland flow and erosion be predicted with process-based model simulations?

5. What are the short and long-term effects of prescribed fire on stream water quality parameters of temperature and suspended sediment?

<u>Study Project 3:</u> Prescribed fire effects on water balance

Management Questions: What effect does prescribed fire have on soil water balance and streamflow and are these effects predictable?

Weather and climate parameters will be monitored throughout the study period at 19 meteorological measurement sites distributed within the Reynolds Creek basin. These sites measure precipitation, air temperature, relative humidity, solar radiation, wind speed and wind direction every hour. Evapotranspiration data will be collected to assess immediate and temporal differences in water uptake between burned and unburned areas. Time domain reflectometry (TDR) instrumentation will be used to monitor changes in soil water content over time throughout the soil profile on burned and unburned sites. Rooting density will also be measured as a function of depth at these sites. Effective rooting depth will be inferred from patterns of soil water content change. Plant (LAI), soil (depth and texture), and weather data will be used to develop and parameterize models to predict fire-effects on hydrologic processes. These models will be tested and refined using soil moisture and E/T (eddy correlation) data. Historic streamflow and ground water measurements (Upper Sheep and Johnston Draw study areas) will be compared to post-fire measurements to quantify changes in hydrologic response and to assess the ability of hydrologic models to predict these changes. Hydrologic measurements at the Upper Sheep and Johnston Draw weirs are expected to continue for the very long-term as they are part of the base experimental infrastructure at the watershed. Vegetation measurements will also routinely monitored in the long-term. The following hypotheses/questions will be evaluated statistically and/or modeled from the -fire sampled data:

1. How does prescribed fire and subsequent vegetation change affect water resource utilization by vegetation, deep percolation of water and streamflow?

2. Can prescribed fire effects on water resources be predicted using Hydrologic analysis and models?

Study Project 4: Post-fire grazing management

Management Question: What factors affect when livestock grazing can resume following prescribed burning in mountain big sagebrush communities?

Following prescribed fires, on private-land areas, at the Breaks and Whiskey Hill study areas, livestock exclosure sets will be constructed in areas representing unburned (2 sets) and high (2 sets) and low fire intensity (2 sets). Each exclosure set will contain 4 adjoining exclosures (0.1 ha each). Four grazing treatments within each set will be applied in June (peak growth) of treatment years by sequentially removing exclosure fences from the set. These treatments will include: 1) moderate cattle stocking, 1 year post-fire (unfenced, no rest), 2) moderate cattle stocking, 2 years post-fire (1-year rest), 3) moderate cattle stocking, 3 years post-fire (2-year rest), and 4) moderate cattle stocking, 4 years post-fire (3-year rest). The remaining exclosure per set will be retained throughout the project as an ungrazed control for the current study and to serve as reference areas for future studies on the long-term impacts of livestock grazing on native plants and juniper encroachment. Livestock distribution and activity patterns before, during and after treatment implementation will be monitored with GPS collars attached to a subset of grazing animals. Plant production, canopy and basal cover, composition, and frequency will be monitored at 1 year post-fire (pre-grazing baseline), immediately prior to each grazing treatment application, and for at least 2 years following each grazing treatment. Pre- and post-treatment data will be used to evaluate treatment effects on plant diversity, abundance, and productivity. The following hypotheses/questions will be evaluated statistically with the sampled data:

1. What is the impact of different post-fire grazing strategies on plant species diversity, abundance, frequency, basal and canopy cover, and aboveground biomass production?

2. What are the interactions between fire severity and grazing strategies on plant species diversity, abundance, frequency, basal and canopy cover, and aboveground biomass production?

3. Is long-term plant diversity, abundance, cover and productivity higher in ungrazed controls than in other grazing treatments?

4. What are the patterns of grazing animal distribution before and after a given fire treatment and do these patterns yield information that would be useful in prescribed fire planning and post-fire management?

<u>Study Project 5:</u> Remote sensing tools for fire planning and management

Management Questions: Can remote sensing tools be developed to provide cost-effective, accurate spatial information describing pre- and post-fire vegetation diversity, cover, and productivity, quantifying fuel characteristics, characterizing fire severity patterns, and identifying soil erosional features?

High resolution, multispectral digital aerial photography of study areas will be acquired during peak growth (June) of the fire treatment year, immediately before and after the prescribed fire treatment (September) and during peak growth for at least 2 years following fire. Classification techniques will be used to stratify imagery into dominant species, bare, rock, and other classes. Classification accuracy will be evaluated using species-level canopy cover data collected in the field at the time of the remote sensing flights. Post-fire imagery will be classified based on fire severity. Classification accuracy will be evaluated using flame characteristic, fire-residence time and rate of spread, fuel consumption, and soil temperature field data collected during or immediately after the fire treatment. Relationships will be investigated between fuel biomass and moisture data collected in the field and remote sensing-derived vegetation index values. The following hypotheses/questions will be evaluated statistically with the sampled data:

1. Can multispectral remote sensing imagery be used to evaluate changes in vegetation diversity, cover and productivity following prescribed fire?

2. Can multispectral remote sensing imagery be used to classify and map fuel types and quantify fuel moisture and fuel load levels before prescribed fire?

3. Can multispectral remote sensing imagery be used to classify and map fire severity patterns and to identify soil erosional features after prescribed fire?