Landscape-Level Interactions Among Ungulates, Vegetation, and Large-Scale Fires in Northern Yellowstone National Park

Monica G. Turner
Oak Ridge National Laboratory
Oak Ridge, TN

William H. Romme
Fort Lewis College
Durango, CO

Linda L. Wallace
University of Oklahoma
Norman, OK

Substantial progress has been made in both the modeling and field studies during the first six months of research funding. Yegang Wu, Jennifer O'Hara, and Michael O'Hara all began working full time for the project on September 1, 1990. Wu is based at Oak Ridge National Laboratory (ORNL) and is working primarily on model development and analyses using the geographic information system (GIS) located in Yellowstone. The O'Hara's are based in Yellowstone and are working full time on the field studies. Here we describe our progress during the past six months for each main area of the proposed work:

1. field studies, including aspen *(Populus tremuloides)* and grassland sampling, and
2. model development and GIS analyses.

✦ Aspen Sampling

Sampling of aspen (*Populus tremuloides*) stands for browsing intensity as a function of distance to burned areas was initiated in May 1990 by Romme, Wallace and Turner. A total of 18 aspen stands were selected for study, including three stands at each of six sites: two burned areas, two unburned areas located near an extensive burn, and two unburned sites remote from an extensive burn. The locations of these stands are stored in the Park GIS, and distances to burned areas have been calculated by using the GIS. In May, a transect was extended through the middle of the longitudinal axis of each stand. From this central transect, all browsed and unbrowsed aspen sprouts were counted in five 1-m belt transects that extended from the central transect to the edge of the stand. Belt transect alternated between the left and right sides of the central transect and were spaced equidistantly. Aspen sprouts were classified as "new" sprouts of the year or "old" sprouts that were greater than one year in age. In addition, sprouts were categorized by height in 10-cm increments.

Preliminary analyses of the May 1990 aspen data suggest that aspensprouts are most abundant in burned stands and least abundant in unburned stands that are remote from the fire. In addition, browsing intensity appeared to be highest in the burned stands and

180

unburned stands located close to an extensive burn.

The 18 aspen stands were resampled in September 1990 to estimate summer browsing intensity and the abundance of sprouts available for winter browsing. Following discussions with park biologist Don Despain, a new category was added. Aspen sprouts were classified by growth form (juvenile or adult) because the juvenile growth form is the only type that can potentially reach tree size. Because our hypotheses address the potential of some individuals to escape herbivory and reach tree size, this additional category will be useful. Sampling of these stands will be repeated during May and September 1991.

During September and October 1990, increment cores were obtained from aspen trees in stands adjacent to the 18 study stands for determination of stand age structure. Data regarding the establishment periods of mature aspen stands in the Park will enhance our interpretation of the implications of fire and ungulate browsing for the potential establishment of new stands following the 1988 fires.

During October and November 1990, the aspen stands are being revisited to obtain samples for biomass abundance and forage quality analysis. Five sprouts > 50 cm in height and five sprouts < 50 cm in height will be collected from the stands but outside the permanent belt transects. These samples will be dried to constant mass, weighed, then ground for chemical analysis.

✦   GRASSLAND SAMPLING

First, extensive analyses were conducted on the Park GIS to locate sampling sites. The study area was demarcated following Houston (1982) then stratified into the following vegetation classes based upon burning status and gross productivity:

1. burned dry grassland;
2. burned mesic grassland;
3. burned moist grassland;
4. burned wet grassland;
5. unburned dry grassland;
6. unburned mesic grassland;
7. unburned moist grassland;
8. unburned wet grassland; and
9. canopy burned forest.

A minimum of three sampling sites were located within each of these classes, spanning the geographic extent of the norther range. At each site, two 100-m

transect will be established such that the transects are perpendicular and intersect at their mid points. Ten biomass samples will be obtained along each transect, for a total of 20 per site. Samples will be dried to constant mass and the mass recorded. Subsamples of the biomass collected from each site will be ground and prepared for forage quality analysis. Sampling sites were also located for the six 30-m x 30-m plots from which we will obtain data describing the spatial variability in available forage at a relatively fine scale.

All project investigators gathered in Yellowstone in October 1990 to establish satisfactory field sampling protocols and begin the grassland sampling. The grassland sampling will serve several purposes. First, a set of pre-winter biomass samples obtained in October will provide estimates of the available winter forage in different vegetation classes. These values will be used to initialize the simulation model. Second, biomass samples obtained from six 30-m by 30-m gridded plots will be used to estimate the finer scale spatial heterogeneity of forage availability and provide greater insight into the foraging decisions made by ungulates within resource patches. Third, biomass samples obtained from grazed and ungrazed sites throughout the winter will be used to estimate grazing intensity as a function of site-specific variables such as snow depth, snow density, slope, and aspect. The grassland sampling was begun during the first week of October and should be completed by mid-November.

✦   MODEL DEVELOPMENT AND GIS ANALYSES

The model we are developing simulates the winter foraging dynamics of large ungulates when the distribution of preferred forage across the landscape is spatially heterogeneous. The original prototype model was expanded to incorporate a larger spatial extent, a greater number of ungulates, variable abundances of forage per pixel, and a variety of alternative rules by which ungulates search for resources and move across the landscape. Our current simulations use a landscape that is represented as a 100 x 100 array in which each grid cell has a resolution of 1 ha. A 1-day time step has been used. The set of model parameters for the initial simulations was derived from preliminary field data we obtained in January 1990 and from the literature. Ungulate foraging was simulated with random and aggregated resource distribution patterns

and with 10-km x 10-km sections of the Northern Range. Simulation results suggest that ungulate foraging may be most efficient when resources are aggregated and least efficient when resources are randomly distributed. When initial resource abundance was reduced by 40% (e.g., by deep snow), the differences in spatial patterns appeared to be less important. That is, the effect of resource limitation alone may exceed the effect of spatial heterogeneity. Simulations conducted using alternative movement rules suggested that different search and movement strategies may be appropriate for alternative spatial distributions of resources. We are presently exploring this by comparing six different ways by which ungulates can search for resources and move across the landscape.

A series of analyses were conducted on the Park's GIS to provide input for the simulation model and to aid in selecting field study sites. The simulation model requires spatially explicit information on topography (elevation, slope and aspect), vegetation types, burning patterns, and precipitation zones because ungulate movement and foraging will be influenced by these factors. Therefore, we created a series of maps and digital data files forthe Northern Range study site in which data were aggregated into a limited number of categories within each data layer. For example, aspect categories were aggregated to represent mesic (north, northeast, and northwest), xeric (south, southeast, and southwest) and intermediate (east and west) sites. Similarly, slope categories were aggregated as flat,

mile, moderate, and steep slopes. The data files created on the GIS will be sent to ORNL on tape and used in the spatial model. Coincidence analyses were done by using the GIS to determine the relationship between areas burned and the aggregated categories of elevation, slope, aspect, and vegetation type. Results of these analyses are being used to ensure an adequate spatial extent of field sampling.

Recent progress in development of the source code for the simulation model includes the ability to input topography data, variable levels of initial biomass, and multiple categories of resource pixels. In addition, the ungulate search and movement rules have been modified to permit variable distances to be moved during a single time step and a reduction in time spent feeding as a function of distance moved. A simulation experiment is in progress to explore the sensitivity of the model to alternative movement rules, variable forage abundance, and variable forage patterns. These results will provide the basis for a paper describing the general model of winter foraging by large ungulates.

✦ **LITERATURE CITED**

Houston, D. B. 1982. The northern Yellowstone elk: ecology and management. MacMillan Co., New York.