Joint Fire Science Program

Fire Science Brief

RESEARCH SUPPORTING SOUND DECISIONS

Patch burning on rangeland was simulated using computer models then field-tested to determine fire behavior, rate of spread and fuel consumption. Field tests were done on wheat stubble plots shown here.

Patch Burning on Grasslands: An Alternative Approach for Rangeland Management

Summary

Large grazing ungulates—notably cattle, elk and American bison—if given a choice exhibit a grazing preference for regrowth on recently burned areas of grassland. Traditional rangeland management approaches that minimize inherent rangeland heterogeneity are increasingly understood as counter to the evolutionary history of rangeland. Heterogeneity is defined as variation in the characteristics of vegetation including species, biomass, and height. Recent research now finds an alternative approach to rangeland management through patch burning, giving a variegated texture to the grazing land and more closely simulating the earlier evolutionary pattern of much North American rangeland.

Patch burning creates a mosaic of patches at varying stages of recovery from burning and grazing disturbance. Advantages include more diverse plant and animal habitats, more consistent fuel stock control, and creation of the grazing habitat preferred by both domesticated cattle and indigenous grazing species. Research sponsored by the Joint Fire Science Program (JFSP) examined whether use of patch burning to increase rangeland heterogeneity is a useful tool for wildland fire management while also serving as a tool for rangeland conservation and improvement.

Key Findings

- Variations occur in the complexity of burning patterns of fires depending on the size of fuel patches within a heterogeneous rangeland. Smaller grain sizes led to more complex burn patterns.
- With equal total fuel content, the rate of spread of fires in homogeneous fuel treatment areas was greater than that of fires in heterogeneous treatment areas, regardless of grain size.
- Within individual burned patches, fuel level heterogeneity increased with time since burning.
- The location of the fire ignition point strongly influences the outcome of fires in larger scale patch heterogeneous landscapes, but diminishes with smaller patch scales.
- Fire followed by focal grazing under patch burning management increases heterogeneity at the pasture level. This is more beneficial for fire management efforts than homogeneous management.

When the bison roamed

Rangeland specialists now understand that in the era before modern settlement on the Great Plains, rangeland was more heterogeneous than it is today. Burned-over patches were initially preferentially grazed, then eventually accumulated dry, mature grasses thereby increasing fuel content. These areas frequently re-burned in cycles of from one to seven years, and the grazing sequence began again. The burns were initiated both by natural processes and in some cases by Native American inhabitants. The result was a variegated rangeland with diverse adjacent habitats for plants, birds and grazing animals. As these areas were settled by non-Native Americans in the late 19th and 20th centuries, livestock producers began fencing and rotating grazing land to create rangeland more homogeneous in character, and without the patch-like successional patterns seen earlier.

Increasingly rangeland scientists are re-discovering the value of patch burning to manage rangeland for both domesticated and indigenous grazing animals. Many of these animals preferentially graze on recently burned rangeland. Credit: Buffalo Gal, Inc., Houston, Minnesota.

Today rangeland scientists are re-learning the value of patch burning, both as a way of controlling fuel buildups and creating preferred habitat for both domestic and wild grazing animals and for other plant and animal species. Techniques have been developed to perform prescribed burns using patch patterns, with individual patches of varying sizes, and burns at varying time intervals and seasons. Heterogeneity also implies fuel load control, a wider range of plant and wildlife resources and better use of rangeland for habitat, livestock production and recreation. Through periodic controlled patch burns, it is also believed that broader catastrophic range fires can be minimized.

Testing the patch burning concept

Recent research on patch burning funded in part by Joint Fire Science Program (JFSP) was done by a team from Oklahoma State University. Principal investigators were Dr. David Engle, Dr. Samuel Fuhlendorf, Dr. Terence Bidwell and Dr. David Nofziger. Research was conducted at various rangeland sites in Oklahoma. This work was an outgrowth of their growing interest in the possibilities of patch burning.

In an earlier article published in August, 2001 in BioScience, Fuhlendorf and Engle proposed patch burning as a tool to increase heterogeneity of habitat and improved biodiversity. They noted that in the United States, many plant and animal species dependent on rangeland heterogeneity are imperiled. They contended that traditional rangeland management techniques reduced heterogeneity by favoring the most productive and palatable forage species for domestic cattle, but at the expense of other species.

Also in this earlier article, the authors proposed patch burning to promote heterogeneity. In this context, the authors define heterogeneity as variability in vegetation stature, composition, density and biomass. They explain that this type of heterogeneity influences species diversity, and a variety of wildlife habitats and ecosystem functions. A heterogeneous rangeland pattern results from differential timing and varied phasing in succession among burned patches. They believed that this type of habitat heterogeneity would parallel fuel stock heterogeneity and would offer improved potential for wildfire control.

Innate grazing behavior

Rangeland specialists understand that grazing animals—both introduced domestic and indigenous species—react to their environment with a variety of instinctive responses and behavioral actions that result in varying distribution within the grazing environment. This commonly results in small, heavily grazed patches interspersed with ungrazed or lightly grazed patches. In the article, Fuhlendorf and Engle noted that in productive rangelands with a long history of moderate grazing, heterogeneity increases. The introduction of patch burning accelerates this process.

Research is being done at Oklahoma State University on the benefits of patch burning for animal and plant species, and as a method for controlling wildfires and managing rangeland.

Engle notes, "In grassland environments, both wildfire and prescribed burning operate in the context of grazing, usually with a combination of native and domestic animals. Because the best grazing practices have been designed to uniformly use forage across the landscape, spread of wildfire is often unimpeded because the fuel base of residual forage, called fine fuel, is continuous. We wanted to test the hypothesis that we could use the spatial interaction of fire and grazing, referred to as patch burning when applied as a management practice, to interrupt the spread of fire while also accomplishing other conservation goals."

Engle and Fuhlendorf pointed out that the interaction of grazing and fire has historically influenced bison grazing patterns because bison prefer the succulent regrowth on recently burned areas. When only a portion of the area available to the bison is burned, grazing on the unburned patches is delayed. This results in a greater accumulation of fuel and increased probability of fire in these patches. They note that this pattern is complicated by seasonal changes in grazing patterns and susceptibility to fire.

An earlier experiment

The article references experiences on the Tallgrass Prairie Preserve in Oklahoma. On a seven square mile portion of this large preserve, a management practice of spatially selective burning was initiated in 1993, and has been followed since that time. Approximately 80 percent of the burns are conducted in the dormant season, half in late spring and half in the fall. The remaining 20 percent of the burns are conducted in the growing season. This regime has demonstrated that bison prefer grazing on the recently burned patches. According to Fuhlendorf and Engle's 2001 article, the bison in the patch burn area have maintained high reproductive rates without nutritional supplementation. Patch burning followed by rotating heavy forage grazing by bison has not degraded resources, but has instead resulted in an increased diversity of plant species following grazing.

Looking for more answers

The more recent Oklahoma State research, supported in part by JFSP, considers the findings from earlier patch burning and grazing research and identifies two fundamental questions relating to the use of patch management tool: (1) What is the effect of altering spatial scale of fuel load heterogeneity on the pattern of spread of prescribed fire, and (2) How does patch burning on rangeland affect the spatial heterogeneity of fuel load? The research included both computer simulations of fire spread through landscapes with varying degrees of fuel load heterogeneity, and actual field tests to complement the computer simulations.

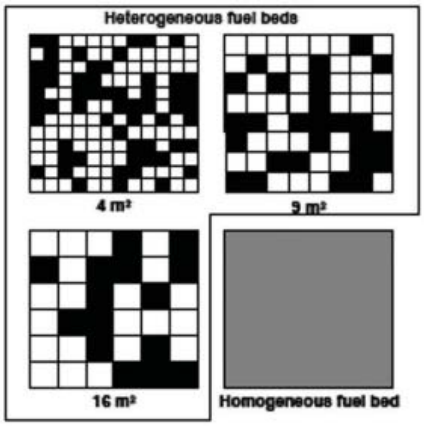
Simulated burns

The researchers created four computer landscapes that were modeled after those that would be created on rangeland by a fire-grazing interaction. In each landscape, the simulation used 80 randomly located ignition points. The simulation mapped the fire perimeter at 30-minute intervals for a total of four hours burn time. The simulations used various grains of patch sizes, and wind direction was simulated. The simulations also included a homogeneous fuel bed for comparison.

The simulations indicated greater complexity in burn patterns in areas with small-size patch elements than in those with larger patch elements. The proportion of each fire type (backfire, flankfire and headfire) was similar among all landscapes regardless of patch size. The simulations supported the supposition that the scale of the patch size influenced fire behavior, and thus subsequent ecological processes. The next step following the computer simulations was to perform field tests of fire behavior in actual rangeland.

Taking it to the field

The goal now was to test the effect of patch scale on actual fire behavior. To do this, the experimenters manipulated spatial scales of fuel heterogeneity while holding fuel load constant. This work was done on fields of wheat harvest residue at the Perkins Research Station. Randomly generated patterns of fuel distribution were manually cut from the wheat residue to create heterogeneous fuel patterns. These treatments were at patch scales of 4 square meters, 9 square meters and 16 square meters plus one homogeneous treatment. The four treatments had equal total fuel amounts.



Example of fuel treatments applied to wheat stubble plots. Blackened areas indicate patches within plots where fuel was removed. Credit: JFSP Final Report, Project 03-1-4-09.

These treatments were burned during a narrow window of similar weather conditions over two days. Fires were carefully observed and video recorded to collect data on rate of spread, flame length, type of flame spread (headfire, flankfire, backfire) and on portion of plots burned. Analysis of the data indicated that the rate of spread and proportion of the plot burned by headfire were greater in homogeneous treatments than heterogeneous treatments. However, researchers found no significant difference in rate of spread among the three scales of heterogeneous treatment. According to Engle, this suggests that presence or absence of fuel heterogeneity is more significant that differences in scaling. Engle says, "With patch burning, a fire can burn itself out by burning into the previous year's burned patch where fuel is insufficient to support the spread of fire. This feature of patch burning makes suppression of wildfire, along with implementing prescribed fire, both safer and easier."

Field experiments using wheat stubble plots evaluated the effects of using patch burning at various scales on fire behavior.

In a second field experiment, researchers used vegetation plot clipping to measure heterogeneity of vegetation, hence fuel loads, at three range sites in Oklahoma where patch burning is employed. The three sites, in Pawhuska, Stillwater and Bessie, represent a broad cross-section of productivity and precipitation conditions across the state. Vegetation from randomly selected 0.25 square meter plots was clipped and weighed to determine fuel loads. Plot samples were evaluated to measure the heterogeneity of fuel levels across four spatial scales—1 meter, 5 meters, transect level and patch level. Statistical methods were used to estimate spatial variation among plots at each scale.

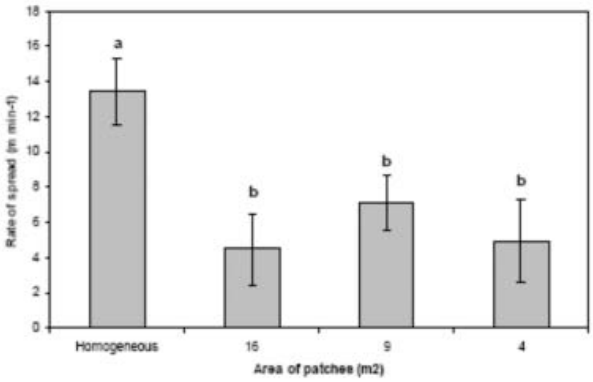
Heterogeneity in fuel content at the smaller resolutions (1 meter, 5 meters, and transect levels) was generally greater in pastures managed by traditional, homogeneous fire and grazing, but pasture level heterogeneity was greater in patch-burn pastures. Heterogeneity was least in recently burned patches and increased within the patches with longer times since burning.

Research objectives met

The overall goal of the research project was to quantify the influence of heterogeneous fuel patterns as created by patch burning on fire spread and fire behavior on grassland. The first step was to evaluate the level of heterogeneity of fuel resulting from patch burning. This was accomplished across a wide range of grassland sites.

Next, researchers evaluated fire behavior in response to the type of changed fuel characteristics as created by patch burning. The research team used existing fire-spread models such as FARSITE to make these evaluations of fire behavior. They found such models sufficient to test fire in patch burn situations, but felt that additional model evaluation should be done in future studies with heterogeneous fine fuels.

Engle indicates that both the computer simulations and the field tests verify the beliefs of the Oklahoma State team that patch burning can not only increase habitat diversity, but can provide improved control over fuel stocks and can control risks of wildfire. Because the recently burned and grazed patches have low potential for spreading the fire, they are natural fire breaks. This characteristic also simplifies the prescribed burning of adjacent patches. He adds, "Patch burning is a powerful tool that can be used to manage rangeland fuel, fire and to manage rangeland use by large herbivores."



Field experiments demonstrated the value of patch burning in creating natural fire breaks in the form of previously burned patches, thus reducing the mean rate of spread. Credit: JFSP Final Report, Project 03-1-4-09.

Spreading the word

The word on the merits of patch burning is spreading. Engle says, "We have received enormous interest among professional biologists and fire managers. This includes federal and state agencies and non-profit organizations, especially The Nature Conservancy." He notes that the research team is seeing widespread adoption on state and federal lands and Nature Conservancy properties from the Northern Plains to the upper Midwest and down to the Southern Plains. He indicates that they are seeing "not so much interest yet among private landowners. This is a future focus area."

In keeping with the objectives of the project, the team engaged in a wide range of technology transfer efforts, including oral presentations at many meetings and symposia, publication of findings in respected, peer-reviewed publications, hosting a field tour and participating in consultations with a wide range of agencies and organizations.

Following multiple consultations on the Wichita Mountains Wildlife Refuge, the U.S. Fish and Wildlife Service has implemented a patch burning approach on much of the refuge's 60,000 acres to enhance habitat for native

species, including free-ranging bison. Similarly, at the Charles M. Russell Wildlife Refuge, operators have adopted a patch-burning approach in conjunction with grazing by cattle and elk to conserve rare and sensitive species. Numerous other projects have been influenced by the patch-burning research. The Nature Conservancy has been a pivotal cooperator with patch burning programs since 2001. Other important interactions and consultations have been held regarding patch-burning in Iowa, Kansas, Missouri, Nebraska, New Mexico, Oklahoma and Texas.

How to get started

Those wanting to get started in patch burning need to follow logical steps. Engle says, "The first step is to clearly identify management goals relative to what result is intended from patch burning." In some cases patch burning may be done to improve wildlife habitat. He notes, "Agency biologists often want to improve habitat for grassland birds." Others may place a higher priority on improved grazing resources or reducing fuel stocks and wildfire risk. He notes that a part of the appropriate "prescription" may include other elements of grazing management, the most important being selecting the appropriate stocking rate of large herbivores.

Conducting patch burns

According to Engle, the team's experience has been that in many ways, a patch burn system is easier to manage that a large prescribed burn on homogenous rangeland. "Holding the perimeter of the burn patch is simplified because the adjacent recently-burned patch serves as a fuel break. Otherwise, the fire perimeter is held the same way as any other prescribed rangeland fire." He suggests that the appropriate portion burned annually depends on the area of the pasture or landscape. "In most cases, we talk about this area as a function of fire return interval. For example, if management goals require herbaceous litter accumulations to return to pre-burn levels (for example for Henslow's Sparrow nesting habitat), then the area annually burned in tallgrass prairie is one-third the pasture area, because litter returns to pre-burn levels in three years."

A patchwork path to the future

The promise of patch burning is its potential to meet the needs of many rangeland constituencies. Wildfire risk is reduced and its management is simplified. An optimum grazing environment for a range of species is maintained on a predictable schedule. A more diverse plant and animal habitat is engendered. Engle says, "Patch burning is a powerful tool that can be used to manage rangeland fuel, fire and rangeland spatial use by large herbivores." For today's rangeland management team, it is an option well worth considering.

Management Implications

- The importance of fuel heterogeneity is subject to amplification or nullification depending on other fire-related variables such as weather.
- Analysis of fuel heterogeneity confirms the hypothesis of Fuhlendorf and Engle (2001) that patch-burning management enhances spatial variability within pastures as opposed to homogeneous management.
- The results of both the computer simulation experiments, fuel modification experiments and observations of actual fuel heterogeneity shows that fuel heterogeneity can markedly alter fire spread. Fire followed by focal grazing increases spatial heterogeneity at the pasture level. This is beneficial as compared to homogeneous management.
- Heterogeneity in fuel characteristics with patch burning is generally paralleled with a desirable increase in habitat diversity in patterns similar to historic rangeland environments.

Further Information: Publications and Web Resources

Engle, David, Samuel Fuhlendorf, Terrance Bidwell, and David Nofziger. 2007. Final Report, Joint Fire Science Program Project 03-1-4-09, Patch Burning of Grasslands: Effects on Fuels, Fire Behavior and Fire Spread.

Fuhlendorf, Samuel D., David M. Engle, Jay Kerby, and Robert Hamilton. 2008. Pyric Herbivory: Rewilding Landscapes through the Recoupling of Fire and Grazing Essay, *Conservation Biology*.

Fuhlendorf, S.D. 2004. Planning Grassland Ecosystem Diversity based on an historical framework. Plenary Session: The 2nd Grassland Symposium of the Thunder Basin Grasslands Prairie Ecosystem Association. May 12–13, 2004. Parkway Plaza, Casper, Wyoming.

Fuhlendorf, Samuel D. and David M. Engle. 2001. Restoring Hererogeneity on Rangelands: Ecosystem Management Based on Evolutionary Grazing Patterns. *BioScience*. August.

Kerby, Jay D, Samuel D. Fuhlendorf and David M. Engle. 2006. Landscape heterogeneity and fire behavior: Scale-dependent feedback between fire and grazing processes. *Landscape Ecology*. October.

Refer to pages 18–20 in the document titled "Patch Burning: Integrating Fire and Grazing to Promote Heterogeneity" for information related to this project. The document can be viewed at the following website: http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-4677/E-998.pdf.

More information for managers can be found at: http://fireecology.okstate.edu/patch_burning.html.

Scientist Profile

Dr. David Engle is Director of the Water Research and Extension Center of the Division of Agricultural Sciences and Natural Resources at Oklahoma State University in Stillwater, Oklahoma. His stated overall goal is to produce knowledge and technologies, including fire use, for sustaining rangelands. The research requires a balance of ecological and rangeland management studies. Specific goals are to determine the influence of rangeland management and other land management activities on ecosystem and landscape properties, including nutrient cycling, threatened and endangered species, and critical habitats, and to develop technologies that protect the rangeland resource from degradation and to promote sustainability of rangeland resources.

Dr. David Engle. Credit: Rollie Henkes, *Midwest Woodlands and Prairies Magazine*.

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