

The **hot topic** in modern agriculture

REGENTS PROFESSOR SAMUEL D FUHLENDORF

Regents Professor Samuel D Fuhlendorf and his colleagues have been testing new ideas for conserving the world's grasslands. Here, he reveals how lessons from the past might hold the key to solving some of today's most pressing agricultural problems



Could you begin by outlining the main focus of your research?

In general I have two primary areas of focus. The first lies in gaining an understanding of how grazing and fire interact (pyric herbivory) as disturbance

processes on diverse landscapes of the world. This involves studying large landscapes and their fires and free-roaming herbivores – including grazing animals such as bison, elk, horses and cattle. Second, I want to use this understanding of pyric herbivory to develop management approaches that sustain agricultural productivity through rangeland management and simultaneously enhance or maintain biodiversity on lands grazed by domestic livestock.

What is pyric herbivory, and how is it beneficial?

Recent research has demonstrated that restoration of pyric herbivory – the spatial and temporal interaction of fire and grazing – can sustainably produce livestock and maintain biodiversity. Similarly, on large landscapes focused on conservation of native herbivores like bison, the reintroduction of these species without allowing them to interact with fire in space and time is not sufficient to conserve

all components of these landscapes. Herbivores strongly prefer to graze on recently burned areas. Most continue to focus on burned areas until somewhere else is burned and they switch their focus to the new patches. Over subsequent years the previously burned portions of the landscape recover in biomass and are prone to fire again. Pyric herbivory simply argues that rather than treating them as two independent disturbances, grazing and fire should be coupled.

What is heterogeneity, and why is it necessary for biodiversity?

Heterogeneity is essentially variability and describes the amount and variety of conditions that occur across a landscape. Its connection to biodiversity is simply based on the assumption that different species require different conditions, so a variety of conditions are required for many species. Variable disturbance patterns like fire and grazing can create a special kind of heterogeneity, known as a shifting mosaic,

where conditions are highly variable in space and time. This patch-level dynamic may be critical to resilience of rangeland landscapes and the species that are dependent upon them. Biodiversity often focuses on species diversity but it can also include patterns and processes essential to ecosystems and landscapes.

Many existing management recommendations are based on the conservation of a specific species; how effective is this approach in relation to heterogeneous environments?

This myopic approach is incapable of sustaining rangeland ecosystems for long-term production and conservation. A short-term focus on one type of habitat or objective leads to the simplification of a landscape and lowers its resilience to future perturbations, such as drought or invasive species. An effective alternative would be a heterogeneity-based approach

that may not maximise a single objective, but does build resilience of the landscape. In some cases, this can be achieved simply by restoring the processes that created patterns across the landscape over thousands of years. In grasslands, for example, this means restoring diverse fauna and heterogeneous fire interactions in space and time.

From an agricultural perspective, the focus of rangeland management has been on minimising negative impacts to dominant forage species and reducing bare ground while maintaining uniform use of forage by grazers. This limits fire because it can create short-term bare ground, leading to an increase in woody plants and minimising habitat for species that require intense disturbance and undisturbed prairie. Also, a landscape with patches cause by fire may be less susceptible to large-scale fires that would burn hundreds of thousands of acres under extreme conditions.

In what way has the study and implementation of fire ecology changed over time?

Over the past 50 years, scientific publications related to fire have grown exponentially. This includes a focus on the importance of fire as an ecological disturbance in sustaining ecosystems throughout the world, as well as a cultural appreciation of the role of fire for indigenous people. In centuries past, people and fire were coupled and those who understood fire were cultural leaders. As we entered the industrial era, we developed the perspective that we were masters of our domain and fire was something destructive that should be controlled. Over the last 50 years, pioneers in fire ecology and the social sciences have developed an understanding of the importance of fire to various landscapes on our planet. There are specific scientific journals focused on fire ecology, as well as web-based tools that assist in planning in the use of fire. However, fire ecology and management is still on the periphery of disciplines like rangeland management and general ecology.

Supporting rangeland heterogeneity

For centuries, Native Americans used fire to control and manage prairie and rangeland grazed by herds of bison. Today, researchers at **Oklahoma State University** have found that this ancient technique could be key to conserving global grassland diversity

RANGELANDS MAKE UP 70 per cent of the Earth's land surface and provide essential grazing areas for all manner of herbivores. Although they are crucial to livestock production, rangelands are also home to a wide array of smaller animals and birds which are under threat from modern land management techniques. The trend to prioritise the grazing needs of livestock over the preservation of biodiversity has led to an increasingly homogenised landscape, to which many other species are struggling to adapt. This has ignited a much needed debate between land managers, scientists and government organisations about how best to preserve the diversity of these complex landscapes.

Regents Professor Samuel D Fuhlendorf and his colleagues at the Rangeland Ecology and Management Department of Oklahoma State University are making an exciting contribution to this debate. They are working to understand the complexities of rangeland ecology and

are applying their findings to developing more sustainable rangeland management techniques. A key focus of their research has been the impact of fire on the flora and fauna of rangeland, and the potential of the so-called patch-burning approach to landscape management. Their research calls into question conventional ideas about livestock rearing and grazing management. In order to describe their findings about the complex relationship between fire and the diversity of rangeland ecosystems, they have coined the term pyric herbivory.

HOMOGENEITY VERSUS HETEROGENEITY

Fuhlendorf's work aims to counter the current decline in rangeland diversity. Contemporary rangeland management has overseen an alarming drop in the populations of 29 bird species native to the North American prairies. This decline can largely be attributed to the agricultural technique of rotational grazing in

addition to fire suppression and cultivation. This style of grazing management controls where and when livestock graze by rotating them quickly through different pastures. It has a homogenising effect on the landscape because each area is grazed in equal measure, so no patches of prairie are over or under grazed. The landscape thus becomes more uniform in terms of the types of plants that grow there and consequently the birds and animals it supports.

This practice is not the most efficient in terms of agricultural output, argues Fuhlendorf: "Rotational grazing treats rangelands and prairies as more similar to agricultural fields than natural ecosystems, limiting the ability of rangelands to sustainably produce agricultural commodities and provide critical habitat for some of the most threatened species in the world," he explains. It is a complete contrast to the method favoured for centuries by Native Americans. They used controlled fires to vary

INTELLIGENCE

ROLE OF HETEROGENEITY IN MANAGING RANGELANDS FOR MULTIPLE USES

OBJECTIVES

To evaluate the fire-grazing interaction on natural landscapes and develop rangeland management practices based on the interaction that can simultaneously enhance production and biodiversity.

KEY COLLABORATORS

David M Engle; Dwayne Elmore; Craig Davis; John Weir; Oklahoma State University

Bob Hamilton, The Nature Conservancy

Numerous graduate students and postdoctoral research associates

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SAMUEL FUHLENDORF is Regents Professor in Rangeland Ecology and Management at Oklahoma State University (OSU). He received the Outstanding Young Professional Award for the Society for Range Management in 2002, the James A Whatley Award of Merit for Research from OSU in 2001, the Outstanding Achievement Award for Research from the Society for Range Management in 2010, the Regents Distinguished Research Award at OSU in 2012 and was awarded Fellow of the DaVinci Institute for Creativity in 2013. His current research is focused on conservation of grassland landscapes. Specific areas focus on: understanding the role of disturbance-driven heterogeneity in the structure and function of grasslands; integrating a landscape perspective into rangeland ecology; fire ecology; and, understanding how herbivores use landscapes. Fuhlendorf currently teaches Applied Ecology and Conservation, Applied Landscape Ecology and Ecology of Fire Dependent Ecosystems. He has published over 80 peer-reviewed articles in international journals.



the landscape, burning patches so that bison or cattle could enjoy the fresh shoots of new post-burn vegetation before moving onto another patch, leaving the previously burned patches to recover their vegetation. This technique created a mosaic effect of different vegetation at different stages of growth, including areas heavily grazed and ungrazed for many years – the opposite of today's trend towards uniformity – and made the rangelands and prairies home to a diverse variety of flora and fauna.

This research thus raises some interesting cultural questions. Modern man, in this post-industrial age, regards fire as a destructive and dangerous force – which indeed it can be, if left unattended. However, it is becoming increasingly clear that sustaining the renowned ecological diversity of rangelands and prairies around the world demands a return to pre-industrial attitudes towards fire. Fuhlendorf elaborates on the existing cultural barriers to adopting traditional pyric herbivory management techniques: "Heterogeneity is something that is inherently challenging for the developed world to embrace. We typically like landscapes that are uniform, linear and constant rather than highly variable landscapes that are chaotic in space and time". Homogeneity may be more straightforward to manage, but heterogeneity is key to conserving biodiversity.

A BURNING ISSUE

Fuhlendorf and his team have never shied away from the difficulties posed by studying heterogeneity. Their work has shown that fire and grazing are irrevocably linked in shaping rangelands; studying them in isolation perpetuates an overly simplistic picture which ignores the complex interactions between grazing livestock, vegetation, fire and the other animals that make up these important ecosystems. This approach makes for challenging research, but it is essential in order to reflect these real-world complexities. The team has carried out careful studies over varying time spans and distances to widen our understanding of these interactions.

A notable example is an original case study conducted in collaboration with the Tallgrass Prairie Preserve in Oklahoma. Here the patch-burn approach was introduced with a very positive impact on the biodiversity of the area. Grazing bison are free to roam and enjoy

unrestricted access to all the different types of grass that grow. They are most attracted to the areas which have been most recently burnt and where the vegetation is mostly made up of new green shoots. This means that longer, unpalatable grasses are left undisturbed by the bison, and overall a heterogeneous environment emerges where a greater variety of animal, bird and plant species can flourish. The burnt patches are randomly distributed to create a mosaic of different vegetation at different stages of growth.

Increased biodiversity was not the only benefit observed by the researchers. Fuhlendorf and his team also found the pyric herbivory approach was good for the livestock. "When pyric herbivory is used as a management tool," Fuhlendorf explains, "it can improve forage quality available to livestock, improve biodiversity, limit woody plants and other invasive species, limit pests, such as ticks and horn flies, and sustain or enhance livestock production when compared to traditional management". The animals at the Tallgrass prairie reserve had a healthier diet and required fewer protein supplements than those in areas managed through rotational grazing, making it significantly cheaper for the livestock producers.

BACK TO THE FUTURE

These convincing results make this work a vital contribution to the debate about how to conserve rangeland biodiversity. In a quarrel otherwise dominated by discussion about the role of grazing herbivores in shaping the landscape, this research has brought a wider, more holistic perspective of rangeland ecology to the fore. Although grazing herbivores are of course an important part of the equation, Fuhlendorf is keen to refocus attention on the use of fire as a management technique for rangeland and prairies. His work has shown that this would be a far more effective way to restore these landscapes to their former diversity.

The idea is slowly but surely catching on. From the initial partnership with the Tallgrass Prairie Preserve, the technique has spread to state and federal reserves across the Great Plains and North America, and now it is even crossing continents. Particularly exciting for Fuhlendorf though is the fact that Native American tribes are keen to restore patch fires to manage the land in their control: "This means we will have come full circle – after all, indigenous peoples are really the ones that invented pyric herbivory".