**////Title: Measuring Ecological Resilience to Combat Wildfires**

**////Standfirst:**

Invasive plants can permanently alter ecosystems to promote conditions that support their own persistence. For example, certain invasive grasses can make areas prone to more frequent and larger wildfires, which negatively impact native species but favour fire-resistant invaders. This self-perpetuating process, termed a grass-fire cycle, can be impossible to reverse. Dr Jeanne Chambers of the United States Department of Agriculture’s Rocky Mountain Research Station and her colleagues – Matt Brooks, Matt Germino, Jeremy Maestas, David Board, Matt Jones, and Brady Allred – recently examined how an ecosystem’s resilience to fire and resistance to invasive grasses influence whether a grass-fire cycle will establish. In their paper, the scientists introduced a geospatial tool and decision matrix that incorporate measures of ecological resilience and resistance to invasive grasses for designing management strategies to combat grass-fire cycles.

**////Main text:**

Fire regimes refer to the historic pattern of wildfires in an area. They are characterised by fire seasonality, frequency, and intensity. The most important characteristics influencing fire regimes are climate, topography, soils, and type of vegetation. Whenever any of these factors shift, the types of fires common to an area may change.

Whether or not a fire ignites and spreads depends on several interactive factors. First, there must be fuel, which means plant biomass – both living and dead. The amount and condition of these fuels matter – how large, how much, and how dry. Second, an ignition source is needed. These are often lightning strikes, but humans can also be the cause. Last, weather conditions – including temperature, relative humidity and wind – are important because they have a big effect on fire severity and extent.

In drylands, invasions by non-native grasses into shrublands and woodlands change the kinds of fuel that are available and the way that fires burn. Invasive grasses can fill the spaces between shrubs and trees, resulting in a continuous bed of fuels. Because the invaders produce more fine fuels than the ecosystems they invade, and often dry out early in the fire season, they also increase flammability. The fire cycles that develop result in larger, more frequent fires. These ‘grass-fire’ cycles can be difficult to reverse as each player – wildfire and grass – perpetuates the other.

By dramatically increasing fine fuels over a short period of time, grass invasions cause fires in areas that rarely burned previously. Native plants in these areas, which had no need to develop fire-resistant traits in the past, often don’t survive, resulting in a landscape dominated by invasive grasses. Climate change is adding more kindling to the mix, by causing longer and more severe fire seasons – a trend that is projected to increase into the future.

Dr Jeanne Chambers of the United States Department of Agriculture’s Rocky Mountain Research Station realised that we could use knowledge of an ecosystem’s resilience to wildfire and resistance to grass invasions to determine an area’s susceptibility to grass-fire cycles. In a 2019 paper published in *Frontiers in Ecology and Evolution*, Dr Chambers and her colleagues describe the factors that determine resilience and resistance, and how they vary across the expansive Cold Desert ecosystems in the western US. They illustrate how geospatial tools can be used to identify an area’s relative resilience and resistance, and to determine which areas will benefit from targeted management actions to prevent grass-fire cycles from developing.

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Dr Chambers and her colleagues discuss the factors that determine an ecosystem’s susceptibility to grass-fire cycles, emphasising the importance of resilience to wildfires and resistance to invasive grasses. They also note the importance of ‘spatial resilience’, which describes the influence of landscape characteristics, such as the patterns of different types of vegetation across landscapes. Interactions among these factors determine an ecosystem’s ability to ‘bounce back’ or recover following a disturbance, such as a wildfire.

Managers can determine whether an ecosystem is resilient to wildfire by evaluating how likely it is to return to its initial state and how much time it takes to recover. This requires knowledge of the ecosystem’s environmental characteristics – climate, topography, and soils – as well as the type and ecological condition of the vegetation. For example, after a wildfire, relatively cool and moist areas with productive native vegetation will typically experience a smaller change from the initial state and recover more quickly than warm and dry areas with low productivity.

In the case of invasive grass resistance, similar factors are evaluated. Climate and soils determine whether a particular invasive grass is capable of establishing and expanding in an area. Competitive interactions with the native plant community determine whether the invader is successful. For example, a healthy, productive plant community can often out-compete and exclude the invader.

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Land managers use geospatial tools such as remote sensing to assess resilience to different types of disturbances over large landscapes. These tools evaluate spatial resilience by considering various factors – including environmental conditions, the distribution of vegetation types, and human-caused changes to landscapes. Imagine looking at a Google Earth image of a recent wildfire in the middle of a pristine forest or shrubland – the disturbance is instantly apparent.

Geospatial tools can also be used to plan management actions in areas at risk of developing grass-fire cycles. Although measures of resilience and resistance are obviously useful in evaluating these at-risk areas, Dr Chambers and her colleagues were the first to suggest that we could use spatial measures of resilience and resistance to refine management plans targeted at preventing grass-fire cycles.

The scientists used soil temperature and moisture regimes from the USDA National Cooperative Soil Survey as a measure of resilience and resistance. They overlayed these regimes with the land cover of native vegetation types derived from remote sensing. By adding the land cover of invasive grasses and an index of fire risk, they were able to assess where grass-fire cycles already existed and where they were likely to develop in the future. The team showed that the susceptibility of Cold Desert ecosystems to grass-fire cycles increases in areas with warm and dry summers that have more woody fuels, fewer competitive native perennial grasses, and higher fire risk. Consequently, these areas should be prioritised for management actions to decrease fire ignitions and spread.

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To help target areas for management actions across large landscapes, Dr Chambers and her colleagues created a decision matrix that considers different levels of resilience and resistance in relation to the land cover of high value native vegetation. For example, ecosystems with high resilience and resistance are typically less susceptible to invasion by annual grasses, show less change after a wildfire, and recover more quickly than areas with low resilience and resistance.

Consequently, an area with high resilience and a moderate to large extent of native vegetation typically has the capacity to recover after wildfire with minimal management intervention. In contrast, an area with low resilience and resistance often requires substantial management intervention to decrease the risk of annual grass invasion and maintain or enhance ecological conditions, regardless of the extent of native vegetation.

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By linking fundamental ecological concepts with geospatial tools and a decision matrix to help prioritise management actions, Dr Chambers and her colleagues have addressed a pressing land-management issue. They have shown that spatial resilience measures can provide the scientific basis for maximising conservation and restoration efforts across large landscapes.

The authors suggest that an adaptive management approach, which monitors outcomes of management interventions and incorporates new information, will be needed to help prevent new invasions and continued development of ‘grass-fire’ cycles in this era of global change.

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This SciPod is a summary of the paper ‘Operationalizing Resilience and Resistance Concepts to Address Invasive Grass-Fire Cycles’, from *Frontiers in Ecology and Evolution.* <https://doi.org/10.3389/fevo.2019.00185>

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