Manage woody plants in grasslands using thresholds

A summary of Dirac Twidwell, Samuel D. Fuhlendorf, Charles A. Taylor Jr. and William E. Rogers, 2013
By Sherry Middlemis-Brown

WHAT ROLE DO ECOLOGICAL THRESHOLDS PLAY IN GRASSLAND RESTORATION?

Land managers often must set restoration priorities without quantitative information on what conditions would reliably eliminate undesirable species and restore ecosystems. Managers apply general ideas, such as that the target, undesirable species are susceptible to fire, without specifics on the necessary fire intensity that will cause mortality for all life stages of the target species. This makes developing a pathway to achieve restoration goals very difficult.

One quantitative approach to prioritizing management actions uses a stepwise process. It starts by quantifying thresholds at which abrupt changes occur within ecological systems. In the case of prescribed fire in grasslands, thresholds can represent the fire intensity that results in death of a target species. By combining ecological models (fire intensity needed for mortality) and fire models (conditions that result in desired intensity), we can understand mechanisms that influence woody plant encroachment in grasslands. Twiddwell, et al. (2013) demonstrated how fire and ecological models can be used to determine appropriate management actions to reduce juniper trees (*Juniperus* spp.) in a grassland.

POSTIVE FEEDBACK SYSTEMS — SYSTEMS ALTER FOR SELF-BENEFIT

Two species of native juniper (*J. ashei* and *J. virginiana*) trees rapidly encroach into grasslands. Being fire sensitive, they should succumb to prescribed fire, but in fact, prescribed fire rarely kills large juniper trees. Subsequent fires fail to remove survivors, largely because loss of fuel loads reduces fire intensity. Moreover, as junipers displace grasses, altering the eco- logical system, fine fuels decrease, further reducing fuels immediately beneath the trees.

Therefore, the manager must be able to link ecological and physical-fire models to estimate the fire intensity needed to eradicate juniper trees and the fuel loading immediately beneath the trees necessary to achieve the required fire intensity. Other conditions, such as moisture content in the crowns of the trees, also affect success in achieving the required conditions to kill juniper trees in all life stages.

THE ECOLOGICAL AND PHYSICAL MODELS

The land manager's problem then becomes determining on-the-ground conditions that will achieve the mortality threshold for the target species. Twidwell, et al., identified the ecological conditions where fire intensity is most likely to reach the mortality threshold needed to achieve restoration objectives in encroaching juniper. Their example of a "state-and-transition model" to restore the juniper woodland transitional system to a grassland system appears on the back of this research brief.

Managers can apply the principles of this example of using ecological and physical-fire models to other grassland / woodland transitional systems. The key is to quantify the fire intensity required to achieve the threshold that changes the ecological system. Once the conditions of the existing system are known, and the conditions required for success determined, the information may be used in management prioritization.

State 1: Desired State. The desired state is grassland. If this state exists, then only maintenance fires are required.

The stability of this grassland is maintained through periodically occurring fires, a natural process.

State 2: Early Degraded. Juniper encroachment has reduced fine fuel load, but fuels can be increased by removing grazers. Meeting objectives and surpassing the intensity–mortality threshold of *J. ashei* (I_s > 160 kJ m^{-1} s^{-1}) depends on herbaceous fuel loads under trees, and on conditions influencing juniper tree flammability. Foliage moisture content of 80% or less results in complete scorch and mortality in mature trees when fine fuels extend under the trees.

Fire can kill isolated juniper trees if managers achieve high fine fuel loads, low fine-fuel moisture levels, or other environmental factors important to fire intensity.

State 3: Moderately Degraded. Fine fuel load cannot be increased to sufficient levels with management to achieve the fire intensity-mortality threshold, but fine fuels can carry surface fires. Therefore, burn when fine fuel and foliage moisture levels are both low to increase fire intensity for complete scorch and mortality in mature trees.

Managers find reversing the trend away from the desired system difficult, but can target low fuel moisture levels to meet restoration goals.

State 4: Heavily Degraded. Fine fuel load is not sufficient to support surface fires. Fire can still occur as ground fires through the juniper duff and as crown fires. For restoration, burn during environmental conditions that lead to sustained crown fires, such as

System has become stable in the degraded state and does not support grassland processes.

Summary of *Dirac Twidwell, Samuel D. Fuhlendorf, Charles A. Taylor Jr., and William E. Roger. 2013. Refining thresholds in coupled fire–vegetation models to improve management of encroaching woody plants in grasslands. Journal of Applied Ecology 50:603-613.*

Dirac Twidwell provided photos on this page.

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