GPGEP-UNL-03

Integrated Pest Management for Woody Encroachment

Dillon Fogarty[1], Casey Matzke[2], Morgan L. Treadwell[2], Carol Baldwin[3], Laura Goodman[4], Torre Hovick[5], Annie Overlin[6], J. Derek Scasta[7], Allison Thompson[4], and Dirac Twidwell[1]

[1]University of Nebraska, [2]Texas A&M AgriLife Extension Service, [3]Kansas State University, [4]Oklahoma State University, [5]North Dakota State University, [6]Colorado State University, and [7]University of Wyoming

Key Takeaways

- Great Plains grasslands are collapsing due to woody encroachment. Past brush management efforts have been unable to stop or reverse the loss of grasslands at county, state, and regional scales, resulting in the loss of 22.4 million tons of rangeland production every year due woody encroachment.
- Integrated Pest Management (IPM) is decision-making process that uses knowledge of pest biology to better manage pests in agricultural and non-agricultural lands.
- When applied to woody pests, IPM overcomes weakness of past brush management efforts and provides many benefits in grasslands, similar to pest control in croplands.
- The Great Plains Grasslands Initiative (GPGI) is the first conservation initiative to use IPM as a framework for improving brush management. This initiative applies the PAMS approach to Prevent, Avoid, Monitor, and Suppress woody pests in grasslands as part of ongoing efforts to save the last Great Plains grasslands.

Top 5 woody pests in Great Plains grasslands

1. **Eastern redcedar** (*Juniperus virginiana*)
2. **Honey mesquite** (*Prosopis glandulosa*)
3. **Chinese tallow** (*Triadica sebifera*)
4. **Ashe juniper** (*Juniperus ashei*)
5. **Redberry juniper** (*Juniperus pinchotii*)

The problem

Past brush management efforts have failed to maintain Great Plains grasslands in the face of woody encroachment [1–3]. Traditional brush management efforts assumed that 1) there are tolerable levels of the top five woody pests in grasslands before encroachment becomes a resource concern, and 2) that mechanical or chemical removal of woody plants will restore a site back to a grassland [4,5]. In reality, brush management begets more brush management because of reinvasion [4,6]. This leads to the horror stories from the southern Great Plains where the value of the ranch was paid three times over to cover brush management costs. Scientists now recommend more integrated approaches for dealing with woody pests and ending the reinvasion cycle [7].

Integrated pest management in rangelands: A new approach

Pests are defined as organisms that pose economic, environmental, and health risks [8]. In cropland agriculture, Integrated Pest Management (IPM) is a preferred approach for managing pests. IPM is defined as "a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks [8]."

Common weedy pests in croplands are palmer amaranth (*Amaranthus palmeri*), kochia (*Kochia scoparia*), and common lambsquarters (*Chenopodium album*), so IPM is used to prevent impacts to crop yields while also minimizing the risks associated with chemical controls.

Applying IPM methods for woody encroachment can provide many benefits in grasslands similar to pest control in croplands. Encroaching woody pests reduce forage production in grasslands and threaten rancher livelihoods. New IPM recommendations for woody encroachment are built around the biology of pests and emphasize proactive controls to prevent losses in forage production. IPM for woody encroachment seeks to:

- Prevent the expansion of woody pests into intact (tree free) grasslands,
- Reduce existing infestations of woody pests, and
- Minimize the economic, environmental, and health risks associated with woody encroachment and control treatments.

Why are encroaching woody plants considered pests?

Encroaching woody plants pose economic, environmental, and health risks in Great Plains grasslands. Woody pests are species that cause state transitions in grasslands and are associated with a wide range of impacts to human well-being [9]:

Economic risks

The annual economic impact of forage production losses due to woody encroachment is valued at $323 million in the Great Plains, with an estimated 22.4 million tons of lost rangeland production [1,10]. These losses increase every year due to ineffective or absent woody plant control measures. In addition, brush management is among the most expensive conservation practices implemented in rangelands, which can result in ranch operating costs that quickly exceed revenues generated from livestock production.

Environmental risks

Woody encroachment causes a myriad of environmental impacts, ranging from reductions in water quantity and quality [11,12], the collapse of grassland biodiversity [13–15], increased risk of soil erosion due to the loss of grassland plants and increased bare ground cover [16], and shifts in carbon storage from highly resilient belowground carbon pools to highly vulnerable aboveground carbon pools associated with woody dominance [17,18].

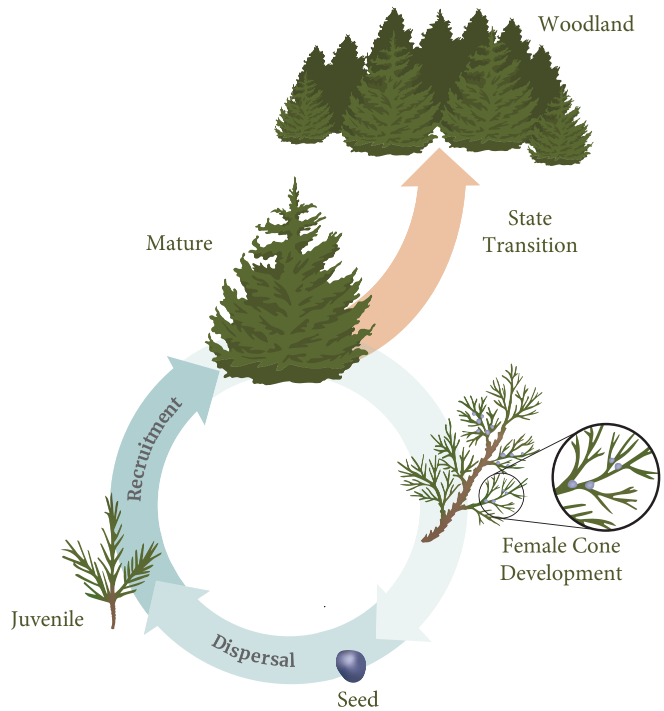


Fig. 1. Traditional brush management targets mature trees and the woodland transition stage (red arrow). IPM provides a framework for targeting seed and seedling stages (blue arrows) that would otherwise cause rapid reinvasion after brush management.

Health risks

Woody encroachment is known to endanger human health through three primary pathways: 1) increased seasonal allergies and reduced respiratory health from woody plant pollen [19]; 2) increased risk of wildfires from woody plants with high fuel volatility [20,21]; 3) increased risk of encountering vector-borne diseases like West Nile virus and Rocky Mountain spotted fever from mosquitoes and ticks which prefer encroached sites [22].

IPM uses the PAMS approach

IPM consists of a combination of strategies to **P**revent, **A**void, **M**onitor, and **S**uppress (PAMS) woody pests in grasslands.

Prevent contamination of intact grasslands

The prevention of woody plant infestations in intact grasslands is the top priority for resource management planners. Best management practices are to prevent the introduction of seed sources into intact grasslands and halt the advancement of seed sources from neighboring lands.

How far should I be from seed sources to prevent the problem?

Most seedling recruitment occurs close to existing seed sources [23], so 200 yards is used as a general guideline for preventing the problem, but the goal is to maximize distance between grasslands and seed sources. Livestock can be a source of long-distance seed dispersal when their manure contains seeds of woody pests (e.g., mesquite and honey locust), so caution should be used when moving livestock from woody infested pastures to intact grasslands (seeds should clear from the digestive tract within approximately 5 days after consumption).

Intact grassland landscape in the Nebraska, Sandhills.

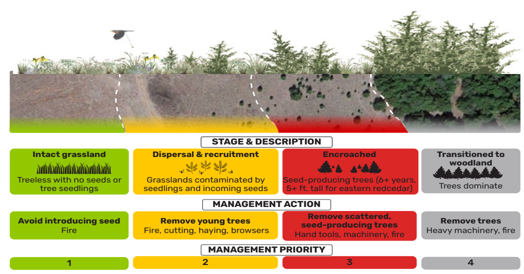
A prescribed fire used to target seedlings. (photo: Shelly Kelly)

Avoid transitions from seedling to seed source

Avoidance practices are used to stop infestations from escalating and can reduce or eliminate the need for more expensive treatments in the future.

What should I target to avoid the problem?

Target seedlings to avoid the development of mature, seed bearing individuals. Prescribed burning, biological control with herbivores, haying, hand cutting, and herbicides are potential tools that can be used to target seedlings.



The stages of woody encroachment and corresponding management actions and priorities.

Monitor to reduce vulnerability

Monitoring is needed to inform prevention, avoidance, and suppression strategies. It is also used to track the progress of your plan.

What should I monitor?

Monitor and map the stages of woody encroachment across the landscape to inform planning and decision-making (see Fogarty and others' (2023) pocket guide [24]).

Suppress the problem, don't wait

Suppression practices are used to reduce grassland vulnerability to woody plant encroachment.

What should I target for suppression?

Suppression requires the right practices in the right place at the right time. Use prescribed fire, mechanical clearing, or chemical treatments to remove mature trees and then follow up with additional treatments to deplete the seedbank and prevent re-infestation.

Suppression of mature woody plants with heavy equipment.

When should I start using IPM?

Agricultural producers are encouraged to start IPM in croplands before problems are detected; the same early intervention is recommended for producers in rangeland and grassland systems. There are no ‘tolerable’ levels of woody pests. By the time woody pests are established, the most cost-effective opportunities for management have passed.

Is IPM for reducing woody pests climate smart?

The Food and Agricultural Organization (FAO) describes climate-smart agriculture as a three pillared approach:

☑ **Sustainably Increase Agricultural Productivity and Incomes**

IPM prevents woody encroachment from decreasing agricultural production, restores lost production in landscapes impacted by woody encroachment, and maintains or increases ranch profitability. In addition, IPM emphasizes sustainable approaches to pest management that reduces the need for expensive management interventions that increase the cost of livestock production.

☑ **Adapt and build resilience to climate change**

IPM provides a sustainable approach for maintaining grasslands as a resilient carbon sink. Approximately 81% of total grassland carbon is stored belowground where it is less vulnerable to rapid loss in a changing climate [17,18]. IPM for woody pests also supports the maintenance of a wide range of goods and services that bolster the resilience of Great Plains communities to climate change, including rangeland production, rancher livelihoods, grassland biodiversity, pollinator communities, water quality and quantity, and regulation of wildfire risk. Lastly, IPM minimizes the use of costly herbicides that increase ranch operating costs and pose environmental risks.

☑ **Reduce and/or remove greenhouse gas emissions where possible**

IPM helps grasslands keep carbon underground and minimizes losses to the atmosphere during wildfire. Grasslands provide a robust, multi-century belowground carbon sink (“entombed carbon”) [25]. In contrast, aboveground carbon pools in woodlands and forests are at risk to switching from carbon sinks to sources given the increasing risk of wildfire associated with woody encroachment in the Great Plains [18,21,26].

Where is IPM being implemented to better manage woody species?

The Great Plains Grasslands Initiative (GPGI) is the first initiative that uses IPM as a framework for better managing woody encroachment. The GPGI is a multi-state effort focused on saving the last remaining Great Plains grasslands from collapse. IPM with PAMS combines practices like brush management, prescribed burning, and monitoring to reduce grassland vulnerability to woody encroachment and overcome central weaknesses of brush management as a stand-alone conservation practice. Oklahoma, Kansas, Nebraska, and South Dakota currently have ongoing GPGI efforts and there is interest in other states within the Great Plains Grasslands Extension Partnership to expand this initiative and adopt IPM for woody encroachment.

References

[1] S. L. Morford et al., “Herbaceous production lost to tree encroachment in United States rangelands,” J. Appl. Ecol., vol. 59, no. 12, pp. 2971–2982, Dec. 2022.

[2] M. O. Jones, D. E. Naugle, D. Twidwell, D. R. Uden, J. D. Maestas, and B. W. Allred, “Beyond inventories: emergence of a new era in rangeland monitoring,” Rangel. Ecol. Manag., vol. 73, no. 5, Sep. 2020.

[3] D. T. Fogarty et al., “Woody plant encroachment and the sustainability of priority conservation areas,” Sustainability, vol. 12, no. 20, p. 8321, Oct. 2020.

[4] S. R. Archer, K. W. Davies, T. E. Fulbright, K. C. Mcdaniel, B. P. Wilcox, and K. I. Predick, “Brush management as a rangeland conservation strategy: A critical evaluation,” in Conservation benefits of rangeland practices: assessment, recommendations, and knowledge gaps, D. D. Briske, Ed. US Department of Agriculture, Natural Resources Conservation Service, 2011, pp. 105–170.

[5] C. P. Roberts, D. R. Uden, C. R. Allen, and D. Twidwell, “Doublethink and scale mismatch polarize policies for an invasive tree,” PLoS One, vol. 13, no. 3, p. e0189733, 2018

[6] D. T. Fogarty, C. de Vries, C. Bielski, and D. Twidwell, “Rapid re-encroachment by Juniperus virginiana after a single restoration treatment,” Rangel. Ecol. Manag., vol. 78, pp. 112–116, Sep. 2021.

[7] D. Twidwell, D. T. Fogarty, and J. R. Weir, “Reducing risk and vulnerability to woody encroachment in grasslands,” Oklahoma Coop. Ext. Serv., p. E-1054, 2021.

[8] 7 U.S.C. 136r-1 - Integrated Pest Management

[9] D. T. Fogarty et al., “Remove, reduce, or manipulate? Best practices for brush management conservation standards in Great Plains grasslands,” Gt. Plains Grasslands Ext. Partnersh., no. GPGEP-UNL-02, 2023.

[10] D. T. Fogarty et al., “Rangeland production lost to woody encroachment in Great Plains grasslands,” Gt. Plains Grasslands Ext. Partnersh., no. GPGEP-UNL-01, 2023.

[11] C. Zou et al., “Impact of eastern redcedar proliferation on water resources in the Great Plains USA—current state of knowledge,” Water, vol. 10, no. 12, p. 1768, Dec. 2018.

[12] Y. Kishawi, A. R. Mittelstet, T. E. Gilmore, D. Twidwell, T. Roy, and N. Shrestha, “Impact of Eastern Redcedar encroachment on water resources in the Nebraska Sandhills,” Sci. Total Environ., vol. 858, p. 159696, Feb. 2023.

[13] J. M. Briggs, G. A. Hoch, and L. C. Johnson, “Assessing the rate, mechanisms, and consequences of the conversion of tallgrass prairie to Juniperus virginiana forest,” Ecosystems, vol. 5, no. 6, pp. 578–586, 2002.

[14] R. N. Chapman, D. M. Engle, R. E. Masters, and D. M. Leslie, “Tree invasion constrains the influence of herbaceous structure in grassland bird habitats,” Ecoscience, vol. 11, no. 1, pp. 55–63, 2004.

[15] V. J. Horncastle, E. C. Hellgren, P. M. Mayer, A. C. Ganguli, D. M. Engle, and D. M. Leslie, “Implications of invasion by Juniperus virginiana on small mammals in the southern Great Plains,” J. Mammal., vol. 86, no. 6, pp. 1144–1155, 2005.

[16] F. B. Pierson, J. D. Bates, T. J. Svejcar, and S. P. Hardegree, “Runoff and erosion after cutting western juniper,” Rangel. Ecol. Manag., vol. 60, no. 3, pp. 285–292, May 2007.

[17] J. M. Adams, H. Faure, L. Faure-Denard, J. M. McGlade, and F. I. Woodward, “Increases in terrestrial carbon storage from the Last Glacial Maximum to the present,” Nature, vol. 348, no. 6303, pp. 711–714, 1990.

[18] P. Dass, B. Z. Houlton, Y. Wang, and D. Warlind, “Grasslands may be more reliable carbon sinks than forests in California,” Environ. Res. Lett., vol. 13, no. 7, p. 074027, Jul. 2018.

[19] M. Flonard, E. Lo, and E. Levetin, “Increasing Juniperus virginiana L. pollen in the Tulsa atmosphere: long-term trends, variability, and influence of meteorological conditions,” Int. J. Biometeorol., vol. 62, no. 2, pp. 229–241, Feb. 2018.

[20] V. M. Donovan, D. T. Fogarty, and D. Twidwell, “Spot-fire distance increases disproportionately for wildfires compared to prescribed fires as grasslands transition to Juniperus woodlands,” PLoS One, vol. 18, no. 4, p. e0283816, Apr. 2023.

[21] V. M. Donovan, C. L. Wonkka, D. A. Wedin, and D. Twidwell, “Land-use type as a driver of large wildfire occurrence in the U.S. Great Plains,” Remote Sens., vol. 12, no. 11, p. 1869, Jun. 2020.

[22] S. R. Loss, B. H. Noden, and S. D. Fuhlendorf, “Woody plant encroachment and the ecology of vector-borne diseases,” J. Appl. Ecol., vol. 59, no. 2, pp. 420–430, Feb. 2022.

2021.

[23] D. T. Fogarty, R. B. Peterson, and D. Twidwell, “Spatial patterns of woody plant encroachment in a temperate grassland,” Landsc. Ecol., vol. 37. pp. 2835–2846, Sept. 2022.

[24] D. T. Fogarty et al., “Reducing Woody Encroachment in Grasslands: A Pocket Guide for Planning and Design.,” Gt. Plains Grasslands Ext. Partnersh., no. GPGEP-PB-01, 2023.

[25] Y. Bai and M. F. Cotrufo, “Grassland soil carbon sequestration: Current understanding, challenges, and solutions,” Science., vol. 377, no. 6606, Aug. 2022.

[26] V. M. Donovan, C. L. Wonkka, and D. Twidwell, “Surging wildfire activity in a grassland biome,” Geophys. Res. Lett., vol. 44, no. 12, pp. 5986–5993, Jun. 2017.