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America's Billion-Dollar Tree Problem Is Spreading

Grasslands are being overrun by drought-resistant invaders that wreck animal habitats, suck up water supplies, and can cost landowners a fortune.



PHOTOGRAPH: LEE RENTZ/ALAMY

FAST-GROWING, DROUGHT-TOLERANT TREES are slowly spreading across grasslands on every continent except Antarctica. Given how desperate we are to reduce carbon in the atmosphere, millions of new saplings sprouting each year might seem like a good thing. But in reality, their spread across vulnerable grasslands and shrublands is upending ecosystems and livelihoods. As these areas transform into woodland, wildlife disappears, water supplies dwindle, and soil health suffers. The risk of catastrophic wildfire also skyrockets.

In a new study published in the *Journal of Applied Ecology*, researchers have shown how woodland expansion also takes an economic toll. American ranchers often depend on tree-free rangelands to raise their livestock. Between 1990 and 2019, landowners in the Western US lost out on nearly \$5 billion worth of forage—the plants that cattle or sheep eat—because of the growth of new trees. The amount of forage lost over those three decades equates to 332 million tons, or enough hay bales to circle the globe 22 times.

“Grasslands are the most imperiled and least protected terrestrial ecosystem,” says Rheinhardt Scholtz, a global change biologist and affiliate researcher with the University of Nebraska–Lincoln. Also called steppes, pampas, or plains, our planet’s grasslands have dwindled drastically. According to Scholtz, less than 10 percent are still intact, as most have been plowed under for crops or bulldozed for human development. One of the most dire threats facing the grasslands that remain is woody encroachment. “It’s a slow and silent killer,” Scholtz says.

Historically, tree expansion onto grasslands was checked by regular fires, which relegated woody species to wet or rocky places. But as European settlers suppressed fires and planted thousands of trees to provide windbreaks for their homes and livestock, trees proliferated. When trees invade grasslands, they outcompete native grasses and wildflowers by stealing the lion’s share of sunlight and water. Birds, often used as a bellwether for ecosystem health, are sounding the alarm: North America’s grassland bird populations have declined more than 50 percent since 1970, a 2019 study in *Science* found.

According to University of Montana researcher Scott Morford, who led the study on rangeland forage loss, tree cover has increased by 50 percent across the western half of the US over the past 30 years. with tree cover expanding steadily year on

year. In total, close to 150,000 km² of once tree-free grasslands have been converted into woodland. “That means we’ve already lost an area the size of Iowa to trees,” says Morford, who emphasizes that an additional 200,000 km² of tree-free rangelands—an area larger than the state of Nebraska—are “under immediate threat” because they are close to seed sources.

To figure out the amount of lost forage production due to woodland expansion, Morford and his team used satellite images in combination with meteorological data, topography, and information about soils and on-the-ground vegetation to estimate the change in herbaceous biomass (that is, non-woody plants, like grasses) in relation to tree cover over time. “Our computer models allow us to turn up or turn down the tree cover like a knob on your stereo to see how production is impacted,” explains Morford.

After quantifying the change in herbaceous plants annually, researchers then determined the “yield gap” each year for every county in the 17 states that contain shrubland or grassland habitat. This gap is the difference between the actual herbaceous production (after trees had moved in) and potential herbaceous production (as if the trees had never moved in). Using pasture rental rates collected by the US Department of Agriculture (USDA), the researchers then converted that lost material into dollars and found that the value of the yield gap has ratcheted up and up. In 2000, close to \$100 million worth of forage was being lost each year; by 2010, that figure had surpassed \$200 million a year; and by 2019 it was over \$300 million. This puts the total losses for the 1990–2019 period at close to \$5 billion, with the cumulative loss accelerating upward.

Farmers often use yield gaps to estimate crop productivity, but this is the first time such figures have been determined for ranchers raising livestock on rangelands. “If there’s one thing we can all agree on, it’s that financial losses are something we don’t like. Linking the loss in rangeland productivity to financial losses—to me, that’s the silver bullet for conserving grasslands,” says Scholtz, who was not involved in the study.

Barb Cooksley, a rancher in the Sand Hills of Nebraska, sets a personal goal to lop at least 1,000 trees each year to keep her family’s patch of prairie thriving. Most are small seedlings that are invading her pastures. A study released earlier this year,

coauthored by Scholtz, identifies the Sand Hills as the most intact prairie left on Earth, and one of just seven remaining large grassland ecosystems. “This place is not supposed to have trees,” says Cooksley, who has a master’s degree in range ecology.

In the past, if a rancher like Cooksley wanted to know how much grass her land produced, she would have to go out with scissors to clip all of the plants growing in a plot, dry them, weigh them, and then extrapolate that across hundreds or thousands of acres. But now the new yield gap data is available online for anyone to use. Cooksley checked out the gap in Custer County, Nebraska, where her family ranches and says the numbers are “truly scary.” Landowners in her county have lost out on \$6.2 million worth of forage since 1990, with the graph showing steep declines in rangeland production beginning in 2007—a signal that grasslands are in trouble.

“From a producer’s perspective, you want to tackle woodland expansion before you start seeing herbaceous production drop off. If you wait until you have 10, 20, or 30 percent tree cover, you’re seeing big impacts on forage production, and tree removal becomes very expensive,” says Morford.

Cooksley says online mapping apps and historical aerial imagery are great outreach tools so “landowners can see what’s happening to their ground” and take action to halt woody encroachment. These tools make it more efficient and cost-effective for ranchers or land managers to pinpoint where to cut trees, use prescribed fire, or spray pesticide on seedlings to combat woody expansion on their grasslands.

Doug Spencer, the Kansas state grazing specialist for the USDA’s Natural Resources Conservation Service, says yield gap information will help “tell the story” of how trees are impacting rangelands that are home to livestock. For instance, Kansas lost nearly the same amount of forage to woody encroachment in 2019 as the state’s entire annual alfalfa supply—the most important type of hay harvested to feed cattle, grown on about 2,630 km² of fields in the state. This fact was met with “shock and awe,” says Spencer, when he shared the numbers at a recent presentation. He hopes the data will provide support for why and where the USDA and its partners invest conservation funding. “This yield gap data can better inform us what’s at risk and where we can defend our core grasslands.”


Woody encroachment is also threatening the viability of ranchers further west in the

sagebrush biome, an arid landscape dominated by shrubs, grasses, and wildflowers that covers an area larger than Ukraine across 11 Western states. According to a [preprint](#) released earlier this year, tree coverage has increased sixfold in sagebrush country over the past 150 years. “Wherever we have thick juniper, we’ve got very little grass. There’s nothing underneath but bare soil,” says Bruce Peterson, a rancher near Sheridan, Montana. Peterson has worked with a collaborative group called the Southwest Montana Sagebrush Partnership that has used [historical satellite imagery and remote sensing technology](#) to target tree-removal efforts. The partnership has restored nearly 40,000 acres of grazing land in Montana.

Similar technology is also being used to evaluate the effectiveness of projects that tackle woodland expansion. A [recent study](#) in the *Journal of Environmental Management* measured the change in herbaceous plants after tree-removal efforts on pastures in Oregon, Nebraska, and Kansas, showing mostly positive results. “These next-generation technologies unify neighbors around dealing with shared problems,” says Caleb Roberts, a research ecologist with the United States Geological Survey in Arkansas who led the study.

Back in the Sand Hills, Cooksley and her husband are making a succession plan to pass on the ranch to their family. Part of that plan includes continuing her legacy of controlling woody encroachment. If she sees a seedling sprouting on her daily drives around the ranch, Cooksley always stops to cut it down, and she makes sure her children and husband keep a pair of loppers handy in their trucks too. She also hires contractors with machines to cut bigger trees each year and sees the value in using prescribed burns or herbicide treatments to keep trees at bay. “We have a continuous battle ahead of us,” she says.

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