Cost of Removing and Assembling Biomass from Rangeland Encroaching Eastern Redcedar Trees for Industrial Use

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On the Ground

- Eastern redcedar trees have encroached on Great Plains grasslands and are spreading at a glacial pace, reducing forage production, destroying native ecosystems, and producing human health harming allergens.
- The study was conducted to determine the expected cost to deliver a flow of feedstock to an optimal factory location for a business designed to use eastern redcedar biomass harvested from grasslands.
- Proportion of trees available for removal, quantity of feedstock required, harvest costs, and tree growth rate are critical factors.
- Assuring investors that a flow of eastern redcedar trees for industrial use would be attainable for 20 years at a reasonable cost may be challenging.

Keywords: eastern redcedar, encroaching species, economics, removal, business.

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Suppression of prairie fires enabled eastern redcedar (*Juniperus virginiana*) to encroach and thrive on thousands of U.S. Great Plains rangeland hectares. Eastern redcedar reduces forage production, destroys native ecosystems, increases the risk of wildfires, and produces allergens that harm human health. The species is costly to control. Researchers have investigated potential uses of the biomass in an attempt to incentivize entrepreneurs to assist landowners by harvesting the unwanted trees and using them as feedstock for a profitable business. Information regarding the quantity of biomass available for the expected life of a processing facility designed to use the trees as well as harvest and procurement cost would be required. The objective of this study was to determine for a case study region the potential available quantity and feedstock cost for a business designed to use eastern redcedar trees. A mixed integer mathematical programming model was constructed and used to determine the cost to obtain the rights to remove, harvest, and deliver a specified tonnage of eastern redcedar trees each year, for a period of 20 years, to an optimally located processing facility. The optimal strategy depends on tree density, proportion available for removal, growth rate, discount rate, harvest cost, transportation cost, and required tonnage.

Introduction

Eastern redcedar (*Juniperus virginiana*) (ERC) is one of 13 juniper species native to the United States.[1] Prior to the settlement of Europeans in North America, this species persisted on rocky bluffs, and in deep canyons and other areas where fire historically did not occur.[2] Suppression of prairie fires enabled ERC to grow and thrive in environments previously dominated by prairie grasses.[2] The encroachment of ERC is a problem in many areas of the Great Plains.[3–8] Engle et al. reported that ERC has encroached on Great Plains grasslands ranging from Texas in the South to Alberta in the North and is spreading at an insidious pace.[9] They refer to the ERC encroachment on grasslands as a green glacier.[9] In addition to the suppression of fire, the encroachment of ERC is facilitated by its adaptability to growing in various types of soils and climatic conditions.[1,9–11]

ERC has become a very serious problem in the Southern Plains state of Oklahoma. It has been estimated that ERC becomes established on an additional 120,000 Oklahoma hectares (297,000 acres) each year.[12] ERC reduces forage production on pasturelands, destroys native ecosystems such as habitat of the lesser prairie chicken (*Tympanuchus cupido*) and produces allergens that harm human health.[8,12–14] ERC has low-hanging branches, and ERC foliage contains volatile oils that can easily be ignited by grass fires. Due to its volatile characteristics, ERC also increases the risk of wildfires and the risk of damage from wildfires.[12,15–18]

In 1933, Oklahoma farmers cropped more than 6.3 million hectares (annual crops and alfalfa hay). In 2016, only 2.9 million hectares were cropped, with another 291,779 hectares in the Conservation Reserve Program (CRP). Thus, more than 3.2 million hectares that were once cropped are no longer cropped and not in the CRP.[19] On average, since 1933, more than 36,000 hectares (89,000 acres) per year in Oklahoma have been removed from crop production and converted to pasture. This land that was once cropped is highly susceptible to ERC encroachment. It has no recent history of being managed to control ERC and no history of prescribed fire.

Efforts have been underway for years to find a use for ERC biomass that would incentivize an entrepreneur, or a for-profit business, to willingly harvest and remove ERC trees from grasslands. A number of potential uses have been identified for ERC biomass, including particleboard, bioenergy feedstock, fiberboard, plywood-faced panels, wood flour, mulch, animal bedding/litter, shavings, "cedar oil" for perfume, "cedar oil" for insect repellent, "cedar oil" for wood preservative, wood/plastic composites for window and door sills or decking, and down hole loss circulation material for the drilling industry.[12,20]

The annual quantity of material required for any of these potential businesses to achieve size economies is unknown. It is not known if any of these potential businesses, even after achieving size economies, could compete with existing alternatives and achieve profitability. However, prior to investing in any of these potential businesses, due diligence would require a business plan for obtaining annually the required quantity of ERC tree tonnage for the expected life of the processing facility. In addition, information regarding the expected cost to deliver the feedstock as well as the most cost-efficient location of the processing business would be essential.

Feedstock procurement for a business designed to use ERC trees exclusively would be unique relative to typical crop or plantation forest production systems. When cut at ground level, ERC does not regrow; after it is removed, landowners would be expected to take measures to prevent re-infestation. Thus, every day for the life of the business, ERC trees would have to be acquired from a unique location. It is unknown if there is a sufficient supply of trees within a reasonable perimeter to provide feedstock requirements for the expected life of a processing business. Another issue is related to the proportion of existing ERC biomass in a region that a business could obtain the rights from landowners to harvest.

The objective of this study is to determine feedstock cost for a business designed to use ERC trees exclusively. A model is constructed and used to determine cost, including the cost (or return) to secure harvest rights, harvest cost, and transportation cost, to deliver a specified quantity of ERC biomass to a processing location each year for a period of 20 years. The model is solved to produce solutions for several different combinations of annual feedstock requirements, proportion of existing ERC biomass in a county available for harvest, growth rate of unharvested trees, harvest cost, transportation cost, and discount rate. The model is used to determine the business location and harvest locations for each of 20 years that would minimize feedstock costs given initial ERC inventory.

Modeling, Data, and Assumptions

A mixed integer mathematical programming model is constructed to determine the cost, including the cost (or return) to secure harvest rights, harvest cost, and transportation cost to deliver a specified quantity of ERC biomass to a business location each year for a period of 20 years. The model is designed to produce least-cost delivered feedstock solutions for several different combinations of annual feedstock needs, proportion of ERC biomass in a county available for harvest, growth rate of unharvested trees, harvest cost, transportation cost, and discount rate. Binary variables are included to enable the model to determine the least-cost delivered feedstock business location. The model is solved using the generalized algebraic modeling system (GAMS) with the CPLEX solver.

Development of infrastructure for collecting and providing a flow of feedstock would be required for an ERC biomass processing industry. For the purpose of modeling, a vertically integrated system is envisioned. It is assumed that the company would acquire the rights to enter fields with ERC trees and clear-cut and remove ERC biomass once during a 20-year period. Then the company would centrally manage the harvest and transportation required to deliver feedstock to their processing facility.[21] The model is used to determine the quantity of biomass to be contracted in each county and the counties in which ERC trees are optimally removed each year. Trees under contract that are not removed in year t are expected to continue to grow and be available for harvest in year $t + 1$.

Case Study Region

The case study region includes 15 counties in the state of Oklahoma: Blaine, Canadian, Dewey, Ellis, Garfield, Kingfisher, Lincoln, Logan, Major, Noble, Okfuskee, Pawnee, Payne, Pottawatomie, and Woodward (Fig. 1). The estimated quantity of existing biomass was obtained from field data produced by Starks et al.[6] It is assumed that the growth rate of ERC trees not harvested is 8% per year.[22] The land areas with ERC trees in these counties have been estimated by the Natural Resources Conservation Service (NRCS).[23] Six of these counties (Blaine, Dewey, Pawnee, Payne, Canadian, and Logan) are considered prospective locations for the processing facility (Fig.1). These potential factory locations were selected based on the density of ERC biomass as well as the accessible road infrastructure. The factory is assumed to