Bioenergy that Supports Ecological Restoration

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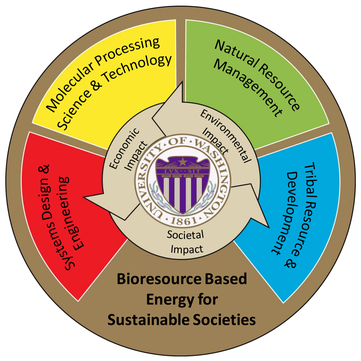
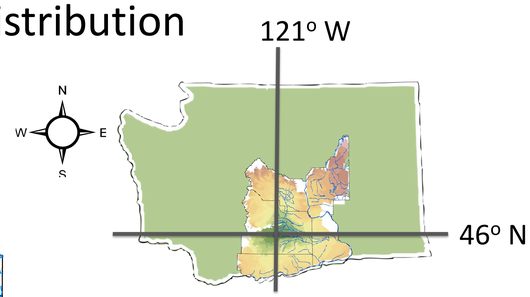
Can invasive tree wood become part of a sustainable bioenergy portfolio?

Our project assessed the feasibility of developing a sustainable bioenergy program for the Confederated Tribes and Bands of the Yakama nation. We paired a multi-disciplinary team of University of Washington PhD candidates with natural resource managers from the Tribe. Herein, we illustrate a framework for understanding how lignocellulosic bioenergy infrastructure may positively interact with ecological goals within the infrastructure's fuelshed. We show that woody residues from invasive tree restoration can be sold at a competitive price into the regional woody-biomass market, significantly expanding the number of acres that can be restored.



Large supply:

widespread invasive tree distribution

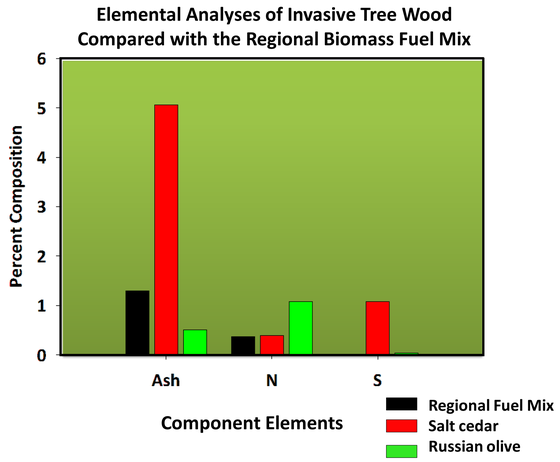


Russian olive (*Eleagnus angustifolia*) and salt cedar (*Tamarisk spp.*) are the most widespread woody invasive plants in the western United States. Russian olive is the predominate invasive tree species in our eastern Washington study region. Over 1500 acres within our four study sites were invaded by Russian olive. Tree densities varied naturally; field research determined the mean density was approximately 15 bone dry tons (BDT) of wood per acre.

Constraints on demand:

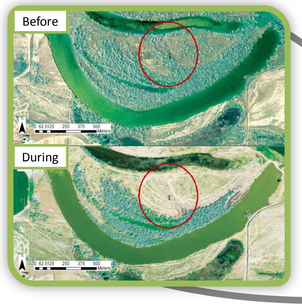
invasive tree chemical properties differ from the regional biomass fuel mix

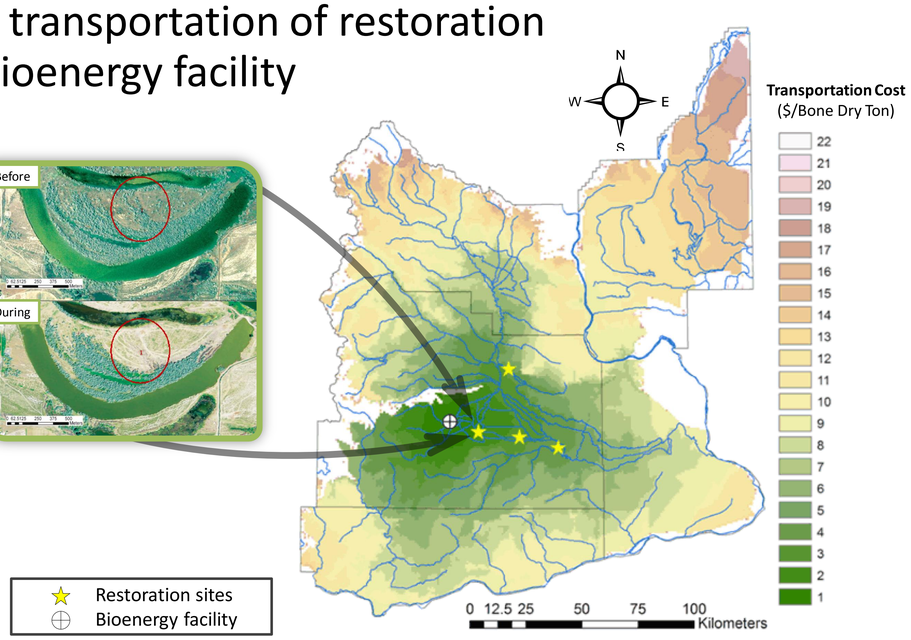
Russian olive and salt cedar have much higher levels of nitrogen, sulfur, and ash than the regional biomass fuel mix. These components are directly related to a bioenergy boiler operation. Thus, combusting large quantities of invasive tree wood would increase rates of slag formation, boiler fouling, and air pollution: including particulate matter, NO_x and SO_x emissions. Such consequences are inefficient or illegal (Clean Air Act). Therefore the physicochemical aberrations place natural constraint on demand for a facility which would be designed to use the predominant regional fuel mix.



Low transportation costs:

Inexpensive regional transportation of restoration wood-waste to the bioenergy facility





The map (above) illustrates the costs associated with transporting wood from a restoration site (stars) to the bioenergy facility (crossed circle). This figure has been developed from a spatially-explicit transportation model for our study region, in eastern Washington. Costs were parameterized by time ($29/hr) and distance ($1.20/mile) for a 30.9 ton chip van. Regional roads (including forest roads) were analyzed for quality, and classified by maximum speed attainable, which provided a more accurate estimate of time costs. Images show a stream invaded by Russian olive trees and also the mechanical removal of Russian olive trees. Adjacent are aerial photographs from 2006 (top) and 2009 (bottom) showing the extent of a Russian olive invasion at one site before and during the restoration process. In the aerial photographs the Russian olive stands are the blue-green clusters.

Reference material: Richardson JJ, et al. (2011) Uncertainty in Biomass Supply Estimates: lessons from a Yakama Nation case study. Biomass and Bioenergy 35:3698-3707
Photos credited to 1. "invaded stream": J. Scott Peterson, USDA NRCS, www.forestryimages.org; 2. "mechanical removal": Tamarisk Coalition (2009) Riparian Restoration: Assessment of Alternative Technologies for Tamarisk Control, Biomass Reduction and Revegetation (Tamarisk Coalition, Grand Junction, CO); 3. "aerial before and after": USDA-FSA-APFO Aerial Photography Field Office (2006, 2009) NAIP Digital Georectified Image (USDA_FSA_APFO Aerial Photography Field Office, Salt Lake City, UT

Bioenergy revenues fund regional restoration

Restoration and delivery costs:
- Avg. Restoration Costs **$400/acre**
- Avg. Transportation Costs **<$8/BDT**

Potential earning:
- Market Price (US DOE, 2011) **$35/BDT**
- Avg. Biomass Removed **15 BDT/acre**

Net Gain **>$5/acre**

Removal costs were developed for salt cedar and Russian olive by the Tamarisk Coalition. Market price—$35/bone dry ton (BDT)--is based on the 2011 US Department of Energy, Multi-Year Biomass Program Plan. Thus for an average restoration project within the 'green zone' (transportation <$8/BDT) costing $400 per acre, and yielding 15 BDT/acre of Russian olive wood, sale into a biomass market has the potential to offset all costs and earn no less $5/acre. Restoration outside the 'green zone' could be supplemented by these earnings.

Restoration wood waste and bioenergy:

potential to provide regional benefits for social ecological and economic communities

Social benefits would be provided by developing a regionally governed, renewable energy source; ecological benefits would be provided through restoration of riparian habitats funded by the biomass market; and economic benefits would be derived from commodity sales into the biomass market as well as regional job creation. Even though demand for Russian olive wood may be low, as a result of aberrant fuel wood properties, positive impacts can still be substantial. For instance, if demand were limited to only 5% of the total regional supply, based on our results, the revenues generated from these sales could fund restoration of roughly 700 acres per year.

We gratefully acknowledge helpful discussions with Mr. Brent Demko, Mr. Kelly Olney, Mr. Jesse Hopkins, and the Tamarisk Coalition; and excellent assistance from Dr. Laurie Stephan. This work would not have been possible without the encouragement and stewardship of Mr. Phil Rigdon, Director, Department of Natural Resources, Confederated Tribes and Bands of the Yakama Nation.

This work was supported by the National Science Foundation IGERT grant DGE-0654252.