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Research paper

Cost-benefit analysis of native warm season grasses for transmission line right-of way revegetation

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ABSTRACT

The rapid reestablishment of vegetation in newly constructed electric transmission line rights-of-way (ROWs) is important for the control of soil erosion and compliance with associated regulations. Following establishment, routine maintenance must be performed to suppress the encroachment of woody vegetation in ROWs to provide for continuous and safe operation of electric transmission lines. Although non-native seed mixes conventionally are used for this purpose in North America, modeling ROW revegetation on locally adapted native communities could reduce longer-term management needs and provide ecological, environmental, and social benefits associated with native systems. We conducted a cost-benefit analysis to determine if ROW revegetation with a seed mix comprised primarily of native herbaceous species could be cost-effective relative to revegetation with a conventional seed mix comprised primarily of exotic herbaceous species. Our analysis synthesized data collected from a feasibility study of ROWs planted with a native seed mix and information obtained from the Tennessee Valley Authority regarding ROW revegetation and maintenance costs. Overall, the cost of revegetation with native species was ~5% more expensive per unit area than the cost of revegetation exotic species. The degree of reduced long-term maintenance costs to make revegetation with native species a worthwhile longer-term investment would be 10–17% using a break-even analysis. Despite the initial greater expense of revegetation with native species, we suggest that associated potential maintenance cost savings and ecological, environmental, and social benefits could favor their use.

1. Introduction

Transmission lines are the vital arteries of electrical transport for the North American energy system, delivering high voltage (≥69 kV) electricity from electric power generation sites to local power stations. As of 2009, existing transmission lines traversed more than 715,000 km of the United States and Canada to form an extensive power grid governed by the North American Electric Reliability Council (NERC, 2009). By 2011, about 48,000 km of new transmission lines were either under construction or planned to be constructed by the year 2019 (NERC, 2011).

To allow for continued operation and maintenance of electric transmission lines, utility providers typically purchase easements of adjacent strips of privately owned land as rights-of-way (ROWs). Most ROWs in North America are 23–90-m wide, depending on their voltage and configuration (USDA, 2009). The construction and maintenance of utility ROWs presents both short and long-term vegetation management challenges to utility providers. Initially, successful vegetation establishment following the cessation of land disturbance associated with transmission line construction is needed for control of soil erosion and sediment escape as mandated by th To facilitate compliance with local, state, and federal regulations, revegetation species mixes and planting protocols have focused on quick establishment. Continued maintenance of a short-statured plant community is crucial for the safe and continued operation of transmission lines. Trees can be especially problematic as was evidenced by the most widespread blackout in North American history in August 2003, which began with the tripping of a 345-kV transmission line owned by First Energy in Ohio by a tree that had grown too tall (NERC, 2004).

With a power service area that includes ~9 million customers in Tennessee and parts of six surrounding states, the Tennessee Valley Authority (TVA) is the single largest public power provider in the U.S. (TVA, 2012). In total, the TVA owns and operates approximately 26,500 km of transmission lines within its power service area; these

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lines are associated with nearly 100,000 ha of ROWs (TVA, unpublished data). Within the TVA region, ROWs traverse a mosaic of land-use types including agricultural, commercial, industrial, residential, silvicultural, and stable wooded and wetland communities (Sparry, 2002). However, the overall location of the TVA region largely within the temperate deciduous forest biome of eastern North America makes the eventual succession of trees on established ROWs a primary management concern for the TVA – [https://www.tva.com/Energy/Transmission-System/Right-of-Way-Maintenance/Anatomy-of-a-Right-of-Way; accessed December 2016]. At present, the TVA spends an average of $10 million annually on ROW mowing and herbicide applications (personal communication with Jason Regg, Senior Manager, TVA ROW Services) to control woody vegetation. Consideration of proactive measures that could reduce the need for active management of woody species encroachment into ROWs could provide long-term maintenance cost savings.

Although not explicitly studied in transmission line ROWs, limited research in other revegetation projects has suggested that seed mixes dominated by native grasses, although initially more expensive to use for revegetation, could provide an viable economic alternative to conventional mixes dominated by exotic grasses given their adaptability to the local environment and the potential for reduced maintenance costs. For example, native grasses established faster and in more severe weather conditions than the typical exotic grasses used by the Texas Department of Transportation along roadsides (Tinsley et al., 2006). Likewise, a seed mix of native grass and forbs established rapidly on a landfill closure cap on the Savannah River in South Carolina (Kwit and Collins, 2008), and the natural presence of these species in nearby old-fields was associated with slow invasion of woody species (Golley et al., 1994; Pinder et al., 1995) suggesting that they may have the potential to resist encroachment of woody species when used for revegetation. The use of native species for revegetation projects also could provide an ecologically viable alternative to exotic species amid growing concerns that commonly used exotic species have the potential to become invasive pests (Harper-Lore and Wilson, 1999; Kwit and Collins 2008). Transmission line ROWs have been demonstrated to have ecological values as refugia for prairie plant species (Davis et al., 2002), food resources for associated pollinators (Wojcik and Buchmann, 2012), and habitats for shrubland birds, reptiles, amphibians, and small mammals (Johnson et al., 1979; Yahner et al., 2001; King and Byers, 2002). The use of native seed mixes for ROW revegetation could help enhance these wildlife benefits.

In support of recent efforts to reduce its operating and maintenance costs (TVA, 2014a), the TVA organized two pilot projects aimed to quantify the feasibility of seed mixes comprised primarily of native warm season grasses (NWSG) for revegetation of recently disturbed transmission line ROWs. As part of these efforts, we conducted a cost-benefit analysis to determine if ROW revegetation with NWSG could be cost-effective relative to revegetation with a conventional seed mix comprised primarily of exotic cool season grasses (ECSG). Cost-benefit analysis (CBA) is a technique commonly applied to economic decision-making by industry and government (Hanley and Spash, 1993). In performing CBA, the costs and benefits of alternative options are quantified with the option that has the greatest benefit relative to its cost deemed to be the best option. This method is often used when setting environmental policy with costs calculated as the capital necessary to implement a regulation and benefits estimated either by valuation of the public health savings of a particular alternative or by conducting willingness to pay surveys for an environmental service (Kahneman and Knetsch, 1992; Revesz, 1999). Our cost-benefit analysis of NWSG relative to ECSG considered a combination of revegetation field trials, information gathered from the TVA about its ROW revegetation and maintenance costs, and the pertinent literature base to estimate potential longer-term direct and indirect benefits.

2. Materials and methods

2.1. Field trials

We used field trials of revegetation with NWSG to determine the costs of ROW revegetation with NWSG. For revegetation with ECSG, a combination of existing revegetation activities and records detailing previous revegetation efforts were used to estimate costs. These contrasting approaches were used because the TVA's typical revegetation contractors use a "turn key" contract to revegetate with ECSG whereas the NWSG contractor worked under a "cost plus" contract, providing detailed equipment and material costs. Likewise, revegetation times associated with NWSG and ECSG were obtained in different ways to account for the inherent differences in planting NWSG versus ECSG such as planting dates, weather, and contractor methods. Specifically, a records review was used to estimate an average time for revegetation with ECSG, while we assessed the actual time for revegetation using NWSG from field trials.

2.1.1. Site descriptions

Two planned TVA transmission line corridor sites were selected for quantitative field trials of NWSG revegetation conducted during fall 2013 and spring 2014 at the Gallatin Fossil Plant (36.31142, −86.40164; GAF) in Sumner County, Tennessee and the Oak Ridge National Laboratory (35.93425, −84.32034; ORNL) in Roane County, Tennessee. Selection of sites was based on their associated construction schedules and budgets, adequate size to accommodate trial NWSG revegetation in a location adjacent to typical ECSG revegetation activities, and location on federally owned property that would preclude future development and thus facilitate long-term study.

The GAF site is located within the Nashville Basin physiographic province and lies between a coal-fired power plant to the north and the Cumberland River to the south. The western part of the transmission line has a northwest-to-southeast orientation, while the eastern part is oriented primarily from west-to-east. The area of GAF is characterized by generally flat topography with a few short, rolling hills. Climate in the GAF vicinity is typical of central Tennessee with adequate precipitation for vegetation in all seasons. Soils are typically clayey and derived from decomposed limestone and alluvium (USDA, 1997). The soils in the immediate project area have been described as Udorthents, indicating that the site has been previously excavated, filled, or homogenized such that the origin of the soil cannot be generally described (USDA, 1997). The surrounding forest is dominated by *Pinus taeda* (loblolly pine) with an understory dominated by exotic *Ligustrum sinense* (Chinese privet). The pine-dominated canopy suggests that the GAF site was heavily disturbed 50–75 years ago, which is consistent with the initial construction of a coal-fired power plant onsite in the 1950s (Wren, 2013).

The ORNL site is located within the Ridge and Valley physiographic province and runs along the southeastern aspect of a ridgeline; the transmission line has a southwest-to-northeast orientation. Topography of the ORNL area generally consists of flat benches, rolling hills, and steep slopes up to 20% in grade. The climate is typical of eastern Tennessee with adequate precipitation for vegetation in all seasons (DeSelm et al., 1969). Surrounding forests are typical of the temperate deciduous forest biome of the region with *Quercus* spp. (oak) and *Carya* spp. (hickory) as canopy dominants and interspersed *Pinus* spp. (pines) and *Juniperus virginiana* (eastern red cedar) as subdominants (DeSelm et al., 1969). Field investigation of a nearby site by GEOServices LLC (Knoxville, TN) and laboratory analyses of soil samples by the University of Tennessee Institute of Agriculture (Nashville, TN) show that the soil strata consist of 102–356 mm (4–14 in.) of topsoil with underlying lean and fat clay residual soils with varying amounts of chert fragments, which is consistent with the band of Fullerton, Dewey, and Waynesboro soil types found to the northeast and southwest of ORNL along the same ridgeline. Soils in the vicinity are derived from