Biosolids Use in Forestry

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Background

Forests are a vital part of the Earth's ecosystem and our society. Forest lands comprise ~3.1 million sq km, or nearly 34%, of the United States (The World Bank Group, 2015). A healthy forest provides an extensive array of ecosystem services such as: carbon sequestration, climate regulation, air and water purification, flood protection, and wildlife habitat. Forests are also a foundation for economic opportunity through recreation and tourism, the creation of green jobs, and the production of wood products and energy. Virginia's forest products contributed over $17 billion to the economy in 2015 and provided over 100,000 jobs (Virginia Department of Forestry, 2015). An additional $9 billion and tens of thousands of jobs were also attributed to forest benefits such as recreation and environmental benefits (Virginia Department of Forestry, 2015). The importance of forests to the economy has led to a great deal of research to maximize the valuable resource of forests and plantations.

Biosolids Use in Forests and Plantations

Forest ecosystems and plantations are one of the most cost-effective and environmentally safe ways to recycle biosolids (Henry and Cole, 1997; Kimberley et al. 2004). Recycling biosolids to forest lands can increase nutrient availability in otherwise deficient forest soils. Applying biosolids to forest land can also reduce the risk of contaminants entering the human food chain (Magesan and Wang, 2003; Xue et al. 2015). With proper management and the continuing shift for wastewater facilities to create cleaner, exceptional quality biosolids, application of biosolids to agricultural land has proven to be environmentally safe. Despite the many benefits recognized and the large extent of forest lands in the U.S., less than 1% of Biosolids generated annually is applied to forest land (Goldstein, 2007).

Biosolids use in forest ecosystems have been studied since the 1970s and shown that biosolids increase total tree production and tree nutrition (Cole et al., 1986; Luxmoore et al., 1999; Harrison et al., 2002; Kimberley et al. 2004; Wang et al. 2004; Scharenbroch et al., 2013; Ouimet et al. 2015). This is most typically attributed to the provision of biosolids-borne nutrients (esp., nitrogen and phosphorus) and organic matter to the low fertility, acid soils on which forests are often established. Organic matter supplied by biosolids can increase vegetation and stabilize forest soil post-wildfire (Meyer et al. 2004). Ouimet et al. (2015) found that forest yield increases over 16-19 years were correlated to biosolids doses and were higher in poorer soils after a one-time application.

Application Techniques

Much research has been done to determine the most effective way to apply biosolids and minimize negative environmental impacts. These strategies include careful selection of site, how to apply, implementing a nutrient management plan, and minimizing risk of nutrients entering waterways.

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Developing a cost-effective plan requires knowledge about the biosolids material. Biosolids can range from a liquid material (< 5% solids) to a dewatered material (a solid material with high moisture), to a completely dried and pelletized material (> 90% solids) (Wang et al. 2008). The drier the product, the cheaper it is for transportation to the site. Most forest-applied biosolids have been performed by spraying liquid or spreading dewatered biosolids prior to planting or beneath the canopy of established stands (Henry et al. 1994). Ouimet et al. (2015) found that neither the incorporation of the biosolids into the soil by tilling nor the form of biosolids applied (liquid or dewatered) influenced yields. Arellano and Fox (2010) compared the application of biosolids types (lime stabilized, anaerobic digested, and pelletized) and rates and inorganic fertilizer on loblolly pine plantation growth and water quality in the Virginia Piedmont. They found that biosolids are a good alternative to fertilizers to increase forest productivity with no increased risk of nutrient impairment of surface or ground waters.

Burying biosolids in deep rows covered by soil has been shown to be an effective, environmentally sound reuse tool for forest establishment and growth (Kays et al., 1997). Deep row incorporation is a single application of biosolids in a wide and shallow trench and covered with soil (overburden). Kays et al. (1999), Felix et al. (2008), and Kostyanovsky et al. (2011) demonstrated the use of a one-time application to sustain hybrid poplar in the Mid-Atlantic region for up to 6 years. Reduced decomposition of the biosolids occurs as the burial creates an anoxic environment. The nitrogen is able to be extended over a longer period of time, due to the slower decomposition rates. Kostyanovsky et al. (2011) found that phosphorus mobility was limited from deep row incorporated biosolids and did not pose a water quality risk, however nitrate and ammonium leaching was excessive in coarse-textured soil. Luxmoore et al. (1999) investigated long-term effects of biosolids on simulated forest productivity using inputs from field research. They found that conifer forests can have greater productivity benefit than application to northern hardwood forests. Additionally, single applications are less effective in productivity than multiple applications for conifer plantations. However, there were no differences in northern hardwood forest productivity.

Issues such as loading rate, nutrient assimilation rates and losses, and growth response for various types of biosolids and tree species must continue to be addressed to maximize productivity benefits and limit offsite contamination. Offsite contamination should be attained if biosolids are excluded from riparian areas and buffer strips along surface drainages.

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