



## Seven-Year Evaluation of Biosolids as a Fertilizer in Mid-Rotation Loblolly Pine

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Biosolids are solid and liquid materials produced from the treatment of municipal sewage sludge. About half of the biosolids produced annually in Virginia is land-applied as fertilizer. Historically, most of these applications have been to agricultural fields, but interest in using biosolids as fertilizers in forest stands has increased. In October 2006, the VDOF research team initiated a study comparing the effects of biosolids and traditional inorganic fertilizer (urea + diammonium phosphate) on the growth of a thinned mid-rotation loblolly pine stand.

The plots were installed in western Essex County in a recently-thinned (summer 2006) loblolly pine stand. The experimental design is a randomized complete block with four replications of four treatments: 1) no fertilizer (check); 2) urea + diammonium phosphate (DAP) at a rate of 200 lbs. of nitrogen plus 25 lbs. of phosphorus per acre; 3) lime-stabilized biosolid material from Arlington County, VA, applied at 200 lbs. per acre of plant available nitrogen (PAN), and 4) the same biosolids at 400 lbs. per acre PAN. All of the treatments were applied in June of 2007 when the stand was in its 21<sup>st</sup> growing season after planting.

Total height, crown height and diameter at breast height (DBH) have been measured on each tree in the tenth-acre measurement plots in every dormant season since the test was installed. The prior results have been summarized in VDOF Forest Research Reviews from April 2008, April 2009, October 2010, May 2011, August 2012 and August 2013 ([www.dof.virginia.gov](http://www.dof.virginia.gov)). After the 2013 growing season, the plots were re-measured and the seven-year responses have been summarized and presented in **Table 1**.

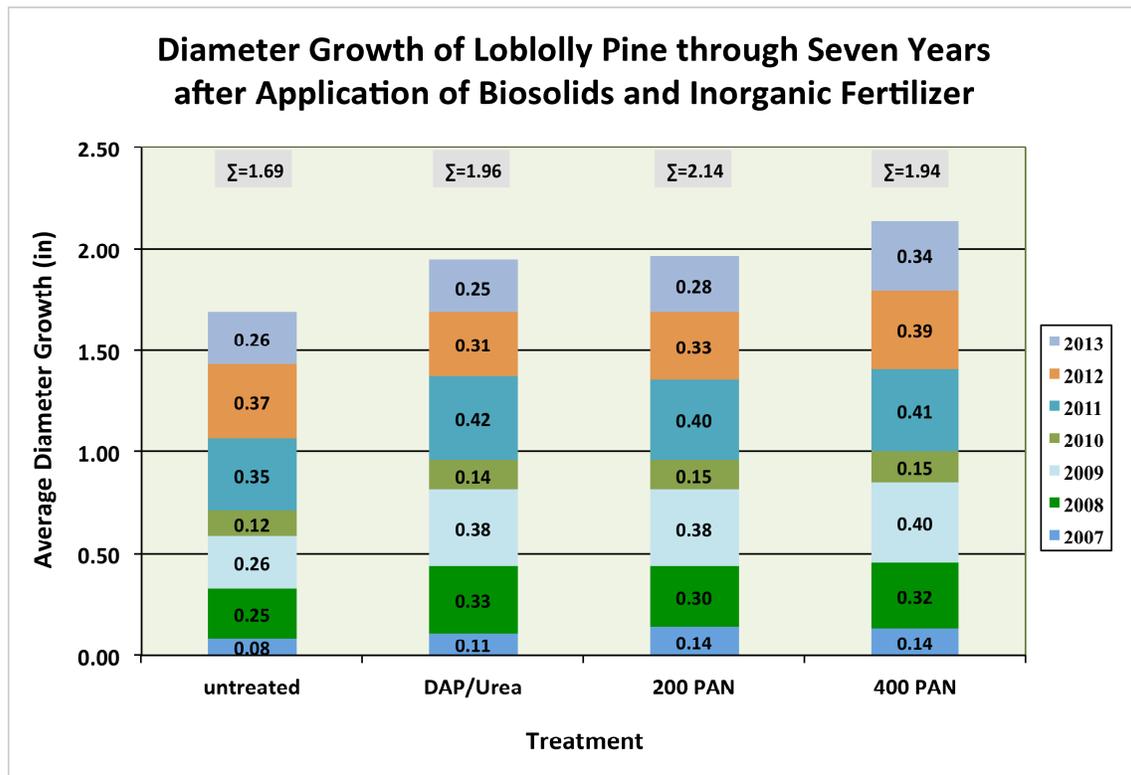
The results of statistical analyses have varied somewhat with growing conditions from year to year over the life of the study, but at age 7 the core differences remain. There have been no impacts on height growth, but diameter growth (and therefore basal area and volume growth, which are calculated based on diameter) have been significantly improved where either inorganic fertilizer or biosolid amendments have been applied. Many studies have documented that larger trees grow more than smaller trees, and this finding is reinforced from these data: dominant and codominant trees have grown between 20 and 25 percent more in dbh than the stand average over the life of the study. Fertilized plots have produced up to 40 percent more total tree volume over the seven years since application, and we may be seeing indications of a divergence between rates, as the 400 PAN plots have exhibited the greatest growth over the last two years (**Figure 1**).

The study continues to show that 1) nutrient additions as either biosolids or traditional inorganic fertilizer are beneficial to tree growth for at least seven years following application, and 2) there is no evidence of any negative effects of the biosolids on loblolly pine growth or vigor.

In early 2013, the stand surrounding the study area was thinned for a second time and, unfortunately, during that operation, two of the study plots (one untreated check plot and one 400 lb. PAN plot) in the first replication were thinned to an extent that will compromise future data; they have therefore been abandoned. There is also evidence that southern pine beetle has become active in some areas of the plots. As a result, we will be monitoring the area closely and it may reach a condition that would make future data impossible to collect or interpret.

**Table 1. Summary of loblolly pine growth attributes seven years after application of biosolids and inorganic fertilizer in Essex County, VA.**

Treatment	DBH (in.)	DBH Growth (in.)	D/CD* DBH Growth (in.)	Height (ft.)	Height Growth (ft.)	Total Volume (cu. ft./ac.)	Volume Growth (cu. ft./ac.)	Volume Response (%)
1) untreated	9.9	1.69	2.03	65	12	3247	1355	---
2) DAP + urea	10.3	1.94	2.39	68	17	3472	1666	23%
3) biosolids-200 lbs. PAN	10.2	1.96	2.38	69	15	3813	1783	32%
4) biosolids-400 lbs. PAN	10.5	2.14	2.67	69	17	3802	1898	40%



**Figure 1. Annual and cumulative diameter growth of loblolly pine growth through seven years after application of biosolids and inorganic fertilizer in Essex County, VA.**

\*D/CD refers to dominant and codominant crown classes.