# Does soil morphology govern spatial patterns of loblolly pine needle and shoot dieback and its response to culture and genetics?

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## INTRODUCTION

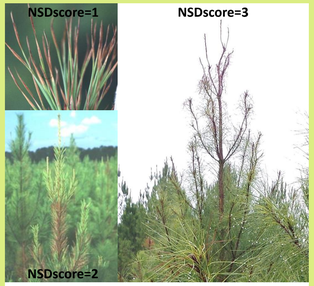


Figure 1. Visual symptoms of loblolly pine NSD at different severities. These symptoms are not accompanied by resin exudation characteristic of pitch canker or tip moth.

Across the southeastern United States young intensively managed loblolly pine (*Pinus taeda*) plantations are plagued by a syndrome called needle and shoot dieback (NSD). NSD kills needles, and in the most severe cases terminal buds, thus lowering primary production of young stands and potentially wood quality of older stands [1,2].

Numerous hypotheses have been posited as the cause of NSD. These hypotheses include freeze damage, heat damage, various pathogens, and nutrient limitations/imbalances [1,2,3]. Certain properties of NSD do indeed suggest that a nutrient limitation or imbalance is related to NSD symptoms. These include its timing (emerging in late summer and progressively worsening to winter), its progression (usually from old to new vegetative material), its restriction to young stands (older stands with larger roots systems might access more diverse or better balanced nutrient pools), and observations of chemical differences across NSD symptomatic and non-symptomatic foliage (potentially involving K and B).

## LOBLOLLY PINE NEEDLE AND SHOOT DIEBACK AT TWO PINEMAP TIER II INSTALATIONS

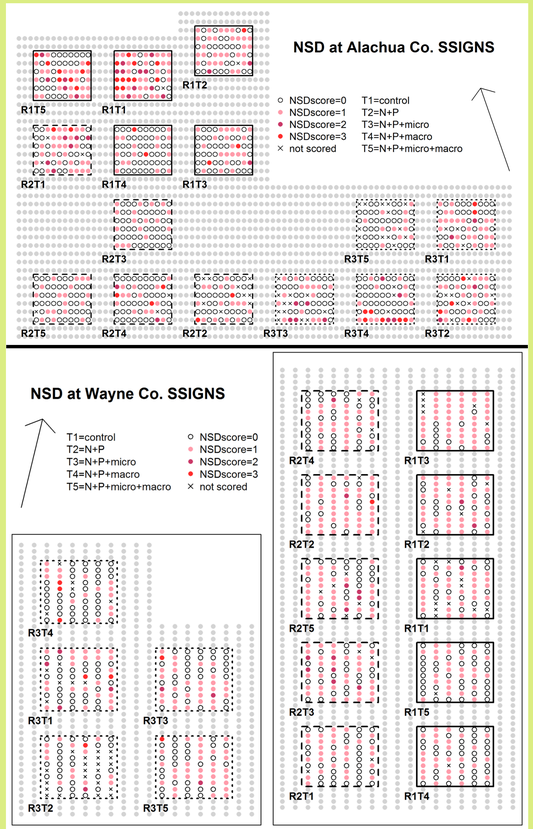


Figure 2. Stem maps with NSD occurrence and severity across two PINEMAP Tier II installations. The Alachua Co. SSIGNS installation is in FL and the Wayne Co. SSIGNS installation is in GA.

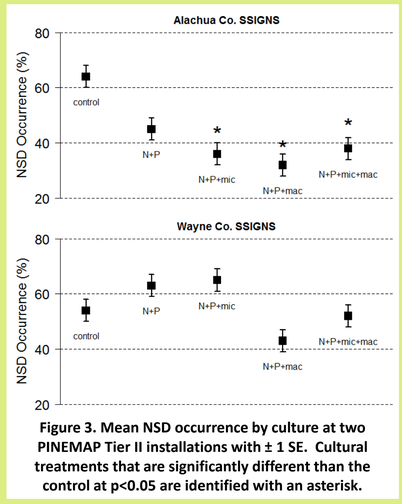


Figure 3. Mean NSD occurrence by culture at two PINEMAP Tier II installations with ± 1 SE. Cultural treatments that are significantly different than the control at p<0.05 are identified with an asterisk.

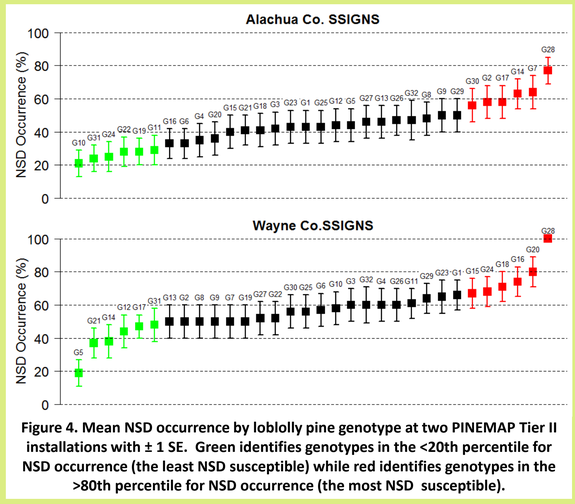


Figure 4. Mean NSD occurrence by loblolly pine genotype at two PINEMAP Tier II installations with ± 1 SE. Green identifies genotypes in the <20th percentile for NSD occurrence (the least NSD susceptible) while red identifies genotypes in the >80th percentile for NSD occurrence (the most NSD susceptible).

In February of 2015 we scored 1800 loblolly pines for NSD symptoms that developed during their second growing season at two FBRC SSIGNS installations (Figure 2). Experimental treatments included culture (five fertilizer treatments), and genetics (30 full-sib families randomly deployed in each plot). NSD was scored as follows (see Figure 1 for examples):

NSDscore=0; no visual symptoms
NSDscore=1; some needle tip browning in upper crown
NSDscore=2; substantial needle browning in upper crown, involving entire needles and flushes
NSDscore=3; NSDscore=2 plus apparent desiccation or death of terminal shoot and/or bud

**The spatial distribution of NSD in Alachau Co. was more variable than that in Wayne Co. (Figure 2).**

**Additions of macronutrients and micronutrients significantly decreased NSD occurrence in Alachua Co. but not Wayne Co. (Figure 3).**

**Loblolly pine genetics were significantly related to NSD occurrence at both installations (p=0.0026 for Alachua Co. and p=0.0378 for Wayne Co.), however the least susceptible and most susceptible genotypes were not consistent across the two installations (Figure 4).**

**These observations suggest that another, currently unaccounted for, environmental factor affects NSD symptoms and their relationship to culture and genetics.**

## OUR HYPOTHESIS

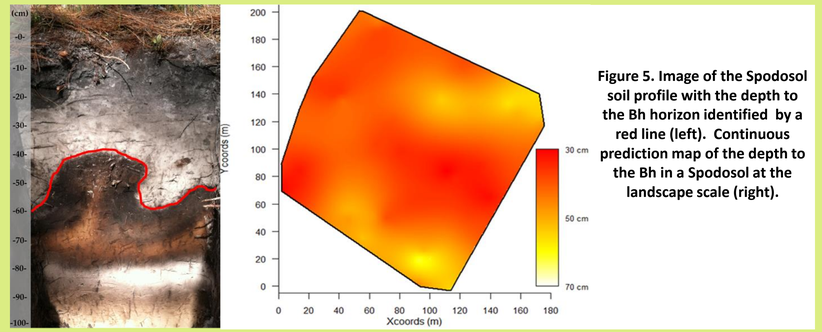


Figure 5. Image of the Spodosol soil profile with the depth to the Bh horizon identified by a red line (left). Continuous prediction map of the depth to the Bh in a Spodosol at the landscape scale (right).

Soils below both installations where we scored NSD (Figure 2) are classified as Spodosols (of the Alaquod great group). These soils are characterized by steep vertical gradients in soil organic matter (Figure 5). Soil organic matter contents are relatively low in surface soil layers compared to that of a subsoil layer referred to as the Bh horizon. Soil organic matter can play a critical role in the availability and supply of nutrients to above ground vegetation [4]. In Spodosols the depth to the organic matter rich Bh horizon can vary greatly at the soil profile and landscape scale (Figure 5).

**Broadly we've hypothesized that depth to the Bh horizon governs spatial patterns of NSD and the relationship of NSD to culture and genetics.**

**More specifically, we expect that NSD is positively related to the depth to the Bh horizon since nutrients in deeper Bh horizons will be less accessible to young loblolly pine roots.**

## THE GOALS OF OUR PINEMAP UNDERGRADUATE RESEARCH ACTIVITIES

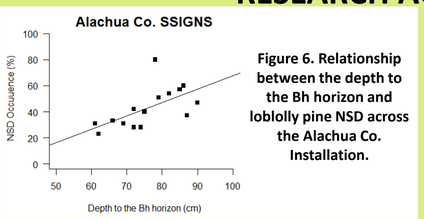


Figure 6. Relationship between the depth to the Bh horizon and loblolly pine NSD across the Alachua Co. Installation.

**Preliminary observations from the Alachua Co. installation indicate that the depth to the Bh horizon and NSD are indeed positively related ($r^2$=0.4).**

**Over the next twelve weeks we will further explore loblolly pine NSD and its relationship to soil morphology:**

Foliar samples that were collected from NSD symptomatic and non-symptomatic trees will be analyzed to identify specific nutrients that may be limiting or involved in a nutritional imbalance.

Soils and subsoil will be collected and analyzed with sequential extractions to determine how the depth dependence of nutrient availability changes according to the depth to the Bh horizon.

We will intensively measure depth to the Bh horizon and use geostatistical techniques to create continuous prediction maps of this ecosystem property (Figure 5) and nutrient availability, and then relate them to observed spatial patterns of NSD.

Monitor the recovery/growth of NSD symptomatic trees during the current growing season.

**REFERENCES:** **[1]** South, D.B., et al. Southern Research Station, USDA Forest Service SRSGTR-48. 2002. **[2]** Martin, T.A. and G. Blakeslee. Forest Biology Research Cooperative, University of Florida IFAS. 1998. **[3]** Jolley , L.W. Dissertation Clemson University. 2001. **[4]** Brady, N.C. and R.R. Weil. Elements of the nature and properties of soils. Upper Saddle River, NJ: Pearson Educational International, 2010.