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Physiological ecology of woody species in response to air pollution and climate changes

Effect of forest thinning and wood quality on the short-term wood decomposition rate in a *Pinus tabuliformis* plantation

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Abstract

The effects of forest thinning and wood quality on wood decomposition in the mineral soil were investigated in a Chinese pine (*Pinus tabuliformis* Carriére) plantation in northern China by measuring mass loss and changes in wood properties (carbohydrates, lignin and nitrogen (N) concentrations) in wood stakes of two tree species—loblolly pine (*Pinus taeda* L.) and trembling aspen (*Populus tremuloides* Michx.). Stakes were inserted to a 20 cm soil depth in stands with three thinning levels (low, moderate, and heavy) and an unharvested control and removed after 1 year. There were significant differences in stake mass loss among the treatments. The species effect on the stake mass loss was marginally significant. Wood N content of both species increased during decomposition in all thinning treatments, and was only correlated with aspen mass loss. Wood properties of stakes placed in each stand before insertion (t = 0) were similar, except for pine lignin concentration and aspen lignin: N ratio, but neither had any effect on thinning treatment results. Lignin concentration increased and carbohydrate concentration decreased in both aspen and pine wood stakes during decomposition across all thinning treatments, which suggests that brown-rot fungi are dominant wood-decomposers on our study site. We conclude that thinning has a significant influence on the wood decomposition in the mineral soil of this Chinese pine plantation.

Keywords Forest thinning · Wood decomposition · *Pinus taeda* L. · *Populus tremuloides* Michx. · Lignin concentration · Nitrogen

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Introduction

Coarse woody debris is a major component for nutrient cycling, fungal refugia, moisture retention, and as nurse logs for tree seedlings in tropical, temperate, and boreal forest ecosystems (Harmon et al. 1986). Woody material is also considered an important terrestrial carbon (C) sink because of its relatively slow decomposition rate (Woodall et al. 2008). Consequently, land managers and climate change modelers need to understand how forest management activities may alter wood decomposition rates and subsequent C sequestration in the mineral soil. Such information is critical for determining the effect of disturbance on the stocks of both live and dead biomass, the interaction with C flux, and impacts on the global C cycle (Campbell et al. 2009).

Wood decomposition on the surface of the litter layer and in mineral soil can be altered by changes in soil nutrients (Ganjegunte et al. 2004; Laiho and Prescott 2004; Titus et al. 2006), climatic regime (Moroni et al. 2009; Remsburg and Turner 2006), silvicultural practices (Finér et al.

2016; Ruiz-Peinado et al. 2013), and wood quality (Devi and Yadava 2007; Palviainen et al. 2008; Weedon et al. 2009; Yatskov et al. 2003; Zhou et al. 2007). Since lignin in plant litter decomposes slowly, it is a very important factor in organic matter (OM) decomposition in terrestrial ecosystems (Entry and Backman 1995), and a significant factor in the C cycle by sequestering atmospheric C into dead biomass (Rahman et al. 2013). Wood decomposition rates are also influenced by the local climatic regimes, especially soil temperature and moisture conditions (Meentemeyer 1978).

Previous studies indicated that wood mass loss rates accelerate when lignin concentration decreases and N content increases (Devi and Yadava 2007; Fogel and Cromack 1977), and both are important factors in determining why wood from broadleaved trees decomposes faster than conifer wood in temperate and boreal forests (Cornwell et al. 2009; Strukelj et al. 2013). In contrast to wood, leaf litter lignin concentration follows a pattern of an initial decrease, and then a slow increase as decomposition progresses, which is likely associated with N mineralization within the litter layer (Devi and Yadava 2007). However, Van Geffen et al. (2010) found no clear relationship between C:N ratio and wood decomposition rate across 15 neotropical tree species. Thus, the relationship of wood species, C:N ratio, and lignin concentration to wood decomposition rate in specific ecosystems is unclear.

Wood decomposition is also influenced by environmental conditions that favor microbial growth (Blanchette 1995). Understanding the role of soil microbial communities on the rate of soil OM decomposition, and the impact of both substrate size and quality are critical factors (Blanchette 1984; Lehmann and Kleber 2015). White-rot fungi (*e.g., Resinicium bicolor*) decay both cell wall lignin and cellulose (Blanchette et al. 1985), while brown-rot fungi (*e.g.*, Fomitopsis *pinicola*) selectively remove carbohydrates resulting in increased lignin concentrations (Pandey and Pitman 2004). Both lignin and cellulose decomposition have been reported to increase in soils containing higher populations of white-rot fungi (Entry et al. 1991). In addition, high N concentrations can increase lignin degradation by some white-rot fungi (Ander and Eriksson 1977; Yang et al. 1980). Entry and Backman (1995) found that added N only increased cellulose decomposition, but when both labile C and N were added, lignin degradation increased. Melillo et al. (1982) also reported a strong correlation of N and lignin concentration with wood mass loss.

Lignin decomposition also has important effects on N dynamics of forest ecosystems. For example, Fioretto et al. (2005) noted that N released from leaf litter begins with lignin decay, and continues throughout the decomposition process. Entry and Backman (1995) found that the cellulose: lignin: N ratio was an accurate predictor of OM decomposition in forest soils of southern Alabama, and the lignin:N ratio is a good predictor of leaf litter decomposability in both tropical and Mediterranean regions (Aerts 1997). However, Talbot et al. (2012) found that the retention of lignin had no effect on total mass loss of woody substrates.

Decomposition rates in forested ecosystems can be affected by the amount of overstory removal. Thinning operations increase the amount of sunlight and precipitation that reaches the forest floor (Simonin et al. 2006, 2007; Thibodeau et al. 2000) and the subsequent changes in soil abiotic conditions on OM decomposition could be short- or long-term (Sanchez et al. 2006) depending on soil type, tree species, ecosystem, or climatic regime (Grigal and Vance 2000). While several studies have examined the rates of wood decay in undisturbed young and old-growth stands (Harmon et al. 1986; Woodall et al. 2008) and after clear-cut harvesting (Finér et al. 2016; Ruiz-Peinado et al. 2013), we could not find any study in the literature that examined the effect of forest thinning on wood decomposition.

Chinese pine (*Pinus tabuliformis* Carriére) is endemic to northern China and plays an important role in reforestation, soil and water retention, and forest ecological functions in this region (Chen et al. 2017; Zhao et al. 2015). Thinning of Chinese pine plantations has become more common (Tian et al. 2010), and woody material often remains on the soil surface as unmerchantable stems and branches. An understanding of how thinning affects wood decomposition is needed to predict subsequent changes in soil C pools, microbial diversity, and soil health. Therefore, the objectives of our study were to determine: (1) how different levels of tree removal affect wood decomposition, and (2) the possible effect of initial wood chemical properties (N, C, lignin, and carbohydrate concentrations) on decomposition results. This entailed placing wood stakes of two tree species—loblolly pine (*Pinus taeda* L.) and trembling aspen (*Populus tremuloides* Michx.)—in the mineral soil of a Chinese plantation previously thinned to three stand densities and measuring wood mass loss and chemical properties at the end of 1 year. We hypothesized that: (1) mass loss of aspen is greater than loblolly pine across all thinning treatments, (2) wood stake mass loss increases as thinning level increases, and (3) initial wood C, lignin, carbohydrate, and N concentrations has little effect on decomposition across thinning treatments.

Materials and methods

Study site

This study was conducted in a Chinese pine plantation located in Pingquan county, Hebei province (118°40′E, 41°13′N), China, at an elevation of 700–800 m. The area has a semi-humid, continental monsoon climate, with a mean annual temperature of 7.3 °C (min. − 32.9 °C and max.

41.5 °C) and has an average frost-free period of 135 days. Precipitation per annum was 542 mm with the majority of rainfall occurring during the summer months of June, July, and August. Soil was from weathered granitic parent material, and texture was sandy loam. Before thinning the soil had an average pH of 6.7, OM concentration of 1.66%, and total N concentration of 0.053%. The dominant understory vegetation species were *Elsholtzia stauntoni* L., *Spiraea salicifolia* L., *Rosa multiflora* L., *Carex lanceolata Boott* L., *Potentilla tanacetifolia* L. *and Caragana sinica* L.

The plantation was established in 1976 from seed, and had an initial stand density of 5000 trees/ha. Average tree diameter was 7.2 cm with a height of 5.1 m before the stand was thinned in 2011. Study plots (20 m × 20 m) were thinned to three stand densities: low (30% overstory removal), moderate (41% overstory removal), and heavy (53% overstory removal), which were randomly assigned across a 40% north facing slope and separated from each other by a 5 m wide buffer. An adjacent portion of the plantation was left unharvested as a control. All thinning residues were immediately removed by hand from the study plots. Air temperature and relative humidity were collected during this study period (Table 1).

Air temperature and relative humidity

Stand air temperature and relative humidity were recorded every hour in each thinning treatment and the unharvested control for the duration of the study by use of JL-18 probes (Handan, Hebei, China). Both temperature and moisture sensors were attached to the Onset data logging system (Onset Computer Corporation, Bourne, MA, USA). Due to limited funding we were unable to collect soil temperature and moisture in each thinning treatment and the control.

Wood stakes

We used standard loblolly pine and trembling aspen wood stakes, which are similar to stakes used to study the effects of harvesting, forest succession, and climatic gradients on decomposition (Finér et al. 2016; Jurgensen et al. 2006; Risch et al. 2013). By using standard stakes, wood quality is held relatively constant, and the resulting mass loss is either due to different abiotic (*e.g.* climate, soil properties) or biotic (*e.g.* microbial biomass, functional diversity) conditions altered by stand management (Jurgensen et al. 2006). Wood stake mass loss serves as an index of how soil properties, soil microclimate, and wood quality affect decomposition, and has been used in forest management models to predict stand productivity and C sequestration (Blanco et al. 2018).

Table 1 Average air temperature and relative humidity in plots from 2012 to 2013

Treatment	Temperature (°C)	Relative humidity (%)
Control	5.40	66.0
Low	5.92	66.0
Moderate	5.98	63.5
Heavy	5.76	65.3

All loblolly pine and aspen stakes were cut from kiln-dried, knot-free sapwood. Two mineral stakes (2.5 × 2.5 × 20 cm) were cut from one 50 cm long stake, and the 10 cm center section was used as a control (time = 0) to determine initial wood chemical properties and for wood stake mass loss during the study. The upper end of each stake was treated with a neoprene sealant to reduce moisture loss from the cut surface after installation. For additional details on stake production, see Jurgensen et al. (2006).

In May 2012 we inserted twenty-five stakes of each species to a vertical depth of 20 cm in the mineral soil of two replicate plots (20 m × 20 m) in each thinned stand and in the unharvested control. Wood stakes were randomly assigned to each thinning treatment and replicates. To minimize changing the soil physical properties surrounding the mineral stakes and limit damage to stakes during installation, the surface litter was pushed aside and a 2.5 cm^3 hole was made with a metal coring tool. Stakes were inserted into the hole with the top of each mineral stake being level with the surface of the mineral soil, and the litter replaced. In May 2013 five stakes of each species were removed from each plot, weighed in the field for subsequent wood moisture content calculation air dried to prevent further decomposition, and shipped to Michigan Technological University (Houghton, MI, USA) for mass loss determination. All samples were then sent to the Rocky Mountain Research Station (Moscow, ID, USA) for lignin, carbohydrate, and N analyses.

Laboratory analysis

Mass loss

All wood stakes were placed in a 65% moisture room for 10 days to equilibrate, and three dimensional measurements were taken to calculate stake volume. Stakes were dried at 105 °C for 72 h and weighed. Wood mass loss was determined by comparing the dry weight of each stake to the weight of its corresponding control section (t_0). Mass loss averages for each replicate plot were used as a treatment observation in the statistical analyses. Two stakes with the largest mass loss and the two stakes with the lowest mass loss of each wood species were selected from each treatment plot to assess the impact of initial stake chemical composition on the decomposition process. A total of 128 wood stakes were analyzed for lignin, carbohydrates, and N

concentration: 2 species × 4 thinning treatments × 2 plots × 4 samples × 2 types (field and control).

Chemical analyses

All wood stakes were coarse ground using a Wiley mill (Thomas Scientific, Swedesboro, NJ), split into representative subsamples, and fine ground with an 8000D Mixer/Mill (Spex SamplePrep, Metuchen, NJ).

Lignin concentration

Total lignin concentration was determined by the acetyl bromide method (Iiyama and Wallis 1988), in which lignin is solubilized in a 1:4 acetyl bromide: acetic acid solution and quantified by measuring absorbance at 280 nm. Ponderosa pine (*Pinus ponderosa*) and poplar (*Populus deltoides* × *Populus nigra*) were used as standards because these species have been analyzed extensively (Balogun and McDonald 2016; Dai and Mcdonald 2014). One gram of dried sample was extracted in weighed and sealed flasks with CH_2Cl_2 (40 ml) with shaking for 16 h. The extracted biomass was filtered and washed with clean CH_2Cl_2 (10 ml) and dried. The extraction was completed in duplicate for each wood block sample. "Extractive free" vacuum dried biomass powder (0.0050 g) was placed in glass COD tube (15 ml) with 25% (w/w) acetyl bromide in acetic acid (5 ml) containing perchloric acid (70%, 0.2 ml) and heated to 70 °C for 30 min with agitation every 10 min. The solutions were then transferred to 100 ml volumetric flasks containing 2 M sodium hydroxide (10 ml) and acetic acid (25 ml) and the volume was made up with acetic acid. The UV spectra of the solutions were measured against a blank. The lignin concentration was measured with the absorbance at 280 nm.

$$\text{Lignin}\% = 100\text{Abs} \cdot \text{V}/\varepsilon\text{W}$$

Abs is absorbance of the sample; V is the volume of the solution; W is the weight of the sample; and $\varepsilon = 20.09\ \text{l g}^{-1}\ \text{cm}^{-1}$ is the absorptivity of lignin.

Carbohydrate concentration

Total carbohydrate concentration of the cell walls was determined by the phenol–sulfuric acid colorimetric method (Kunhamu et al. 2009). Extractive free vacuum dried biomass (10 mg) was weighed into a glass COD tube and 77% H_2SO_4 (100 µl) was added before mixing for 5–10 min. After that, 5% phenol (1 ml) was added into the same COD tube and 5 ml conc. H_2SO_4 was briskly added into the mixture. The tubes were then immediately placed on a vortex mixer for several seconds. Color reactions indicative of carbohydrate concentration were measured after 30 min at room temperature using a spectrophotometer (Perkin Elmer Lambda2) at 490 nm. Biomass absorbance values were compared to the carbohydrate calibration curve to determine the concentration of carbohydrates present in the biomass samples.

Nitrogen concentration

Wood samples were cut from the control and deployed wood stakes. As noted above, samples were ground before analyzing for N concentrations using a Leco TruSpec CN analyzer (Leco Corp., St. Joseph, MI).

Statistical analyses

Mass loss, as a proportion of original weight, was the dependent variable in this factorial experiment. Factors assessed were thinning treatment (low, moderate, heavy, and unharvested control), and wood species (aspen and loblolly pine). All main effects and interactions were included in the ANOVA model. Where significant differences occurred, we used Tukey's grouping to test for multiple comparisons. If the initial concentration of any wood stake chemical property were significantly different among the thinning treatments, it was used as a covariant in the ANOVA analysis. Multiple regression was used to analyze the relationship between mass loss and initial chemical compositions (lignin, carbohydrate, lignin: carbohydrate, nitrogen and lignin: nitrogen). A correlation analysis was conducted between wood N gain and mass loss. Mass loss was arcsine square root transformed to meet assumptions of normality (Shapiro–Wilk test) and homogeneity (Levene's test) criteria. All statistical analyses were conducted with a level of significance at $\alpha = 0.05$ and conducted using SAS v. 9.40 software (Cary, NC).

Results

Wood mass loss

Average mass loss of aspen and loblolly pine stakes were significantly affected by thinning treatment (Table 2). Mass loss of both species were lower in the unharvested and in the heavily thinned stands than in the low and moderately

Table 2 Results of the ANOVA identifying single factors and two-way interactions for wood stake mass loss

Factor	DF	*F* value	*p*
Treatment	3	14.26	< 0.001
Species	1	3.68	0.060
Treatment × Species	3	0.73	0.537

thinned stands ($p < 0.01$, Table 3). There was a marginally significant difference between aspen and pine stakes.

Wood N concentration of both species increased with time in all thinning treatments, and there was a marginally significant difference in average N increase between pine (44%) than in aspen (24%) stakes ($p = 0.075$). N gains during decomposition were correlated to stake mass loss in aspen ($p < 0.001$), but not in pine ($p = 0.942$). Lignin concentration increased especially in the low and moderately thinned plots whereas carbohydrate concentration decreased in both species.

Wood lignin, carbohydrate, and N concentrations

As expected, loblolly pine stakes averaged across all stand thinning treatments had significantly higher initial concentrations of lignin, and higher lignin: carbohydrate, lignin: N, and C: N ratios than aspen, while aspen stakes had a higher N concentration than loblolly pine (Table 4). There were no significant differences in initial carbohydrate concentration between the two wood species. The lignin: N ratio in the aspen control blocks was the only chemical characteristic that was generally higher in the thinned treatments than in the unharvested stand.

Both lignin and carbohydrate concentration changes had a strong correlation with wood stake mass loss (Fig. 1).

Discussion

Compared to aspen, pine wood has significantly higher levels of lignin and lower N concentrations, which is one reason these two species were selected for this study. Therefore, we were surprised by the small differences in mass loss after 1 year between aspen and loblolly pine stakes, which contradicts our hypothesis based on woody residue decomposition studies in unharvested forests (Shorohova and Kapitsa 2014; Strukelj et al. 2013). However, studies in other forest

Table 3 Wood stake mass loss, and change in select chemical properties (mean ± standard error) of aspen and loblolly pine stakes in the mineral soil of three thinning treatments (low, moderate, and heavy) treatments and an unharvested control after 1 year

Thinning	Mass loss (%)	Nitrogen concentration increase (%)	Lignin concentration increase (%)	Carbohydrate decrease (%)
Aspen				
Control	26.4 ± 7.4bc	15.9 ± 5.7b	9.5 ± 3.8b	8.7 ± 3.6a
Low	49.7 ± 8.1a	4.3 ± 3.7b	28.0 ± 6.1a	22.7 ± 5.0b
Moderate	38.0 ± 2.0ab	9.5 ± 4.6b	19.1 ± 4.8ab	15.9 ± 1.4ab
Heavy	13.6 ± 1.9c	65.2 ± 9.7a	5.3 ± 1.6b	6.9 ± 1.2a
Average	31.9 ± 4.2	24.4 ± 7.4	15.4 ± 2.4	13.5 ± 2.0
Loblolly pine				
Control	9.4 ± 4.1c	-8.7 ± 5.5c	7.8 ± 2.0b	7.2 ± 2.0a
Low	40.9 ± 6.4a	63.6 ± 8.3ab	27.8 ± 4.6a	26.4 ± 3.8c
Moderate	34.1 ± 8.0ab	44.5 ± 6.3b	22.2 ± 5.2ab	20.3 ± 4.6bc
Heavy	12.3 ± 8.0bc	80.6 ± 9.7a	11.0 ± 2.0b	9.3 ± 1.8ab
Average	24.2 ± 6.5	44.4 ± 10.4	17.2 ± 2.3	15.8 ± 2.1

Different letters indicate significant differences among thinning treatments within the same species

Table 4 Initial wood stake chemical properties (mean ± standard error) in loblolly pine and aspen stakes with high and low mass from three thinning treatments (low, moderate, and heavy) and an unharvested control

Thinning	Lignin (%)	Carbohydrate (%)	Nitrogen (%)	Lignin: carbohydrate ratio	Lignin: *N* ratio
Aspen					
Control	19.9 ± 1.4	70.1 ± 5.1	0.119 ± 0.008	0.29 ± 0.01	168.5 ± 15.2a
Low	20.6 ± 0.9	67.2 ± 2.4	0.106 ± 0.008	0.31 ± 0.01	196.0 ± 14.4b
Moderate	20.7 ± 0.7	69.3 ± 2.8	0.105 ± 0.007	0.30 ± 0.01	191.8 ± 10.2ab
Heavy	21.3 ± 0.8	68.1 ± 2.4	0.110 ± 0.014	0.31 ± 0.01	202.1 ± 16.3b
Loblolly pine					
Control	30.8 ± 2.2	58.4 ± 3.7	0.083 ± 0.008	0.53 ± 0.03	372.4 ± 15.5
Low	30.6 ± 2.0	59.7 ± 2.5	0.077 ± 0.013	0.52 ± 0.02	473.8 ± 17.2
Moderate	32.1 ± 1.7	59.5 ± 1.4	0.071 ± 0.022	0.54 ± 0.01	419.1 ± 14.4
Heavy	30.9 ± 2.5	60.9 ± 2.4	0.081 ± 0.019	0.51 ± 0.02	412.0 ± 10.0

Lowercase letters indicate significant differences among thinning treatments

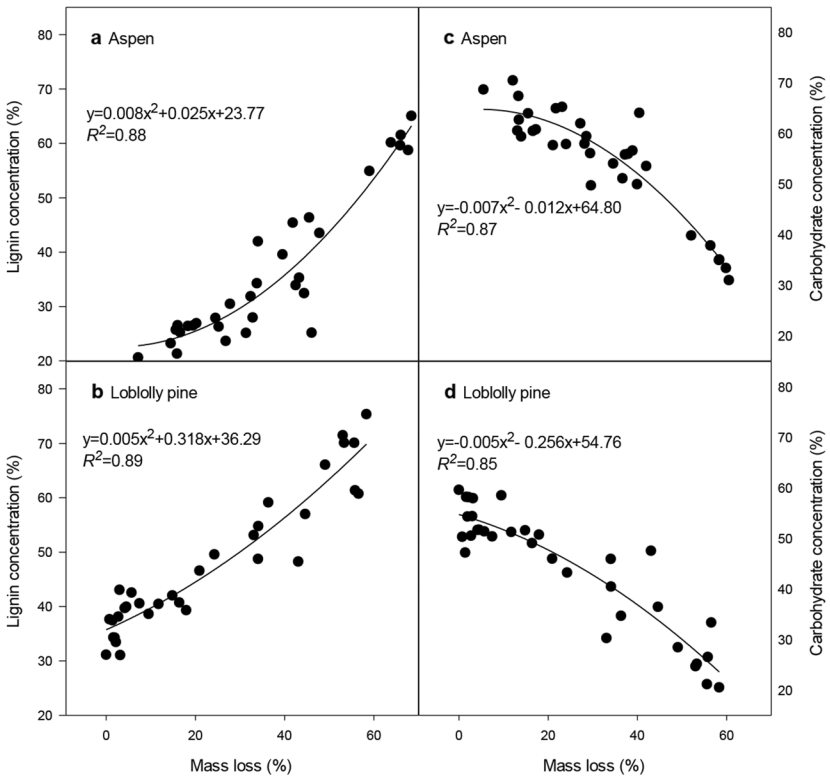

Fig. 1 Regression between mass loss of wood lignin and carbohydrate concentrations averaged across thinning treatments after 1 year decomposition: aspen and lignin (**a**), loblolly pine and lignin (**b**), aspen and carbohydrate (**c**), and loblolly pine and carbohydrate (**d**)

ecosystems using similar wood stakes found that mass loss differences between the two species accelerated after 2 years (Finér et al. 2016; Risch et al. 2013). Although loblolly pine stakes had higher lignin concentrations and C: N ratios, our results indicated that after 1 year the wood stakes were still in the early stages of decay.

Both aspen and loblolly pine stakes had the least mass loss in the unharvested control stands which confirms our second hypothesis. However, mass loss was also lower in the heavily thinned stand as compared to the low and moderately thinned stands which may due to the higher soil temperature after removing a large portion of the overstory. Forest thinning can alter soil processes, such as N cycling or fungal growth, in response to changes in both temperature and moisture (Kunhamu et al. 2009; Osono et al. 2003; Titus et al. 2006). In addition to large- and micro-scale climatic influences on decomposition rates caused by harvesting (Janisch et al. 2005), substrate quality (*e.g.*, species, wood density) can also alter these rates. However, since average air temperature and relative humidity were similar among the thinning treatments and the unharvested control throughout the first year, atmospheric microclimatic differences seem to have little impact on mass loss or change in wood quality chemical properties in the mineral soil. However, mineral soil microsites may have different temperature and moisture regimes and much greater variability than atmospheric weather conditions within a treatment plot (Cassel et al. 2000).

Many studies have shown that OM substrate quality is an important factor affecting decomposition rates (*e.g.* Ge et al. 2013; McClaugherty et al. 1985; Yang and Chen 2009; Zhang et al. 2008), especially in leaf litter which has been closely correlated with lignin content (Fogel and Cromack 1977). In our study, within each species, initial stake chemical properties were relatively similar, as they were made from carefully selected, knot-free sapwood. However, aspen lignin:N ratio was significantly higher in the heavy thinning treatments as compared to the stakes installed in the moderate and unharvested control, but had no effect on subsequent mass loss. Although initial pine stake lignin concentration was significantly different between stakes with high and low mass loss in all thinned stands, it had no effect on mass loss which confirmed our third hypothesis. Wood strength, which is influenced by the concentrations of lignin and carbohydrates, is primarily a function of these components and affects the speed at which microorganisms can degrade the wood (Carling et al. 2002).

Wood N concentration of both species increased in all thinning treatments during decomposition, and was positively correlated to aspen stake mass loss. These N increases could come from increased mineral soil N availability after thinning (Thibodeau et al. 2000) or from the activity of non-symbiotic N (N_2)-fixing bacteria (anaerobic or microaerophilic) present in wood (Jurgensen et al. 1984; Spano et al. 1982). However, a majority of N likely came from fungal hyphae which were beginning to move into the stakes from

the surrounding mineral soil (Chen and Hicks 2003; Jurgensen et al. 1989). Wood decay fungi are known to translocate significant quantities of N through their mycelial cord and rhizomorph systems (Connolly and Jellison 1997). While pine stakes in the three thinned stands accumulated more N than aspen, the additional N did not affect pine mass loss. This lack of N response may be due to high lignin concentrations and lignin: N ratio in pine wood stakes. Previous studies also found that lignin degradation increased with higher N concentration (Ander and Eriksson 1977; Yang et al. 1980), but higher loblolly and aspen wood N gains in our study did not lead to greater lignin loss after 1 year.

Compared to initial wood properties, both aspen and loblolly pine stakes generally had lower levels of carbohydrates 1 year after being placed in the mineral soil and this is similar to previous research on forest litter decomposition (Jurgensen et al. 1984; Pandey and Pitman 2004). Berg et al. (2007) also found an increase in the concentration of lignin and its recombination products during litter decomposition. Lignin-degrading microorganisms normally grow very slowly and lignin is resistant to decomposition, while cellulose and hemicelluloses are decomposed at a faster rate (Rahman et al. 2013). Substrate-preference may be important for determining which fungal communities dominate the wood decomposition process (Handa et al. 2014), but we did not sample our wood stakes to determine which fungal communities might be active. However, the increase in carbohydrates and the concomitant decrease in lignin concentration during decomposition of both loblolly and aspen stakes in all thinning treatments and the unharvested control indicate wood decomposition in our study was dominated by brown-rot fungi (Blanchette 1995; Jurgensen et al. 1984).

Conclusions

In contrast to our hypothesis, mass loss of aspen and pine stakes across the four thinning treatments were similar to each other, which suggests that 1 year is too early for substrate decomposition differences to occur in this mineral soil. As we hypothesized, both aspen and loblolly pine stakes had the lowest mass loss in the unharvested control stand, but they also had low mass loss in the heavily thinned stand. Finally, initial wood lignin, carbohydrates, and N concentrations had little effect on decomposition across thinning treatments, confirming our 3rd hypothesis. When averaged over all thinning treatments, initial pine lignin concentrations were correlated to stake mass loss. Thinning treatments played the dominant role in our wood decomposition study, probably because of changes in soil environment. Further study on fungal succession and land management is needed to provide information for sustainable management of Chinese pine plantations.

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