

## Needle Sampling Dates for Nutrient Evaluation in Christmas Tree Production

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**Abstract:** Christmas tree needle sampling to evaluate nutrient need is an established practice. Data to support the recommended fall sampling time in Oregon and Washington was not found. In addition, the recommendation for needle sampling of Fraser fir in North Carolina was made without data from winter months. The goal for this paper is to affirm or modify recommended needle sampling time. Needles of Douglas-fir, Turkish fir, Nordmann fir, Noble fir, Grand fir, and Fraser fir Christmas trees were collected monthly for a year, dried, and analyzed for N, P, K, Ca, Mg, and B. No single period was found for any species when needle nutrient concentration was stable for all elements investigated. Revised recommended needle collection times were chosen by integrating cultural practices, likelihood of nutrient deficiency, and needle nutrient concentration changes for species grown in an area. Needle collection is recommended during

February in western Oregon and Washington. The current sampling time, fall, is logical for Fraser fir Christmas tree production in North Carolina.

**Keywords:** Tissue sampling, Douglas-fir (*Pseudotsuga menziesii*), Noble fir (*Abies procera*), Nordmann fir (*Abies nordmanniana*), Turkish fir (*Abies bornmuelleriana*), Grand fir (*Abies grandis*), and Fraser fir (*Abies fraseri*)

## **INTRODUCTION**

Christmas tree needle sampling to evaluate nutrient sufficiency is an established practice in the Pacific Northwest. Growers are directed to collect Christmas tree needles in the late summer or early autumn, before the rainy season begins (Hart et al., 2004). This choice for needle collection time is probably taken from forestry practice since Douglas-fir is the dominant forest species in the area. Forest managers consider fall the time to sample needles (Walker and Gessel, 1991), and Douglas-fir was the initial species used for plantation-grown Christmas trees. No published data were found supporting the choice of fall as the optimum sampling time for Christmas tree production.

Currently, Douglas-fir Christmas tree production is approximately equal to noble fir production, and acreage of Nordmann and Turkish fir Christmas trees is increasing. Nordmann fir is the predominant Christmas tree species in Denmark, where Christmas tree producers are directed to collect needle samples between November 15 and March 1 (Pedersen et al., 2006).

Sampling in the fall after onset of dormancy is specified for sampling needles of Fraser fir in North Carolina (Campbell and Hinesley, 2000). Hockman et al. (1989) suggested October as time to sample Fraser fir Christmas trees. However, their recommendation was made without data taken in November, December, January, and February.

The goal for this paper is to affirm or modify recommended needle sampling time of mid-September to mid-October for routine needle nutrient monitoring of Christmas trees in the PNW and October or after onset of dormancy for Fraser fir Christmas tree production in North Carolina.

## **METHODS AND MATERIALS**

Current-season needles were collected from three replications of Douglas-fir (*Pseudotsuga menziesii*), Nordmann fir (*Abies nordmanniana*), and Turkish fir (*Abies bornmuelleriana*) from one western Oregon Christmas tree plantation. Six-year-old Noble fir (*Abies procera*) and 5-year-old Grand fir (*Abies grandis*) tree needles were sampled from a second plantation.

Approximately 15 trees per replication were sampled monthly for a year beginning in October of 2005 and ending in September of 2006. The same trees were sampled each time. Samples were taken approximately the middle of the month from new or current-season growth. From October 2005 through July 2006 the “current-season” needles were those grown in the 2005 growth year. From July 2006 to September 2006 the “current-season” needles that were sampled were those from the 2006 growth year.

Needles were dried at 65°C, ground in a Wiley mill to pass a 20-mesh screen, and prepared for nutrient analyses by heating at 500°C for 8 hours, dissolving the ash in 10 ml of 5% nitric acid, brought to volume and filtered. Analysis of P, K, Ca, Mg, and B was performed by ICP (Gavlak et al., 1997). Nitrogen was determined with a LECO 2000 CNS analyzer (Gavlak et al., 1997 with substitution of ceramic boats).

For each species, nutrient concentrations from the 12-month sampling period were compared using ANOVA with a randomized complete block model in Statistix 8.0. Means were separated using LSD in the same program.

A single Fraser fir (*Abies fraseri*) needle sample was collected from each of four commercial Christmas tree plantations situated between 1100 and 1250 meters elevation in western North Carolina. Three of the four sites were located on the same soil series and planted with seeds from the same source. Sites were used as replicates for statistical analysis. Sample collection began the first week of November 2005 and continued the first week of each month through September 2006. Needles were collected from the upper one-third of the same 10 trees each month by clipping a single 10-cm branch section of most recently matured foliage. The trees were between 1 and 2 meters tall and had been in the fields from 3 to 5 years.

Mineral nutrient analysis of plant tissue samples was conducted by the Agronomic Division of the N.C. Department of Agriculture and Consumer Services (NCDA&CS), Raleigh, NC. Prior to analysis, the samples were dried at 80°C and ground to pass a 20-mesh (1-mm) screen (Campbell

and Plank, 1992). Total nitrogen (N) was determined by combustion using a CE Elantech NA1500 (Campbell, 1992). Samples were open-vessel digested with HNO<sub>3</sub> using a CEM microwave (Campbell and Plank, 1992). Total P, K, Ca, Mg, and B were determined by ICP (Donohue and Aho 1992).

## **RESULTS AND DISCUSSION**

### **Douglas, Noble, Grand, Nordmann, and Turkish Fir**

Selection of a single needle sampling time for the five species presented a challenge, as needle nutrient concentration varied by species and nutrient. For example, needle N concentration changed less than 2 g/kg from August through December for Douglas-fir, while varying approximately 6 g/kg for Grand fir during the same period (Figure 1A and 1C).

The change in Douglas-fir needle N concentration from August to December was approximately 10% of the highest concentration measured. In contrast, K concentration for the same species and time decreased 3 g/kg, approximately one-third of the highest concentration measured (Figure 1A and 1D). In addition, the variation in annual needle K, and B concentration approached two-fold as shown in Figures 1D, 1E, 1F, and 3E, and was more than two-fold for Ca in all Oregon species (Figure 2A, 2B, and 2C).

The pattern of change in nutrient concentration was not the same for each species. N concentration in Grand fir was relatively constant from October through May and decreased to another plateau from June through September, while K concentration increased in a somewhat

linear manner from June through October (Figure 1C and 1F). Differences in needle nutrient concentration were expected based on Nordmann fir temporal concentration reported by Pederson and Christensen (2007).

The greatest change in nutrient concentration was generally associated with bud break and branch elongation that follows. In western Oregon, bud break occurs in mid-May to early June, depending on the year, species, and elevation. For most nutrients, branch elongation stops before nutrient concentration is stable. An example of needle nutrient concentration change after branch elongation ceased is found with N concentration of Grand fir. The N concentration increases approximately 5 g/kg between September and October.

A consecutive two-month period when needle nutrient concentration did not change was desired. Ideally, a one-month recommended collection time could be placed in the middle of this period. To identify a period for needle collection, needle nutrient concentration was analyzed using ANOVA. Statistical separation of nutrients provided small differences between sampling dates that were significantly different ( $p \geq 0.05$ ), as shown by standard error bars (Figures 1A through 3F). The statistical analysis informed us that the sampling technique was reproducible and small fluctuations could be measured. It was not helpful for identifying a stable time for sampling.

Since slight needle nutrient concentration change was common, an approach to accommodate small change was required. If the variation in monthly needle nutrient concentration did not alter the interpretation or estimation of nutrient sufficiency, we considered the period sufficiently stable for sampling. A similar procedure was used by DeMoranville and Deubert (1986) with

cranberry tissue. For example, Douglas-fir needle N concentration in January, February, March and April differed but was below 16 g/kg, the concentration required for adequate tree color (Hart et al., 2006) (Figure 1A).

Douglas-fir needle nutrient concentration was plotted monthly and examined using our criteria for a stable period. Needle N, P, Ca, Mg, and B concentration in Douglas-fir is sufficiently stable for reproducible needle collection in late summer and early fall, explaining the choice of needle sampling time for this species (Figures 1A, 2A, 2D, 3A, and 3D). In contrast, N, K, Ca, Mg, and B concentration for Noble fir was not stable in the fall (Figures 1C, 1E, 2B, 2E, and 3E).

Danish recommendations are to collect needle samples between November 15 and March 1 (Pederson et al., 2006). Growers are busy with harvest during November and December. Needle sampling during this time is not compatible with harvesting activities, and therefore would not be suggested to American producers.

Comparison of the remainder of the recommended needle sampling time in Denmark, January and February, was made for nutrients in rank by expectation of growth and/or color change from application of the nutrient. Nitrogen was ranked highest in expectation to produce a growth or color change.

Changes in N concentration for Douglas, Noble, Grand, Turkish, and Nordmann fir were relatively small during January and February, making these two months a possible time to sample needles for N evaluation. During January and February, needle nutrient concentration for

P, K, Ca, Mg, and B varied by species. Needle K was stable for Douglas and Turkish fir in March and April. Sampling needles in March or April for a current-season nutrient application is not prudent with the Mediterranean climate of western Oregon and Washington, as rainfall needed for incorporation of N declines in amount and frequency during March. Application of nutrients in early March is the latest date growers should expect sufficient predictable rain for incorporation of N.

### **Fraser Fir**

Needle collection instructions for Fraser fir in North Carolina are similar to directions from Denmark: collect samples in the fall after onset of dormancy (Campbell and Hinesley, 2000; Pedersen et al., 2006). Needle N concentration from February through April did not differ for Fraser fir ( $p \geq 0.05$ ), making this period ideal for needle sample collection if only N concentration is considered. Needle N concentration changed less than 3 g/kg from September through November, making this period acceptable for sampling (Figure 1B).

Potassium and phosphorus needle concentration changed less during February through April than in the fall (Figures 1E and 3A). If only changes in nutrient concentration are considered, February through April would be the time to collect Fraser fir needles for evaluation of nutrient sufficiency.

### **SUMMARY**

Choice of needle collection time for evaluation of nutrient sufficiency is a combination of plant physiology, importance of nutrient, environment, and management considerations. Although many nutrients examined gave clear choices for ideal needle sampling times, changes in annual needle K concentration for Douglas-fir, Noble fir, Turkish fir, Grand fir, and Nordmann fir, coupled with decreasing spring rainfall in Oregon and Washington, made selection of a time to sample needles difficult. Needle nutrient concentration was not stable for all nutrients and species during a single period.

Our approach was to choose the most stable period for N, a time when needle concentration for other nutrients changes least, and sampling is logical from a management perspective. For western Oregon and Washington, the recommendation from this research is to collect needle samples for routine evaluation of nutrient sufficiency during February. The current sampling time, fall, is logical for Fraser fir Christmas tree production in North Carolina, considering elevation, climate, educational effort needed for change of sampling time, and the fact that nutrient concentration is relatively stable during the current sampling time.

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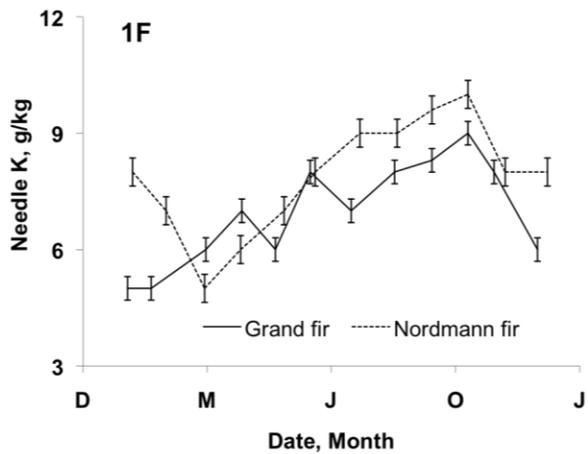
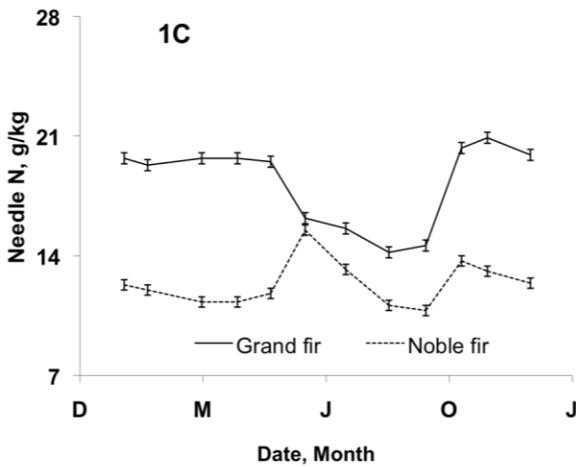
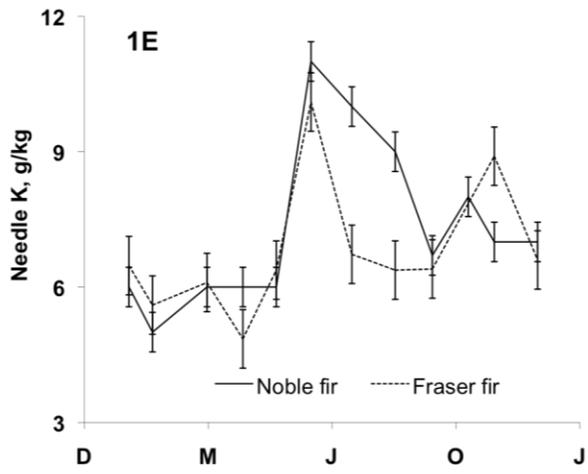
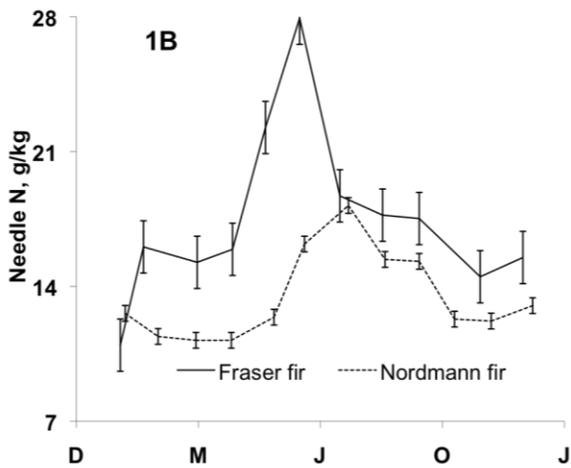
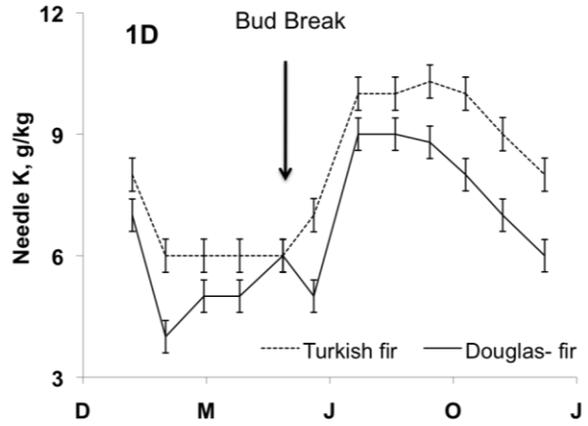
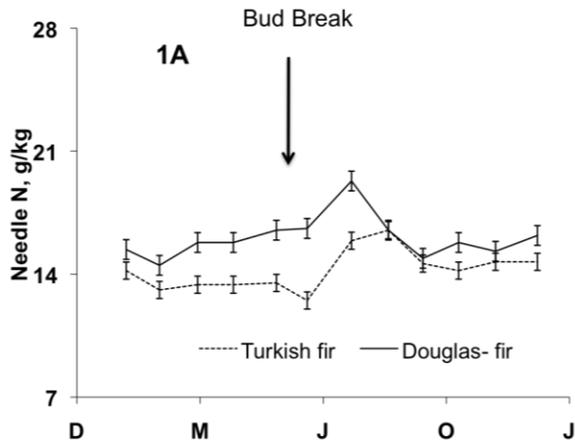


Figure 1. Annual needle nitrogen (N) concentration for Turkish fir and Douglas-fir (A), Fraser fir and Nordmann fir (B), Grand fir and Noble fir (C), and potassium (K) concentration for Turkish fir and Douglas-fir (D), Fraser fir and Noble fir (E), Grand fir and Nordmann fir (E) grown for Christmas trees.

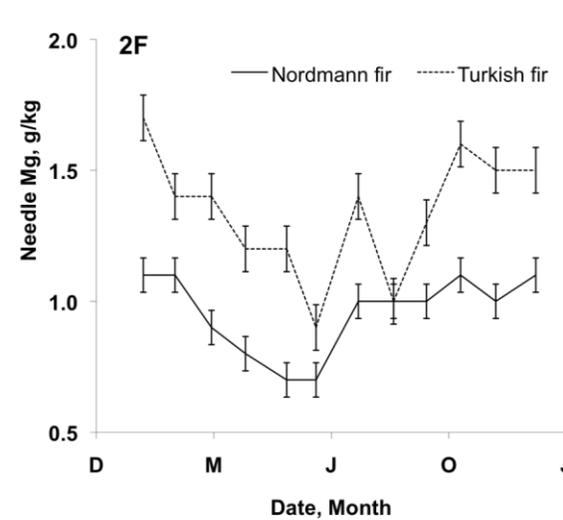
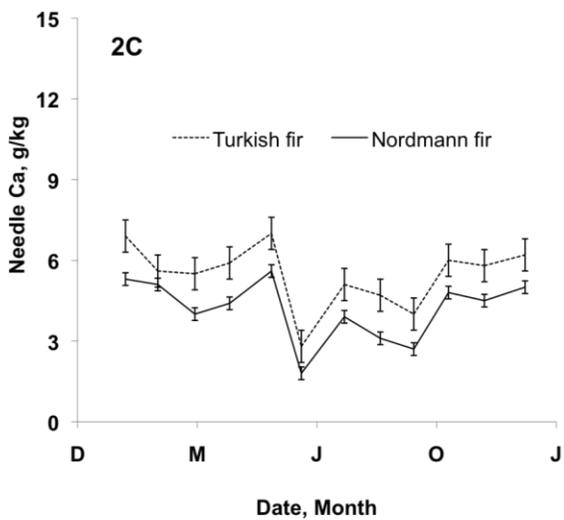
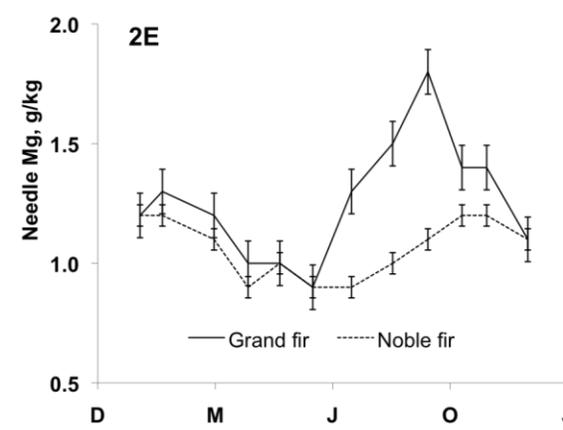
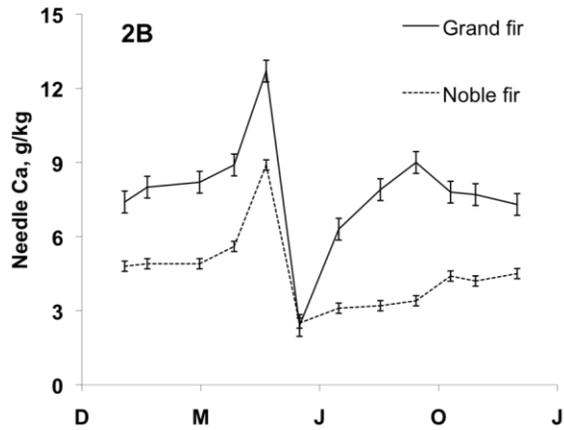
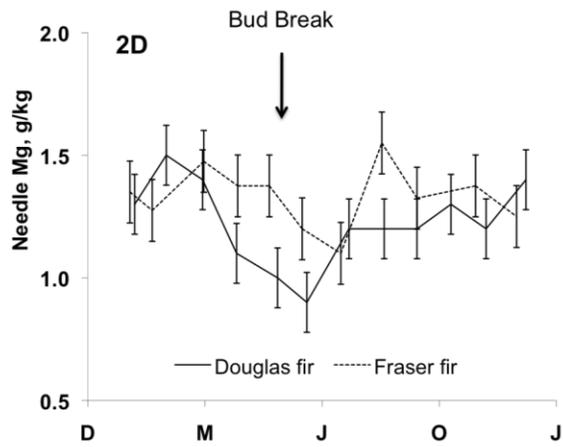
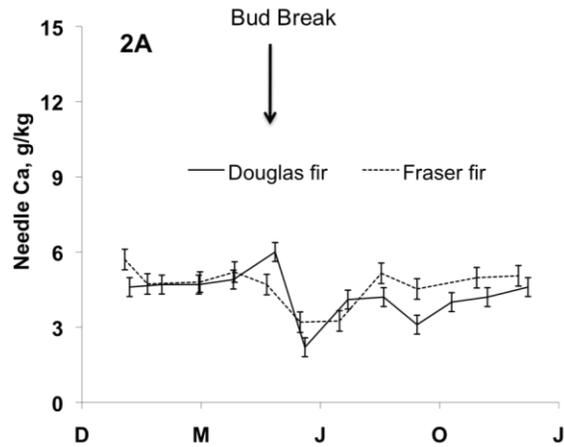


Figure 2. Annual needle calcium (Ca) concentration for Fraser fir and Douglas-fir (A), Grand fir and Noble fir (B), Turkish fir and Nordmann fir (C), and magnesium (Mg) concentration for Fraser fir and Douglas-fir (D), Grand fir and Noble fir (E), Turkish fir and Nordmann fir (F) grown for Christmas trees.

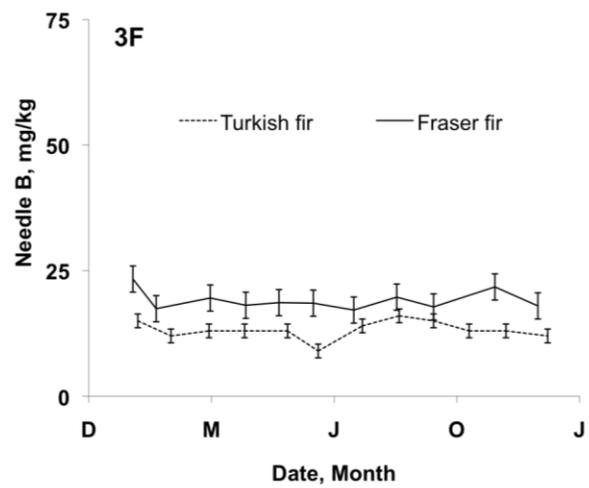
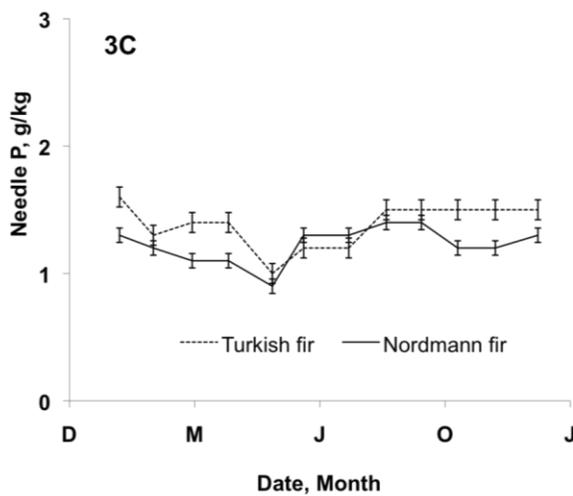
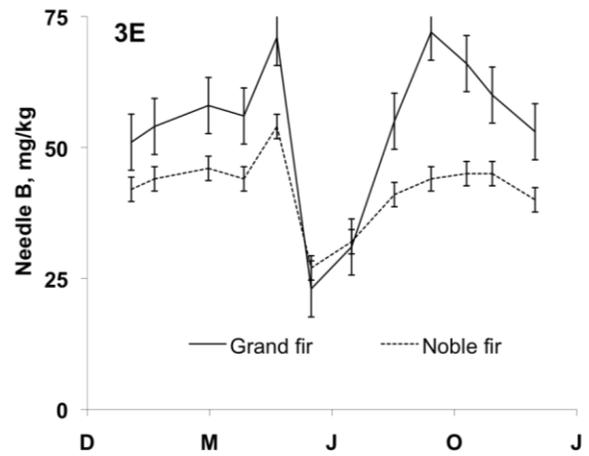
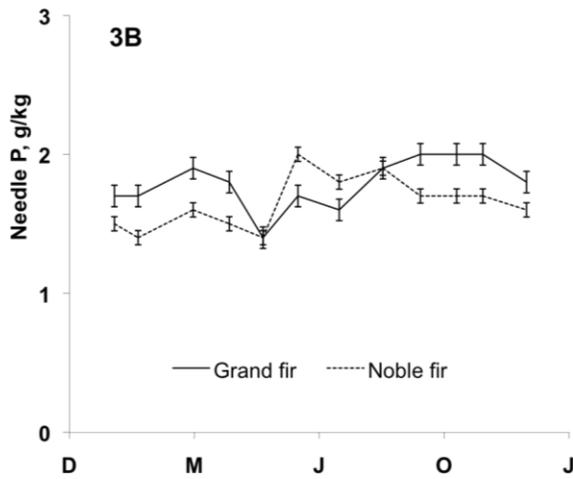
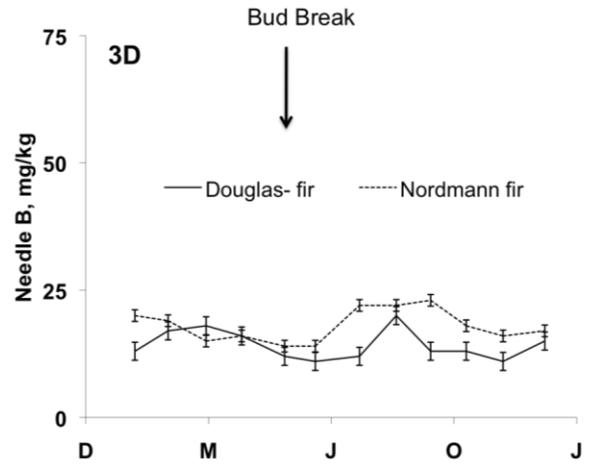
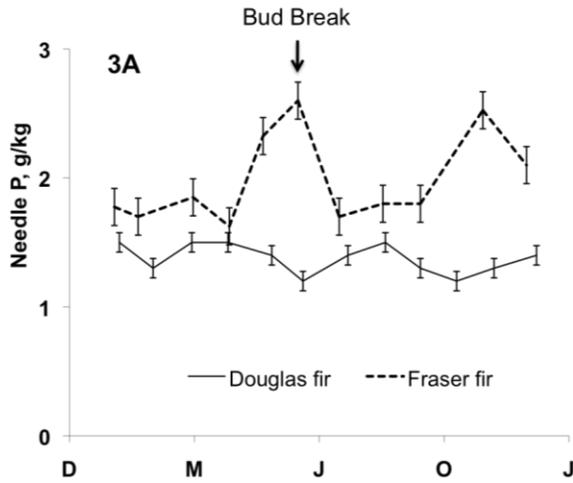


Figure 3. Annual needle phosphorus (P) concentration for Fraser fir and Douglas-fir (A), Grand fir and Noble fir (B), Turkish fir and Nordmann fir (C), and boron (B) concentration for Nordmann fir and Douglas-fir (D), Grand fir and Noble fir (E), Turkish fir and Fraser fir (E) grown for Christmas trees.