

Seasonal Patterns of Plant Flammability and Monoterpenoid Content in *Juniperus ashei*

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BOTTOM LINE

Ashe juniper trees are more flammable in summer than other seasons due to the concentration and composition of volatile oils in the needles and twigs.

- Plant flammability was directly related to the concentration of two monoterpenoid oils. Manipulating the concentration of these two oils may help us develop a fire management system for Ashe juniper.
- Secondary chemicals, usually considered as anti-herbivore mechanisms, may also serve an important role in determining the likelihood of a plant being consumed by fire.

Introduction

The susceptibility of *Juniperus* communities to prescribed fires can vary greatly throughout the year. Naturally occurring fires often originated during the hot, dry summer months whereas man-made fires are usually conducted in early- to mid-winter for increased safety. Besides the obvious differences in environmental conditions between summer and winter, plant flammability changes with season, potentially resulting in different fire intensities. Plant moisture and heat content of plant tissues vary seasonally and directly influence plant flammability. Plant phytochemicals, particularly monoterpenoids, may also increase the combustibility of plant material by increasing the probability of ignition. To develop effective fire management systems for juniper communities we need to understand the relationship between environmental factors, plant secondary chemicals and flammability. The objectives of this study were: 1) to document the seasonal changes in secondary chemistry in Ashe juniper (*Juniperus ashei* Buchh.); and 2) to relate the observed changes in monoterpenoid concentrations and composition to plant flammability.

Experimental Approach

The study was conducted on the Sonora Research Station located 28 miles southeast of Sonora, Texas and on the Annandale Ranch near Concan, Texas. Twenty Ashe

juniper trees (10 male and 10 female) were permanently marked at each site in March 1993 and sampled approximately every 6 weeks for 16 months. Approximately 80 gm fresh weight of mature juniper foliage and twigs were collected at each sample date. Twenty grams were used to analyze volatile oil concentration and composition and gross energy. Flammability was determined by placing 50 gms of juniper needles and small twigs on a screen above an open flame. The open flame was placed under the sample for 60 seconds and then removed. Four thermocouples were placed in the sample and one was placed between the sample and the open flame. Temperatures were recorded every 5 seconds and averaged every minute. After 5 minutes, the remaining sample was re-weighed to determine the percentage of the plant material actually burned. Xylem water potential was measured at each sampling date to estimate water stress using a pressure bomb (Scholander et al. 1965).

The relationship between plant flammability and plant characteristics was analyzed using a growth curve model. Independent variables were the concentrations of the three dominant oils (camphor, bornyl acetate and limonene), percent plant moisture, caloric content on a fresh weight basis, and on a dry weight basis, site, tree sex, and xylem water potential. The dependent variable was the percentage of the plant which burned.

Results

Total monoterpene concentration was significantly affected by season and by plant population. Mean monoterpene concentration of a population from the Annandale Ranch was 9.16 mg g^{-1} fresh weight of juniper needles while the mean concentration of the Sonora population was 11.62 mg g^{-1} of fresh weight.

Monoterpene concentrations were typically lowest during the summer and highest during the spring and winter in the western population, but there was no seasonal pattern in the eastern population. Plants were most flammable in the summer when maximum temperatures reached 520°C within 2 minutes of the flame being placed under the sample. Temperatures and flammability were much lower during the winter (Figure 1).

The eastern population of trees was slightly (4.8%) more flammable than the western population, and male trees were slightly (3.8%) more flammable than female trees. The concentration of limonene was positively related to plant flammability and could increase flammability by 30% over the range of concentrations found in this species. Bornyl acetate was negatively related to flammability with each 1 mg g^{-1} increase in concentration resulting in a 2% decrease in flammability (Figure 2). Caloric energy content and percent leaf moisture were not significant factors in determining the percentage of the Ashe juniper plant actually burned.

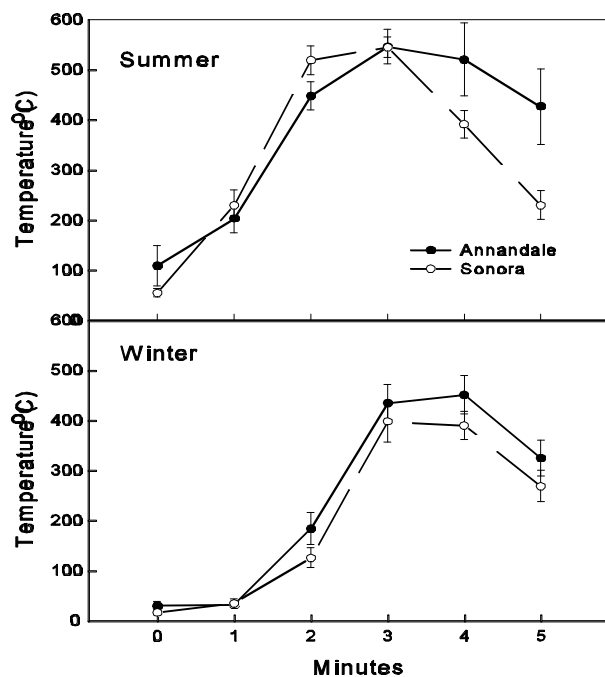


Figure 1. Temperature profiles of juniper needles during summer and winter burning experiments.

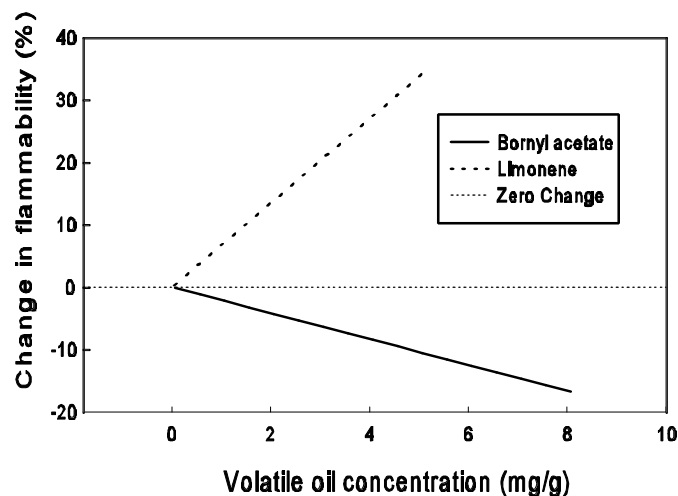


Figure 2. Effects of 2 monoterpenoids on juniper flammability.