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The relationship between tree diameter growth and climate for coniferous species in northern California

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Abstract: The difference between actual and predicted growth rates for the conifer regions of northern California has been observed to vary with climatic changes. This study presents a method to investigate the relationship between growth and climate. Growth variations attributable to biological and cultural factors were removed by using the CACTOS (California conifer timber output simulator) program. The remaining variation was then associated with relative precipitation and temperature for the projected period and the CACTOS calibration period. Climatic data from the current and preceding years were considered. Elevation, stand density, and species were also investigated to determine their effects on the format and magnitude of the relationship between growth and climate. The results of this study, which included tests of stem analysis data taken over 15 years, indicate that growth variation is associated with the climatic changes of winter precipitation and summer temperatures for the region, in addition to biological and cultural factors. Winter precipitation and summer temperatures affect growth in the current and the subsequent years. Moreover, the relationship between climate and growth changes by densities and species. This study provides a basis for using short-term growth data to make long-term growth projections with growth adjusted to long-term climatic conditions.

Résumé : La différence entre les taux de croissance réel et anticipé varie selon les changements climatiques dans les régions de conifères du nord de la Californie. Cet article présente une méthode pour étudier la relation entre la croissance et le climat. Les variations de croissance attribuables aux facteurs biologiques et culturaux ont été éliminées à l'aide du programme CACTOS, un programme de simulation de la production de bois chez les conifères de la Californie. La variation résiduelle a été associée à la température et à la précipitation relatives pour la période visée par la simulation et la période de calibration de CACTOS. Les données climatiques de l'année en cours et des années précédentes ont été considérées. L'altitude, la densité du peuplement et l'espèce ont également été considérées pour déterminer la forme et l'ampleur de la relation entre le climat et la croissance. Les résultats de cette étude, qui incluait des tests avec des données d'analyse de tige prises sur une période de 15 ans, montrent que la variation de croissance est associée aux changements climatiques reflétés dans la précipitation hivernale et les températures estivales de la région, en plus des facteurs biologiques et culturaux. La précipitation hivernale et les températures estivales affectent la croissance de l'année en cours et des années subséquentes. De plus, la relation entre le climat et la croissance change selon la densité et l'espèce. Cette étude fournit les bases nécessaires à l'utilisation de données de croissance à court terme pour faire des projections à long terme en ajustant la croissance aux conditions climatiques à long terme.

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Introduction

Climatic effects on trees and forests have been recognized by a number of researchers investigating the occurrence of species, distribution of plants, and the formation of structural characteristics (formation of growth) (Fuller 1914; McLean 1917). Climatic variations are particularly important in the process of estimating tree height and diameter growth, because characters like stem elongation, formed over long time periods of meristematic activity, are more responsive to climatic influences than characters like reproductive structures that are formed rapidly (Bradshaw 1965). Climatic factors, therefore, must be considered when projecting future growth in trees.

The ability to predict future growth patterns is essential to credible forest management planning (Davis and Johnson 1987; Barrett et al. 1994), and it is especially important in the process of permitting timber harvests where long-term projection is required. The current practice has been to base projections on biological or environmental variables, excluding climatic factors from consideration. Biological variables such as site index, tree age, diameter at breast height (DBH), tree height (HT), and stand density have been used, and environmental variables such as elevation, aspect, and slope have also been considered. Examples of biological and environmental models include CACTOS (Wensel et al. 1986), STEMS (Belcher et al. 1982), PROGNOSIS (Stage 1973; Wykoff et al. 1982), and ORGANON (Hann et al. 1995). The climatic information drawn from these models may not accurately reflect long-term climatic conditions, because

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