16 avo TALLER DE BIOLOGÍA FORESTAL DE AMÉRICA DEL NORTE

"Impacto del cambio ambiental global sobre los bosques e impacto de los bosques sobre el cambio ambiental global"

MÉRIDA, YUCATÁN, MÉXICO

Julio del 2000

PRESENTACIÓN

La Secretaría de Agricultura, Ganadería y Desarrollo Rural a través del Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), la Delegación de la SAGAR en el Estado de Yucatán y la Comisión Forestal de América del Norte (COFAN), en coordinación con el Gobierno del Estado de Yucatán a través de las Secretarías de Desarrollo Rural y la de Ecología, la Fundación Produce Yucatán A. C., la Universidad Autónoma de Yucatán, el Centro de Investigación Científica de Yucatán A. C., la Universidad Marista, el Consejo Nacional de Ciencia y Tecnología, el Instituto Tecnológico Agropecuario No 2, Conkal, la Secretaría del Medio Ambiente, Recursos Naturales y Pesca, el Instituto Nacional de Capacitación del Sector Agropecuario A. C., la Sociedad de Forestales Americanos (SAF) y la Asociación de Genetistas Forestales del Oeste de E. U. (WFGA), convocan a la comunidad científica forestal, a los profesionales forestales y afines, así como a las personas interesadas del sector público y privado de Canadá, Estados Unidos y México, al **"16 avo Taller De Biología Forestal de América del Norte"**, ***"Impacto del cambio ambiental global sobre los bosques e impacto de los bosques sobre el cambio ambiental global"***, que se llevará a cabo en la ciudad de Mérida, Yucatán, México, del 16 al 21 de julio del 2000.

ANTECEDENTES

Los Grupos de Trabajo en Fisiología y Genética Forestal de la Sociedad de Forestales Americanos (SAF) han organizado de manera periódica desde hace 30 años el Taller de Biología Forestal de América del Norte, como un foro para presentar y discutir los avances de la investigación básica y aplicada en las diferentes disciplinas de la Biología Forestal, en el contexto del manejo sustentable de recursos forestales y de la problemática en general que enfrentan los bosques en Norteamérica. En esta ocasión, con el apoyo de los Grupos de Estudio en Recursos Genéticos Forestales, Silvicultura y Cambios Atmosféricos de la Comisión Forestal para América del Norte (COFAN), la Asociación de Genetistas Forestales del Oeste de E. U. (WFGA) y las Instituciones Mexicanas anfitrionas se organiza por primera vez este Taller en México. En las reuniones anteriores se ha destacado la necesidad de reforzar los vínculos y esfuerzos en el ámbito regional con el fin de mejorar la comunicación e intercambio de experiencias, especialmente en aquellas áreas que tienen repercusiones en el ámbito global, como lo son actualmente las interrelaciones entre los bosques y el cambio ambiental.

Problema por abordar

El desarrollo forestal en la región de América del Norte, a pesar de los avances tecnológicos, no alcanza todavía los niveles y resultados esperados por los sectores oficiales, privados y gremios profesionales; sin embargo, existen grandes expectativas sobre la contribución y el papel que esta actividad debe jugar en el desarrollo sostenible de los países de la región, especialmente ante el reto que plantea el ingreso a un nuevo milenio. Aunado a esto, los acuerdos adoptados durante la Conferencia Mundial sobre el Medio Ambiente de 1992, plantean una serie de desafíos, metas y resultados esperados que deben ser analizados y evaluados con el fin de establecer mecanismos y estrategias que contribuyan a potenciar dichos acuerdos. Los profesionales forestales han sido testigos y actores de una significativa evolución en los enfoques y desarrollo de políticas y estrategias sobre el uso de los recursos forestales en los últimos años. Un problema común que se enfrenta es la gradual disminución de las superficies de bosques y selvas, con el inexorable deterioro de los recursos genéticos forestales, la disminución de la biodiversidad, particularmente en las selvas, y sus repercusiones en el ambiente en general. Con la participación de investigadores de diferentes países se abordarán los avances recientes en las diferentes disciplinas de la Biología Forestal (Fisiología, Genética, Ecología, Silvicultura, etc.), especialmente en lo que se refiere al "Impacto del cambio ambiental global sobre los bosques e impacto de los bosques sobre el cambio ambiental global". La generación y difusión de nueva información son indispensables para que las empresas forestales, comunidades rurales y demás Instituciones que participan directamente en el manejo de los recursos forestales logren sus propias metas de desarrollo.

OBJETIVOS

El objetivo fundamental es intercambiar experiencias y discutir el estado actual del conocimiento en el área de la Biología Forestal como base científica para asegurar el manejo y conservación de los bosques y selvas en el ámbito regional, ante los retos que plantea el cambio ambiental global. Asimismo, se pretende contribuir al desarrollo de estrategias de desarrollo del sector forestal que propicien una mayor calidad de vida de la sociedad en general. Otros objetivos son: Discusión de las interrelaciones existentes entre los bosques y selvas y el cambio ambiental global. Análisis del papel de la Biología Forestal en la generación de conocimiento para un mayor entendimiento de esas interrelaciones. Lograr un mayor acercamiento entre los países de la región para desarrollar políticas y estrategias comunes. Análisis del potencial de los recursos forestales, a fin de lograr una contribución más significativa en los programas de desarrollo socioeconómico en el ámbito de los países y la región en su conjunto.

TEMÁTICA

La temática que enmarca este importante taller es:
Cambios en las condiciones atmosféricas (Changing atmospheric conditions).
Captura de carbono (Carbon sequestering).
Semilla recalcitrante y conservación de germoplasma (Recalcitrant seed & germplasm conservation).
Respuesta biológica al cambio (Biological response to change).
Respuesta de la vegetación y cambio climático (Vegetation response & climate change).
Genética y mejoramiento de árboles forestales (Genetics and forest tree improvement).
Fisiología de árboles forestales (Forest tree physiology).
Cruzamientos para tolerancia al estrés (Breeding for stress tolerance).
Silvicultura tropical (Tropical silviculture).
Adaptación y cambio climático (Adaptation & climate change).

RESÚMENES

INVITED PAPERS

CONFERENCIAS MAGISTRALES

GLOBAL CLIMATE CHANGE AND ITS IMPACTS ON THE TERRESTRIAL ECOSYSTEM.

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Abstract: Global climate change is a complex, integrated system of atmospheric processes and their products. Among the many variables involved, of concern in the context of terrestrial ecosystems are increases in the concentrations of carbon dioxide (CO_2) and ozone (O_3) and levels of ultraviolet (UV)-B (280-315 nm) radiation and changes in the air temperature (T^0C) (climate warming) and precipitation patterns. There is a significant temporal and spatial variability in the occurrences of these variables, particularly with elevation. For example, high elevation forests are subjected to distinctly different patterns of CO_2 and O_3 exposures compared to the low elevation ecosystems. Similarly, although there are several models that predict future increases in the average global air temperature, historical records for the last 100 years show no measurable increases in the average daily T over North America, but a clear increase in the nighttime T during the last several decades. Independent of these observations, data from multi-year measurements of the parameters relevant to forest ecosystem responses are relatively sparse. Among all climate change related parameters, at the forest ecosystem level, emphasis during the last three decades has been on the effects of O_3 and other photochemical oxidants. With the development of ambient exposure systems, there is an increasing effort to study the effects of elevated CO_2 concentrations. Forests are both a sink and a source for CO_2. Only recently have scientists begun to study the importance of this flux, relative to the storage of C in forest ecosystems. Results from a four-year study show significant inter-annual variability attributed to temperature and soil moisture availability. Overall, there are a number of uncertainties associated with our current knowledge of climate change effects on forest ecosystems. Although many of the simulation models have produced differing outputs, one can nevertheless, draw some general conclusions.

TROPICAL N-FIXING TREES, VIRUS RESISTANCE, AND THE COLLAPSE OF MAIZE-BASED CIVILIZATIONS.

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PRESENTATION PROVIDED

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Abstract: The Classic Maya civilization of 300 to 900 AD thrived on the calcareous Yucatan peninsula. Two factors undergirded its growth to >2,000,000 people–maize and N-fixing trees. This incredible civilization collapsed mysteriously in the 9th century. Abandoned were 1300 ceremonial centers and, importantly, rich agricultural lands that had been carved out of tropical rain forests without metal tools, wheels, or beasts of burden! No reoccupation occurred of these farms and temples. Survivors presumably migrated south to highlands and northward to areas (e.g., Chichén Itzá) with a long dry season. It is evident that legume tree regrowth in fallow periods undergirded the remarkable intensity of Maya maize culture. A leafhopper-borne virus of maize is believed to account for the collapse (Brewbaker, 1979, Econ. Bot. 33:101-118). The hopper and virus are restricted to maize, thus to areas (e.g., Hawaii) where maize is grown year-round. Maize diseases are implicated in similar collapses in the late 1st and early 2nd millennia of maize-based civilizations of Zapotec, Teotihuacan and Anasazi peoples. Tropical forests are currently lost (often to corn fields) at a devastating rate exceeding 1% per year. Sustainable agroforestry systems with multipurpose trees of immediate value to local peoples offers one of the few long-term solutions to this loss. N-fixation is integral to the success of such systems in tropical soils, and NFTrees have evidently evolved with high virus tolerance. Breeding of tropical trees wisely focusses on the exploitation of interspecific heterosis of multipurpose trees that can be used (as green manure, forage, food, shade, and yes wood) by the four billion people living in the tropics. But who is going to pay for it?

EL USO DE ESPECIES ARBÓREAS MEXICANAS PARA PROPÓSITOS PALEOCLIMÁTICOS.

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Las cronologías mexicanas procedentes de anillos de algunas especies arbóreas son particularmente sensibles a cambios de precipitación y aquellas generadas en el norte de México (Durango, Coahuila, Chihuahua y Sonora), registran de manera particular la influencia a largo plazo. Del fenómeno del Niño, Oscilación del Sur (ENSO) y del Monson Mexicano (MM). Trabajos conjuntos con el personal investigador del Laboratorio de Dendrocronología de la Universidad de Arkansas (UA) y con investigadores del Instituto Mexicano de Tecnología del Agua (IMTA), han derivado en la obtención de nuevas colectas de abeto o Douglas-fir (***Pseudotsuga manziesii***) en sitios de la Sierra Madre Oriental de los estados de Coahuila, Querétaro, Veracruz, Hidalgo y Tlaxcala y en algunas localidades de la Sierra Madre del Sur en Oaxaca. Estos rodales aislados de Douglas-fir se encuentran restringidos a exposiciones norte generalmente en sitios con pendientes escarpadas, suelos someros y microclimas húmedos y fríos a elevaciones entre 2350 a 3400 m. Los árboles de esta especie muestran anillos de crecimiento bien definidos con edades que fluctúan entre 200ª 300 años de edad, que pueden ser visiblemente divididos en bandas de madera temprana y tardía, cada una influenciada por condiciones climáticas distintas durante su formación. Una reconstrucción de precipitación para el período invernal y de verano de 600 años de longitud con esta especie en el estado de Durango, muestra la presencia de períodos secos en los siglos XV, XVIII y XX. Otra especie que ha sido motivo de extensa colecta es el sabino o ahuehuete (***Taxodium mucronatum***) especie que se encuentra ampliamente distribuida en territorio mexicano y que se considera el árbol nacional de México. Muestras maderables de esta especie se colectaron en fechas recientes en el "Parque de Chapultepec" de la Cd. De México, "El Vado", Oaxaca y "Jalpan", Querétaro. Estas muestras no han sido analizadas completamente y aún no han derivado en índices cronológicos, aunque existe el potencial para ello, debido a la presencia de anillos de crecimiento anual bien definidos. Las muestras del "Parque de Chapultepec", indican visualmente períodos de crecimiento restringido a mediados del siglo XIX y una liberación en crecimiento a inicios del siglo XX. Lo anterior puede estar relacionado a condiciones de menor o mayor precipitación. Dos cronología de ahuehuetes de 400 años de longitud se han desarrollado de colectas obtenidas en Río Sabinas, Tamaulipas y Río Verde, San Luis Potosí. Análisis preliminares, indican una buena correlación entre la cronología del Río Sabinas y la lluvia total para el período mayo-junio, si lo anterior se corrobora con posteriores análisis estadísticos, entonces será posible utilizar esta cronología como "proxy" para una reconstrucción de factores climáticos. La reconstrucción del período mayo-junio en esta región es muy importante para las actividades agropecuarias y forestales y un análisis histórico de esta variable resulta primordial para un mejor entendimiento de la

influencia histórica de esta variable climática en las actividades indicadas. México es un país rico en biodiversidad y es muy importante tomar ventaja de esta condición y explorar el potencial dendrocronológico de nuevas especies presentes en climas templados, semiáridos y tropicales. Actualmente estudiamos tasas de crecimiento y colectamos muestras maderables de mezquite (***Prosopis spp***), encinos (***Quercus mexicana, Q. Rugosa,*** etc.) especies localizadas en zonas semiáridas y templadas y que tienen alta demanda para leña, carbón muebles, etc. En zonas semitropicales hemos observado la presencia de capas de crecimiento anula bien definidas para especies como cedro (***Cedrela odorata***) y liquidambar (***Liquidambar styraciflua***) especies tropicales maderables muy importantes. Probablemente con algunas de estas especies no sea posible generar cronologías para fines paleoclimáticos, sin embargo esta información puede ser de fundamental valía para un mejor aprovechamiento y conservación de las mismas. Para realizar esta tarea contamos con el apoyo económico de instituciones internacionales como lo es el de la Universidad de Western Ontario, Canadá, a través de un proyecto financiado por el Instituto Inter-Americano y por personal investigador del Laboratorio de Dendrocronología de la Universidad de Arkansas, de los cuales hemos recibido un apoyo incondicional mediante un proyecto colaborativo de investigación financiado por NFS. La problemática del agua es un tema cada vez más relevante en muchas regiones de nuestro país, debemos hacer mayor uso de esta herramienta para conocer el pasado y contar con mejores fundamentes técnicos para entender el futuro.

POTENTIAL CONTRIBUTIONS OF MANAGED FORESTS TO CARBON SEQUSTRATION: A CASE STUDY EXAMINATION OF SOPUTHERN PINE FORESTRY. K.H. Johnsen

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Abstract: The South represents about 24% of the land area of the United States; outside of Texas and Oklahoma, about 58% of this land is forested and about 20% of the forestland is owned by forest industry. From 1962 to 1992 the total land area of commercial pine forest rose 27% to 11,291 million ha. The extent of managed forests has increased because southern pine forests are extremely productive. The warm climate of the south extends the growing season and reduces rotation length; pines reach sawlog size in 25 to 35 years on many southern sites. In managed forests, the amount of C further sequestered (relative to present day) will be determined by three factors: 1) the increased amount of C in standing biomass (due to land use changes and increased productivity); 2) the amount of recalcitrant C remaining belowground at the end of the rotation; and 3) the amount of C sequestered in products created from the harvested wood, including their final disposition. Therefore, managed southern pine forests sequester C both *in situ* (biomass and soil) and *ex situ* (products). In my talk. I will assess the magnitude and primary controls of the major C pools, suggest management options for increasing C sequestration and indicate important research needed so that Southern pine forest C sequestration can be better quantified, predicted and managed.

GENES, CLIMATE, AND WOOD: A STORY OF LODGEPOLE PINE. Gerald E. Rehfeldt

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Link to PRESENTATION PROVIDED

Abstract: Analyses of long-term provenance tests of lodgepole pine (Pinus contorta) at 60 environmentally disparate test sites in British Columbia have produced population response functions driven by climatic descriptors for 20-year height, diameter, survival and, therefore, volume per ha. The functions demonstrate that populations have different climatic optima and different growth potentials but tend to occupy suboptimal environments, with the degree of suboptamility much greater in the north than in the south. The functions are ideally suited to assessing the impact of changing climates during the transient phase of vegetal response. This phase presages an approach to equilibrium and consists sequentially of (1) direct effects on contemporary forests that are governed by the physiological plasticity of individuals and (2) long-term evolutionary adjustments that produce the optimal genotypes for the new climates. According to the response functions, direct impacts of global change on contemporary populations should be highly complex but largely negative, accruing from the inability of physiologic systems to cope with the amount of change. In time, the evolutionary process will optimize adaptedness, growth, and productivity, and, as equilibrium is approached, productivity of the lodgepole pine forests of British Columbia should increase greatly. This optimistic outlook, however, must be tempered. The bulk of global climate change is expected to occur in merely a century less than one generation for lodgepole pine. Yet, quantitative genetic principles suggest that evolutionary adjustments should take only 3 generations in the north but nearly 12 generations in the south. The transient period, therefore, should last between 300 and 1500 years. The results show clearly that a change in climate will disrupt the genetic system throughout a species distribution even when changes in the distribution itself are inconsequential. They also show that the speed of climate change is much more daunting than the amount of change. Maintaining productive forests during the transient period will require intensified planting programs designed to assist the evolutionary redistribution of genotypes.

CHANGING ATMOSPHERIC CONDITIONS

CAMBIOS EN LAS CONDICIONES ATMOSFÉRICAS

EFFECTS OF FORESTRY PRACTICES, INCLUDING CLEARCUT HARVESTING AND ALTERNATIVE VEGETATION MANAGEMENT TREATMENTS ON FOREST MICROCLIMATE.

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PRESENTATION PROVIDED

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Abstract: The Fallingsnow Ecosystem Project was initiated in northwestern Ontario in 1993 to assess the effects of alternative conifer release practices on ecosystem processes and components. Treatments included two herbicides, glyphosate and triclopyr applied aerially at maximum label rates, and two cutting treatments, manually with brushsaws, and mechanically with a Silvana Selective mower. Treatments were applied to 4 clearcut blocks (30-60 ha each) harvested between 1986 and 1988, and planted with spruce. Clearcut controls (5-7 yrs old in 1993) constituted a 5th treatment, and unharvested controls (approximately 100 yrs old and predominantly aspen, fir, and white birch) adjacent to each block, constituted a 6th treatment. Study objectives were to quantify treatment-related microclimatic differences and to assess the duration of these differences. Weather stations, programmed to continuously monitor photosynthetically-active radiation (PAR), air temperatures, and relative humidity (RH) at 0.25 and 2.0 m above the forest floor and soil temperatures at 5 and 15 cm depth, were established from 1994 through 1998. Stations were deployed on a maximum of 3 blocks, in the clearcut control (C), brushsaw (B), glyphosate (G), and unharvested forest (F) treatments. epeated measures ANOVA's were used to assess treatment differences in 1998 for 2 replicated blocks, 5 years after B or G treatments, and 12 years after harvesting. nalyses revealed significant treatment differences for 20 of 22 measured parameters. Lower PAR and higher RH (mean seasonal values for June 2-October 14 at 2.0 m) were observed for the unharvested forest compared with the clearcut control. PAR values for the F, C, B, and G treatments were 619, 789, 1629, and 1852 umol . s^{-1} . m^{-2}, respectively. RH values (daily lows) were 58, 53, 52, and 43%, respectively. Seasonal air temperature extremes (^{o} C), for daily highs and lows, were associated with the glyphosate treatment, where non-woody vegetation was dominant. Temperatures at 2.0 m were 19.9, 21.2, 21.6, and 22.9^{o}, respectively, and 12.7, 11.8, 10.8, and 10.8^{o}, respectively. Temperatures at 0.25 m were 21.0, 21.8, 23.0, and 26.0^{o}, respectively, and 11.5, 10.3, 8.5, and 7.8^{o}, respectively. Mean seasonal soil temperatures at 15 cm depth (daily highs) remained highest for the glyphosate treatment, and higher than for all other treatments. These data suggest that the effects of routine forestry practices in altering forest microclimate are longer-lasting than anticipated. Changes in forest microclimate are likely contributing to global warming and to global environmental change. The extent and significance of these contributions are yet to be determined.

WILDFIRES AND GLOBAL CLIMATE CHANGE ALONG A TRANSECT THROUGH THE AMERICAS.

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Abstract: This paper presents over 25 years of research experience that the Fire and Environmental Research Applications team of the US Forest Service, PNW Research Station has been conducting in the boreal, temperate forests, and rangelands of the United States and Mexico, and tropical ecosystems in Florida, Hawaii, and Brazil. A line drawn from the tundra of Alaska to the Atlantic forest of Brazil transects virtually all of the Earth's biomes. This "Transect of the Americas" provides a compact global ecological laboratory for comparative ecosystem studies; and for testing the rigor of theories across multiple ecosystems. FERA's research underlies decision support systems for fire management, air quality management, and global change response. The applied and theoretical research conducted by FERA addresses issues that concern to those management and scientific communities in the United States and elsewhere. Some of FERA products include: tools for biomass loading and flammability assessment, predicting biomass consumption across major ecosystems, thermodynamic modeling of smoldering consumption, smoke management and health assessment tools, and biomass Emissions assessing greenhouse gas emissions from wildland fires. Since the 70's, the group has conducted extensive research on combustion and carbon emissions through North America, Mexico and Brazil that has lead to the development of combustion algorithms used by fire managers and scientists. Research in tropical savannas and temperate rangelands is conducive to the development of equations and methods to evaluate fuelbed characteristics, biomass consumption, air pollution, and greenhouse gas emissions from fires across environmental gradients. Flammability and fire severity thresholds are being investigated in the boreal, temperate forests, and rangelands in the United States, as well as logged and primary Amazon forest. FERA scientists are responsible for assessing the risk of smoke exposure to the health of firefighters and rural communities in the United States.

WILDFIRES IN TROPICAL FORESTS. Ernesto Alvarado[1] and David V. Sandberg[2]

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Abstract: Occurrence of catastrophic wildfires in the last few decades in different parts of the world has raised awareness of devastating local effects, and the potential impact across international borders. A steady increase of wildfire risk has been detected in temperate forests of North America, as well as tropical ecosystems of the world. Uncontrollable wildfires in the tropics are increasing in number and extent at rates higher than temperate forests. Public is more aware of issues such as biomass burning and greenhouse effects, loss of natural habitat, international haze and pollution, public health and safety, loss of industrial and agricultural production, decline in tourism, and increased health care costs. Ordinarily, undisturbed tropical rain forest is considered a fireproof ecosystem. Severe fire can only occur during sustained droughts when the ecosystem is dry enough to sustain smoldering combustion, or when the canopy is disturbed by natural events or human activities. It is important to anticipate weather and land use patterns that result in high fire danger so that management and regulatory remedies can be applied. The Spring 1998 wildfire season in Mexico and several other countries across the world signaled how vulnerable are tropical ecosystems to wildfires and that the immediate effects can be felt across borders. The land use/land cover classes most extensively impacted in the SE Mexico were the tall/medium *selvas*, open/fragmented forests, and perturbed areas. The estimated total prompt emissions during a two-month period contributed an additional 24% to the region's average annual net C emissions from forestry and land-use change. If fire episodes such as the one that occurred in Mexico and around the world become the norm due to warmer and drier conditions, then an increase in C emissions may represent a significant positive feedback to global climate change.

VALIDATING THE INTEGRATED BIOSPHERE SIMULATOR (IBIS) AT REGIONAL AND LOCAL SCALES IN CANADIAN FOREST ECOSYSTEMS.

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Abstract: The need for improved understanding of ecosystem processes and related carbon dynamics in response to changes in global climate has led to the construction of several dynamic global vegetation models (DGVM). Simulations performed with such models have generally been successful in approximating the distributions and magnitudes of key ecosystem indicators at the global scale. However, detailed validations against observations made in different ecosystems at smaller spatio-temporal scales are still highly desirable. The objectives of this paper address some of these validation requirements. First, we present and discuss results of site-based simulations of energy, water and carbon fluxes for different forest stands in central Canada, using the Integrated BIosphere Simulator (IBIS) of Foley et al (a DGVM). Agreements between observed and simulated energy balances and CO2 fluxes were generally very good. In a second validation exercise, the results of a national scale simulation of Canada's forests were compared with a recently compiled gridded dataset of forest biomass derived from the CFS Canadian Forest Inventory (CanFI) database. Plant functional types (PFT) used in IBIS were parameterized to more closely represent the characteristics of Canada's forest vegetation. Simulated vegetation distribution and biomass densities were found to agree with the gridded dataset better than were obtained using the global PFT parameterization.

CARBON SEQUESTERING

CAPTURA DE CARBONO

QUANTIFICATION OF SITE- AND SPECIES-SPECIFIC WOOD PRODUCTION AND CARBON SEQUESTRATION IN RELATION TO CLIMATE CHANGE - LODGEPOLE PINE, INTERIOR SPRUCE AND INTERIOR DOUGLAS-FIR.

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Abstract: Forests as an atmospheric $C0_2$ sink or source is still a debated issue. Studies in recent years have indicated that forests may function as a significant sink, accounting for as high as 20% of the total carbon budget. These studies are mostly based on the analyses of satellite image of ground vegetation cover, forest inventories, statistics of wood trade or model simulations, and at a continental or global scale. Because of its spatial scale, estimates of sink size varied widely from study to study. High resolution requires site- and species-specific estimates at regional and local scales. In our study, we used site index-volume-carbon conversion as the baseline process of quantifying C sequestration. Site index is a commonly used and reliable predictor of site productivity with regards to stem wood production. We expect our quantification of C sequestration would result in estimates with good precision. Our procedure involved 1) refitting the Rehfeldt climate models to improve the models' predictability within the sampling range of the three species, 2) constructing empirical models predicting SI in relation to climate variables in both single- and multi-variate modes, 3) converting SI to volume through the growth and yield model TIPSY, and 4) calculating C sequestration as C= stem wood volume x wood density x 0.5, assuming 50% of dry matter is carbon. The process yielded some rather interesting results. The three species responded very differently to climate change. Lodgepole pine was sensitive to temperature, but less so to precipitation; correlation coefficients of SI with temperature-driven climate variables were 0.43 to 0.61, and 0.21 to 0.32 with precipitation-dependent variables. On the contrary, interior Douglas-fir was more responsive to precipitation than to temperature; correlation coefficients of SI with precipitation variables were 0.32 to 0.73, and 0.23 to 0.38 with temperature variables. Interior spruce was the least responsive to both temperature and precipitation, correlation coefficients were 0.00 to 0.20. A temperature increase of 1^0 C would improve the wood production of lodgepole pine by 1.35 m^3/ha/year and C sequestration by 275 kg/ha/year. An increase in annual precipitation by 100 mm would improve the wood production of interior Douglas-fir by 2.20 m^3/ha/year and C sequestration by 929 kg/ha/year. We have not yet delineated the zone of linear response along the gradients of temperature and precipitation. As a norm of biological phenomenon, we expect a detrimental response beyond the linear zone. The above quantification assumes changing climatic conditions would not alter the basic physiological mechanism of wood formation.

SOIL CO_2 EFFLUX IN RESPONSE TO FERTILIZATION AND MULCHING TREATMENTS IN A TWO-YEAR-OLD LOBLOLLY PINE PLANTATION IN THE VIRGINIA PIEDMONT.

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Abstract: In an effort to examine the response of soil CO_2 efflux to changes in nutrient availability, temperature, and moisture, soil respiration rates were measured over an entire year in a two-year-old loblolly pine (*Pinus taeda* L.) plantation subjected to fertilization and mulching treatments. A dynamic, closed-chamber infrared gas analysis system was used to measure efflux rates from plots treated with one of four treatment combinations including: nitrogen (115 kg/ha) and phosphorus (11.5 kg/ha) fertilization with black landscape cloth (mulch), fertilization without mulch, mulch without fertilization, and no treatment (control). For each treatment combination, plots were established at the seedling base and 1.22 m away from the seedling base to examine the affect of seedling roots on efflux rates. Fertilization had no significant effect on efflux rates during any of our monthly sampling sessions. Rates in plots with mulching were significantly different from non-mulched during some measurement sessions, but differences were inconsistent and often could not be attributed to temperature or moisture differences in mulched plots. Rates at the seedling base were always significantly higher than rates in plots away from the seedling. Although rates were always higher at the seedling base, the variability observed did not correlate with the amount of pine roots present beneath respiration chambers. Average efflux rates ranged from a high of 2.39 $\mu mol/m^2/s$ in July to a low of 0.142 $\mu mol/m^2/s$ in January. Utilizing environmental, soil, and plant variables in a regression model explained 51.4 % of the variance in soil CO_2 efflux rates. Soil temperature alone explained 42 % of the variance followed by soil moisture and stem biomass at 3.2 % and 2.8 % respectively. Only an additional 3.4 % of the variance was explained by a large number of other factors such as coarse woody debris, soil coarse fragment %, and fine root biomass.

THE EFFECTS OF PLANTING DENSITY ON CARBON PARTITIONING BETWEEN FINE ROOTS, LEAF BIOMASS AND STEM GROWTH. Colter Burkes, Rodney E. Will and Robert O. Teskey

Abstract: The effect of stand density (740, 2220 and 3700 trees per hectare) on growth and dry matter partitioning was examined in four-year-old loblolly (*Pinus taeda* L.) and slash pine (*P. elliottii* Engelm.) in four intensively managed plantations in southern Georgia. In the third and fourth growing seasons stem biomass growth did not increase proportionally with density but in a curvilinear fashion. The ratio of leaf biomass: stem biomass growth was significantly greater for loblolly pine stands planted at 740 trees ha^{-1} compared to the other densities. There was no difference between the stands planted at 2220 and 3700 trees ha^{-1}. This indicated that growth efficiency of the lowest spacing was significantly lower than the other two spacings. Density had the same effect on the ratio of fine root biomass: stem biomass growth as on the leaf biomass: stem growth ratio for both species. Therefore, less fine root biomass was necessary per unit stem growth at the two higher stand densities. Density had no effect on the ratio of fine root biomass: leaf biomass for both species indicating a constant partitioning between fine root and leaf biomass at different densities. However, the fine root: leaf area index ratio was greater in slash than loblolly pine due to the lower specific leaf area of slash pine. These results indicate that partitioning to stem growth does not decrease with increasing density, rather partitioning to stem growth is lower at the lowest stand density due to increased partitioning to fine root growth.

RECALCITRANT SEED & GERMPLASM CONSERVATION

SEMILLA RECALCITRANTE Y CONSERVACIÓN DE GERMOPLASMA

GERMINATION OF CO_2 ENRICHED *Pinus taeda* L. SEED AND SUBSEQUENT SEEDLING GROWTH RESPONSES TO CO_2 ENRICHMENT.

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Abstract: To understand the combined effects of seed production and seedling growth under elevated atmospheric CO_2, we collected *Pinus taeda* L. seed that developed in ambient or elevated (ambient + 200 ppm) CO_2 environments and germinated them in ambient and elevated CO_2 greenhouse chambers. The seedlings were allowed to grow under treatments for 121 d in pure sand without the addition of nutrients to determine the effect that seed reserves might have on seedling growth. Seeds that developed in elevated CO_2 had 91% greater weight and 265% greater lipid content than those that developed in ambient CO_2. The elevated seed source also had three times the germination success, and germinated up to 5 d earlier compared to the ambient seed source, regardless of greenhouse chambers. There were few significant seedsource or treatment effects on seedling growth, although the elevated seed source tended to produce seedlings that were taller and had more needles, greater root length, and higher root and leaf N concentrations compared to the ambient seed source. Carboxylation efficiency of the seedlings was significantly reduced by growth in elevated CO_2 suggesting that the nutrient-poor conditions had a significant effect on the CO_2 growth responses. We concluded that *Pinus* seeds produced in a CO_2-enriched environment may have fundamental changes in their viability and germination. Growth characteristics of new germinants may affect subsequent tree development and measurable responses to elevated CO_2.

STATUS OF BUR OAK (*Quercus macrocarpa*) IN NEW BRUNSWICK, CANADA AND IMPLICATIONS FOR GENE CONSERVATION.

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Abstract: The natural range of bur oak extends from eastern Canada to the mid-west and as far south as Texas. In the central part of its range the species is under no threat, but the eastern-most populations are small and isolated. In maritime Canada, published range maps depict the species extending only along the Saint John River and around the Grand Lake region in the province of New Brunswick. Today however, this range has shrunk and remaining small populations are physically isolated from the contiguous range by approximately 750 km. A study conducted to examine the current distribution and genetic status of the New Brunswick populations, determined that aside from individual trees or small clumps, only eight stands of bur oak remain in the province. Of these only one has more than 500 mature trees. Genetic diversity of these stands, other isolated stands in eastern U.S. and populations on the fringe and within the contiguous range was examined using isozyme analysis. Data from 19 isozyme loci indicate that the New Brunswick populations have retained high levels of genetic diversity, similar to populations within the species contiguous range. Though the small populations are threatened by increasing land use pressures, prompt conservation action, including maintaining existing stands and using local seed for restoration plantings, should be effective. It is considered important to maintain the species in New Brunswick because of its potential ecological significance with the expectation of a warmer climate.

BIOLOGICAL RESPONSE TO CHANGE

RESPUESTA BIOLÓGICA AL CAMBIO

EFFECTS OF ELEVATED CO_2 AND TEMPERATURE ON THE RESPONSE OF PONDEROSA PINE TO OZONE: A SIMULATION ANALYSIS.

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Abstract: Forests regulate numerous biogeochemical cycles, storing and cycling carbon, water, and nutrients, however, there is concern how climate change, elevated CO_2 and tropospheric O_3 will affect these processes. We investigated the potential impact of increased O_3 in combination with projected climate and atmospheric CO_2 concentrations on growth of *Pinus ponderosa*, at 7 sites in California, Oregon, and Washington, USA, using TREGRO, a process-based whole-tree growth model. The model provides a tool to study interactions among various factors and processes that give rise to synergistic responses. Simulated plant growth increased proportional to CO_2 concentration, however, the magnitude of the growth increase varied among sites as other factors influenced response. Increasing air temperature (+1.3 C) increased growth at most sites. Elevated CO_2 increased the temperature optimum for growth at 4 sites and decreased it at 2 sites. The annual biomass increment decreased with increasing O_3 exposure. The differences in O_3 sensitivity among sites is primarily controlled by differences in precipitation. Simulations indicate that increasing levels of tropospheric O_3, changing climate and rising atmospheric CO_2 can alter the C sequestrating potential of forests. Although increasing CO_2 reduces O_3 sensitivity, it does not eliminate the impact of O_3; elevated CO_2 would enhance C storage in forests more if O_3 exposures were reduced, especially in more polluted sites. Although the greatest benefit in C storage will come from reducing O_3 exposures in the most polluted sites, we must also consider those sites that have high inherent O_3 sensitivity because of their mesic conditions. Limiting the increase of O_3 levels in those areas will also increase C storage in forests. In contrast, C storage in other areas, that have a lower inherent O_3 sensitivity would likely not be as impacted by increasing O_3 exposures as the plants are climatically less sensitive to O_3.

EFFECTS OF WATER STRESS ON WATER POTENTIAL AND STOMATAL CONDUCTANCE OF FOUR *Pinus* SPECIES.

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Abstract: In a greenhouse study, we investigated the response of water relations of seedlings of Arizona pine (*Pinus arizonica* Engelm.), Apache pine or pino real (*Pinus engelmannii* Carr.), Durango pine (*Pinus durangensis* Mart.), and Ponderosa pine (*Pinus ponderosa* Laws.) subjected to stressing treatments. The two treatments were well-watered and water-stressed, conducted over three replicated drying cycles during the dormant season. The well-watered treatment ranged between 67 and 36% of volumetric water content of the growing media; the water content in media of the stress treatment ranged between 8.0 and 2.0% of volumetric water content. Due to inherent species differences in morphology and physiology, the level of water stress at the end of the drying cycles was not the same for all species. Xylem water potential and stomatal conductances were measured in needle fascicles at the ends of two drying cycles. Water stress caused significant and highly significant treatment and diurnal differences in plant water relations in at least three of the species during those two cycles. At midday, stomatal conductance was reduced significantly (by more than 60%) in the water-stress treatment. For each species, a maximum midday stomatal-conductance value was defined, based on the mean and standard deviation of midday conductance in the well-watered treatment over the three drying cycles. This maximum value was used as the baseline (100%) from which relative values were estimated for conductance readings in the well-watered and water-stress treatments. For each species, we identified a predawn water potential range associated with less than 50% of the maximum midday stomatal conductance.

DEEP ROOT GROWTH OF LOBLOLLY PINE IN RESPONSE TO THROUGHFALL EXCLUSION.

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Abstract: Deep root growth is needed to maintain physiological activity as water availability decreases. The objective of this study was to evaluate relationships between root growth and available water to a 1 m depth and tree physiology across a range of soil water availabilities. Plastic tarps were used to exclude throughfall in a 19-year-old loblolly pine plantation. The soil environment, root growth and fascicle physiology of eight dominant trees were monitored during the 1999 growing season. The soil profile to a 1 m depth was partitioned into four texturally distinct increments and soil water content in each was quantified daily by time domain reflectometry. Moisture release curves were developed to express soil water content as available water. Root initiation by depth was measured in vertical Plexiglas rhizotrons. Twice each month, predawn water potential and physiology of upper crown fascicles were measured three times daily. Drought during 1998 and 1999 was associated with a 37 percent decrease in predawn water potential during the 1999 growing season when compared to the average of four previous non-drought years (1993-1996). Both shallow (0-20 cm) and deep (56-100 cm) root initiation were reduced by throughfall exclusion. During July and August, stomatal conductance and net photosynthesis at 1300 and 1500, but not at 1100, were limited by elevated air temperature and vapor pressure deficit. Physiological processes at 1100 were not related to shallow available water; however, stomatal conductance and net photosynthesis at 1100 were positively correlated with available water at the 33 to 56, 56 to 100 and 33 to 100 cm depths. We also observed significant but weak positive relationships between physiological activity at 1100 and root growth at all depths. Before daily atmospheric limitations to physiology occurred, physiological processes appeared to be a function of deep available water and root growth throughout the soil profile. However, available water and root growth responses to throughfall exclusion indicated that the spatial variation associated with soil properties that control water retention and root advancement was high. At our study site, therefore, stand-level prediction of physiological activity may require information on the spatial variability of soil physical properties that affect the availability of water and the depth of the root zone.

ENVIRONMENTAL INFLUENCES ON GAS EXCHANGE IN FERTILIZED AND NON-FERTILIZED LOBLOLLY PINE STANDS.

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Abstract: Spatial and temporal variation in foliar gas exchange was examined in 15-year-old fertilized and non-fertilized loblolly pine stands located in the North Carolina sandhills. Foliar gas exchange in both the upper and lower thirds of crowns for both fertilized and non-fertilized stands was monitored monthly for a year beginning in March 1999 using an open gas exchange system. Monthly measurements consisted of morning, early afternoon, and late afternoon measurement periods taken during a single day. Gas exchange rates were recorded for a single detached fascicle at ambient temperature, humidity, vapor pressure deficit, and at a constant CO_2 concentration of 350 ppm. Average photosynthetically active radiation was determined for the upper and lower thirds of crowns and kept constant for each crown level in the block during a measurement period. Mean photosynthesis between fertilization treatments was statistically different for only three months: February, April, and May ($p<.1$). In February, fertilized stands exhibited higher photosynthesis rates while in April and May non-fertilized stands had higher photosynthesis rates. Photosynthesis rates were greater in the upper third of the crown compared to the lower third of the crown for all months. Empirical models were developed to estimate carbon uptake and compare response surfaces among treatments and seasons. Statistical comparisons of parameter estimates reveal that foliage from the upper third of the crown in both fertilized and non-fertilized stands have higher predicted respiration rates and exhibit greater responsiveness to light compared to the lower third of the crown. Prediction models also show that foliage from fertilized stands is more sensitive to vapor pressure deficit than foliage from non-fertilized stands. Foliage during the growing season appears to be more responsive to light compared to foliage during the non-growing season. Other trends in seasonal gas exchange will be discussed with an emphasis on carbon uptake.

CARBON DIOXIDE CONCENTRATIONS IN TREE STEMS AND THEIR EFFECT ON APPARENT STEM RESPIRATION.

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Abstract: We used microelectrodes placed in tree stems to measure the carbon dioxide (CO_2) concentrations in the stems over time. Measurements were made on small, medium and large diameter trees of three species, yellow-poplar (*Liriodendron tuliperfera*, L.), white oak (*Quercus alba*, L.) and loblolly pine (*Pinus taeda*, L.) during the summer at a field site near Athens, Georgia, USA. The trees ranged from 14 to 72 cm in diameter at 1.5m, and were growing in the same stand. Carbon dioxide concentrations in the stems fluctuated over time in the range of 2 to 10%. The CO_2 concentrations were similar in all species, and similar among trees in the three diameter classes. Diurnal changes in CO_2 were clearly evident and were correlated with the rate of water movement through the xylem, as measured by thermal dissipation sap velocity probes placed near the CO_2 microelectrodes. Using cut branches of these species in the laboratory, we were able to demonstrate that the rate of CO_2 efflux from the branch directly depended on the concentration of CO_2 in the xylem sap, which we experimentally manipulated over a range of 1 to 10%. Using an infrared gas analyser, stem CO_2 efflux was measured in the field. Efflux varied diurnally and was directly correlated with xylem CO_2 concentration measured with the microelectrodes. The results from these experiments indicate that previous estimates of stem respiration made using measurements of carbon dioxide concentrations, such as those obtained with infrared gas analyzers, are incorrect. Carbon dioxide efflux from tree stems appears to be mostly a function of the concentration of CO_2 in the xylem sap and the rate of diffusion of CO_2 from the stem.

LEAF BIOCHEMICAL CHANGES INDUCED IN *Populus trichocarpa* BY ENHANCED UV-B RADIATION AND CONCOMITANT EFFECTS ON HERBIVORY BY *Chrysomela scripta* (Colepoptera: Chrysomelidae).

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PRESENTATION PROVIDED

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Abstract: Glasshouse-grown *Populus trichocarpa* Torr. & Gray (black cottonwood) were subjected to none (0X), ambient (1X) or twice ambient (2X) levels of biologically effective UV-B radiation for Pullman, WA, USA in a randomized block design. Supplemental UV-B radiation was supplied over a 10 h period centered on solar noon using UVB 313 lamps (Q-Panel Co., Cleveland, OH, USA) mounted in frames suspended above the pots and filtered with polyester (0X - removes $\lambda<315$ nm) or cellulose diacetate (1X, 2X - removes $\lambda<300$ nm). Different treatments were obtained by varying the distance between lamps and the plant canopy and monitored using a spectroradiometer (Optronics Laboratories, Orlando, FL, USA). After a 10-week treatment period, an ontogenetic series of leaves were sampled. Apparent photosynthesis was determined *in situ* using $^{14}CO_2$. Subsamples were analyzed for nutrients (C, N, S), chlorophylls, UV-absorbing compounds, tannins and specific flavonoids. Effects of changes in leaf biochemistry on feeding by a major cottonwood herbivore, *Chrysomela scripta* Fab. (cottonwood leaf beetle), were determined in two ways: (1) a choice or preference test where the third (final) instar was presented foliage samples from each treatment; and (2) evaluation of larval growth rates fed tissue samples from each treatment. There was strong ontogenetic separation of treatment effects; significant differences in leaf biochemistry were seen in LPI≤2, becoming progressively less significant as the leaves aged. Apparent photosynthesis increased with increased levels of UV-B radiation, coinciding with higher levels of chlorophylls. Enhanced UV-B radiation also increased production of leaf proteins (as increased N and S concentrations), flavonoids, and changed flavonoid composition. The 2X treatment caused higher levels of UV-absorbing compounds than the 1X treatment, but tannins were reduced with increased UV-B radiation. Larvae showed higher preference for, and had higher growth rates when fed foliage from the 2X treatment compared to the 1X or 0X treatments. Tissue palatability appears linked to UV-B-induced changes in foliar nutrient composition and protein-binding tannins. Results suggest that enhanced UV-B radiation induces shifts in carbon allocation resulting in altered foliar biochemistry conducive to increased levels of herbivory.

PHYSIOLOGICAL RESPONSES OF FIELD-GROWN LOBLOLLY PINE TO SUMMER DROUGHT.

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Abstract: Gas exchange variables of current-year first-flush foliage were recorded in a 14-year-old loblolly pine plantation (*Pinus taeda* L.) from July through September in 1995 (a wet year) and 1998 (a dry year) to contrast year-to-year differences in leaf carbon assimilation and water relations as impacted by summer drought. Diurnal measurements were taken four times each day (0900, 1100, 1300 and 1500 h) on sunny days (at least three days each month during the two summers). Physiological data were collected in the upper and lower tree crowns under field conditions. A severe drought occurred during the summer of 1998 and the amount of rainfall was only 35 mm in July, which represents 41% of the July rainfall in 1995. Mean predawn leaf pressure potential and stomatal conductance were substantially lower in July of the dry year than in the same month of the wet year. Mean net photosynthetic rate and transpiration (per unit leaf surface area) in July were also drastically lower in the dry year versus wet year. Low gas exchange continued through August in the dry year due to the prolonged drought effect. In contrast, net photosynthesis and stomatal conductance were significantly higher in September of dry 1998 than in the same month of wet 1995, because rainfall was substantially higher, while leaf temperature and leaf-to-air vapor pressure deficit were lower in September of the dry year. Predawn xylem pressure potential was significantly correlated with net photosynthesis and transpiration during the summer months ($r = 0.66$ and 0.56, respectively). A close relationship between stomatal conductance and net photosynthesis ($r = 0.84$) suggests that summer drought may greatly affect leaf gas exchange by strong stomatal limitations to CO_2 uptake. Implications of our findings for potential impacts of global climate change on southern pine forests will be discussed.

A COMPARISON OF SOIL TEMPERATURE EFFECTS ON GROWTH AND PHYSIOLOGY IN WHITE SPRUCE (*Picea glauca*) AND ASPEN (*Populus tremuloides*)

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Abstract: Low soil temperatures are a common feature in the boreal forest and are a key factor in limiting tree growth, especially on sites with thick layers of organic matter. White spruce (*Picea glauca* (Moench) Voss) and aspen (*Populus tremuloides* Michx.) are the two major components of the boreal mixedwood forest of western North America. We hypothesize that white spruce, because of its later successional status, possesses adaptations which makes it less sensitive to cold soil temperatures than aspen. The objective of this growth chamber study was to compare the physiological and morphological response of aspen and white spruce seedlings to different soil temperatures (5, 15 and 25 °C) during the growing and dormant season. Aspen responded very strongly to low soil temperatures by reducing leaf area and shoot and root growth. In white spruce, first year above-ground growth was not significantly affected low soil temperatures. While at 5°C soil temperature, there was virtually no root growth in aspen, white spruce increased its root mass by about 10%. The dormant season measurements showed that root mass in both species increased from the growing season measurement while root volume remained constant. The exception were aspen roots grown at 5°C which did not show an increase in root mass during the dormant season. Net assimilation and stomatal conductance in aspen was significantly reduced with decreasing soil temperatures, while in white spruce these physiological variables were not affected by low soil temperatures. Total non-structural carbohydrates reserves were significantly higher in aspen during the growing seasons in all plant parts than in the dormant season; these differences were not apparent in white spruce. The results of this study showed that spruce is capable of functioning more efficiently under low soil temperatures than aspen. The results could have important implication for the interpretation of successional pathways in northern boreal mixedwood systems.

EFFECT OF DIFFERENT DAY-TIME AND NIGHT-TIME TEMPERATURE REGIMES ON THE FOLIAR RESPIRATION OF *Pinus taeda*; PREDICTING THE EFFECT OF VARIABLE TEMPERATURE ON ACCLIMATION.

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Abstract: The objectives of this study were to determine the acclimation of loblolly pine (*Pinus taeda* L.) foliar respiration to different night-time low temperatures, day-time high temperatures, and daily mean temperatures, and then to use the responses of temperature acclimation to various temperature regimes to predict acclimation under fluctuating temperatures. Experiments were conducted on two-year-old seedlings in growth chambers using different combinations of day- and night-time temperatures. The first experiment exposed trees to 22/22, 29/22, 22/15, and 29/15^{o}C day/night. When measured at a common temperature (15, 22, or 29^{o}C), respiration rates were lower for trees exposed to higher treatment temperatures and acclimation was influenced by both day- and night-time temperature. However, the extent of acclimation did not relate to mean temperature, i.e., respiration rates measured at a common temperature ranked as follows for seedlings exposed to different temperature regimes, 22/15 d/n > 22/22 d/n > 29/15 d/n ≅ 29/22 d/n. Rather, acclimation of foliar respiration was linearly related to mean daily respiration rate, where mean daily respiration rate is the average of the respiration rates measured at the day- and night-time treatment temperatures. The discrepancy between mean daily respiration rate and mean daily temperature occurred because respiration increased exponentially with increasing temperature. In a second experiment, the same seedlings were exposed to 22/22, 15/15, 25.5/18.5, and 25.5/15^{o}C day/night to test the relationship between mean daily respiration rate and acclimation. As in the first experiment, acclimation was linearly related to mean daily respiration rate. The concept of effective acclimation temperature, which is the temperature at which the mean daily respiration rate occurs, was derived from these results as a means to predict the extent that foliar respiration acclimates to treatment temperature.

ROOT BIOMASS AND SOIL CO_2 EFFLUX OF MID-ROTATION LOBLOLLY PINE EXPOSED TO ELEVATED CO_2 AND FERTILIZATION.

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Abstract: We exposed 13-year-old loblolly pine trees to two levels of atmospheric CO_2 under a high and low nutrient regime and then assessed root biomass quantity and distribution, as well as soil CO_2 evolution. The trees were part of a 2 x 2 factorial fertilization and irrigation study at the Southeast Tree Research and Education Site (SETRES) located in Scotland County, North Carolina. Whole-tree, open-top chambers were used to expose trees to ambient or ambient plus 200 ppm CO_2; exposure lasted from August, 1996 through February, 1999. The tank CO_2 was depleted in ^{13}C, relative to atmospheric CO_2, and resulted in the foliage of elevated CO_2 trees having a $\delta\ ^{13}C$ of –42.91, compared to –29.05 for ambient CO_2 trees. This ^{13}C signature allowed us to quantify the spatial distribution of individual tree root systems through the stand. During February, 1999, we sampled at a frequency proportional to area (using a soil core down to 1 m), at 1 m intervals to a 7 m horizontal distance from the base of each tree. Cores were stratified to three depths, roots were sorted into 3 size classes, dried and weighed and then analyzed for ^{13}C:^{12}C ratio. There was no difference in root biomass between the two CO_2 treatments. Fertilizer treatments differed greatly in root biomass; there were 18% less fine roots (<2 mm), and 58% more coarse roots (>2 mm), in fertilized versus non-fertilized plots, respectively. Elevated CO_2 grown trees roots 1 m from the tree stem did have a decreased $\delta\ ^{13}C$, relative to control trees and this ^{13}C signature was apparent, on average, up to 5 m away from the trees. Soil CO_2 efflux was assessed at 1.6 and 2.6 m from the base of each tree using an automated carbon efflux system. Similar to root biomass results, there was no difference in soil CO_2 efflux between CO_2 treatments. Although, fertilized trees had, on average, 37% more below-ground biomass, they also did not differ in soil CO_2 efflux compared to non-fertilized trees. Thus, forest fertilization might be an effective way to increase below-ground C sequestration in southern pine plantations.

VEGETATION RESPONSE & CLIMATE CHANGE

RESPUESTA DE LA VEGETACIÓN Y CAMBIO CLIMÁTICO

NATURALLY REGENERATED LONGLEAF PINE SEEDLING DYNAMICS IN A CHANGING CLIMATE.

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Abstract: Significant climate change is expected to occur during this century due to warming caused by increasing CO_2 in the atmosphere. One of the major changes expected will be substantial change in the range limits of many tree species, concomitant changes in species composition and importance in forest communities. Longleaf pine (*Pinus palustris* Mill.), which once dominated the southern forests, has now been severely reduced in range. However, the significant loss of longleaf pine acreage has not changed its regional distribution. It is an excellent source of timber as well as the dominant species of a highly diverse fire maintained ecosystem. Longleaf pine stands cover some 1.3 million ha in the southern United States of which 1.18 million ha (91%) support natural stands and contain 94% of the species' growing stock volume. It is imperative to understand what site conditions in natural stands will ensure the survival of seedlings. While it is known how site conditions affect the growth of seedlings, the relationship between site characteristics and seedling mortality has not been well documented. Recent research efforts in south Alabama, USA examined naturally regenerated longleaf pine seedling mortality. It is with this research that we intend to make available to landowners and industries alike a tool for predicting seed crop fate of naturally regenerated longleaf seedlings. Because of its broad geographic range and wide variety of habitats (climate niche), longleaf pine should be well suited to adjust to possible changes in climate. With concerns over increasing CO_2 and the need to retain carbon on site, longleaf pine is the best-suited southern pine for longer rotations.

THE INFLUENCE OF ELEVATED TEMPERATURE ON BIOMASS ALLOCATION AND FOLIAR RESPIRATION IN JACK PINE (*Pinus banksiana* Lamb.) AND PITCH PINE (*Pinus rigida* Mill.) Schedlbauer, J.L. Day, M.E., and Livingston, W.H.

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Abstract: Jack pine (*Pinus banksiana*) and pitch pine (*Pinus rigida*) meet at their respective southern and northern range limits in a narrow band in Maine. Although the ranges of these species are quite different, both have similar site requirements. If climate is involved in limiting the ranges of jack pine and pitch pine, it is possible that an increase in temperature associated with global climate change will induce a shift in the current ranges of these species. Our objective was to determine whether jack pine, a cold adapted species, responded negatively to elevated temperature relative to pitch pine. Three-year-old jack pine and pitch pine seedlings were exposed to night temperatures ~5°C higher than ambient conditions to examine the effect of elevated night temperatures on biomass allocation. Photosynthetic and foliar maintenance respiration rates of the two species were also studied. Measurements of photosynthesis made on current year foliage did not differ significantly between species. Respiration rates of jack pine and pitch pine on both mass and area bases did not significantly differ over a range of temperatures and therefore, both species had similar Q_{10} values. The species did not differ in their response to elevated night temperatures in terms of aboveground, belowground, or total biomass. However, pitch pine consistently had a significantly greater total needle mass than jack pine, and the species responded differently, in terms of shoot-to-root ratios, to the elevated night temperature treatment. These differences in allocation may make pitch pine a superior competitor and may permit to extend the northern boundary of its range at the expense of jack pine as global climate change progresses.

15-YEAR HEIGHT OF *Pinus ponderosa* IS CORRELATED WITH DIURNAL TEMPERATURE VARIATION DURING BUD ELONGATION.

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Abstract: An inverse correlation exists between mean diurnal temperature variation (DT) during the bud elongation season and the 15-year height of *Pinus ponderosa*. Environments with larger DT result in slower growth rates than environments with smaller DT for all families tested. The coefficient of determination (R^2) for the mean height of 17 open pollinated families was 0.99. Comparable R^2 of 0.90 and 0.93, respectively, were found for local trees (same seed zone and similar elevation as the plantations) and general trees (same seed zones but not necessarily similar elevations). In contrast, R^2 for mean local tree height correlation with the more commonly considered variables of elevation, latitude, mean temperature, and mean daily high temperature for the warmest month of the year were 0.46, 0.73, 0.57, and 0.19, respectively. The available data indicates that the strong correlation between DT and growth rate can be used to select for site fitness, growth rates on untested sites, and adaptation of a species to a site, and to predict the response to climate change. The strong correlation between growth season temperatures and growth rates may be more effective than using geography and elevation in definition of seed and breeding zones.

POTENTIAL IMPACT OF CLIMATIC CHANGE ON GROWTH AND WOOD QUALITY IN WHITE SPRUCE.

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PRESENTATION PROVIDED

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Abstract: Forest tree species growing in eastern Canada are expected to be highly affected in the near future by global climatic changes. To mitigate the negative impacts on forests, a better knowledge of the response of tree species to climatic change must be acquired. In this study, we used data collected in a provenance-progeny test of white spruce [*Picea glauca* (Moench) Voss] including 41 provenances originating from the province of Québec (Canada), each represented by four open-pollinated families. The test was replicated on three different sites. In contrast with previous works, we considered several important traits such as height growth and wood density which are known to be negatively correlated at the phenotypic level and unrelated at the genetic level. Polynomial regression models were developed to predict provenance performance, based on temperature and precipitation differentials (and more generally on climatic differentials) between experimental site locations and provenance origins. Global climatic models predict an increase of temperature and precipitation in the near future for eastern Canada. Our results showed, for all the traits studied, that such rapid environmental disturbance would produce a decrease in performance relative to a locally adapted seed source. However, the general response patterns to climatic variation for height growth and wood density were completely different one from each other. These models were validated using data collected in a second provenance-progeny test series based on provenances present in both series as well as on provenances tested only in the second one. These results showed the complexity of tree's response to climatic change, which could not be properly assessed without a multivariate approach. The models will be used to identify the best adapted white spruce seed sources for reforestation in the new growth conditions induced by global warming.

GENETICS AND FOREST TREE IMPROVEMENT

GENÉTICA Y MEJORAMIENTO DE ÁRBOLES FORESTALES

FOREST MANAGEMENT IMPACTS ON THE GENETIC DIVERSITY OF EASTERN HEMLOCK.

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Abstract: Genetic diversity assessments were conducted on eastern hemlock (*Tsuga canadensis* (L.) Carr.) trees resulting from active silvicultural experiments in Maine, U.S.A. Treatments include fixed diameter limit cuts (in 1952, 1973 and 1994) which removed trees 24 cm or larger and selection cuts (in 1957 and 1977) which removed inferior, unmerchantable and poor risk trees. Stand-level genetic diversity estimates were obtained for stands representing each silvicultural treatment using starch-gel electrophoresis and were compared to estimates for an unmanaged control stand to estimate genetic changes resulting from these long-term silvicultural treatments. Compared to genetic estimates for the unmanaged control stand, a series of selection cuts have had limited impact on the level of genetic diversity in the residual stand. However, there was a loss of rare alleles that may be valuable for future evolution. Trees remaining after repeated diameter-limit cuts had significantly higher levels of heterozygosity, polymorphic loci, and effective number of alleles per locus. These counter-intuitive results reflect an apparent association between rare alleles and defective phenotypes. Several alleles that occurred at very low frequencies in the unmanaged control stand occurred at much higher frequencies in the diameter limit cut because the defective residual trees preferentially possessed these rare alleles. That is, rare alleles conferred a negative fitness impact. If rare alleles are disadvantageous, there may be a loss of fitness in the diameter limit stand compared to the unmanaged stand. Because residual trees in the selection cut stand contained fewer rare alleles than the control stand, there may be an increase in fitness resulting from repeated selection cuts, at least in the short term. However, in the long term this loss of rare alleles in the selection cut compared to the control stand may come at an evolutionary cost because rare alleles are the raw material for evolutionary change.

EVOLUTIONARY RELATIONSHIPS OF SLASH PINE (*Pinus elliottii*) WITH ITS TEMPERATE AND TROPICAL RELATIVES.

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Abstract: Allozymes in bud tissue and monoterpene contents in xylem oleoresin of slash pine (*Pinus elliottii*) were analyzed from populations across the natural distribution, as well as those from other species in the AUSTRALES pines. Allozyme diversity measures of slash pine were similar to those found in other southern pines. The two slash pine varieties, the slower-growing south Florida variety (var. *densa*) and the more commercial "typical" variety (var. *elliottii*), were not separated in the cluster analysis of allozymes. Variation was continuous from south to north in Florida in slash pine, with no distinct transition between the two varieties. The monoterpene data also showed continuous variation between the two slash pine varieties. Expected heterozygosity declined from south to north, supporting the hypothesis that slash pine resided in a Pleistocene refugium in south Florida or the Caribbean, migrating northward at the close of the ice age. Allozyme frequencies as well as monoterpene compositions of slash pine and its AUSTRALES relatives showed a very close relationship between slash pine and Bahamian Caribbean pine (*P. caribaea* Morelet var *bahamensis*).

HYBRIDIZATION AND GENE FLOW BETWEEN *Pinus caribaea* AND *P. oocarpa*.

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Abstract: Although hybrization between *Pinus caribaea* and *P. oocarpa* is well established in the literature, the extent of gene flow between the species in the wild is not. We present evidence that hybridization events and introgression is highly restricted. Twenty-three seedlots, which included 7 populations of *Pinus caribaea* and 8 of *P. oocarpa*, were assayed for 10 allozyme loci. Differentiation between the species was low: allelic frequencies differed by less than 0.5; F_{st} = 0.12 between species. In contrast, multilocus differences by canonical analysis were high: 95% of individual genotypes could be correctly classified to species. Using the canonical model we developed a Baysian estimator of admixture, *m*, which could be applied to individual genotypes. This estimator of pollen and megagametophytic genotypes indicated that putative hybrid seedlots were largely simple mixtures of the two species. In tests of F_{is} in seedlots, only a putative hybrid lot was statistically significant, again indicating a simple mixture. Linkage disequilibria were generally significant in seedlots at the zone of contact between species, though the trend was not strong. A plot of *m* by elevation indicated a steep stepped cline. An analysis of this stepped cline indicated a cline width of 150 m, an effective gene flow rate of 20 m/generation$^{0.5}$, and a barrier to gene flow of about 1.5 km. These data indicate that introgression would be complete in about 5600 generations. The palynological record for the region, though scant, suggests that the two species have been in contact, episodically, at least, over the past 200,00 years, thus explaining the single-locus similarity between species.

GENETIC VARIATION IN THE PERFORMANCE POTENTIAL OF INTERIOR SPRUCE SOMATIC SEEDLINGS. Steven C. Grossnickle and Raymund Folk

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Abstract: Somatic embryogenesis is a tissue culture method of asexual propagation used in forestry as a means of rapidly multiplying elite genotypes. This vegetative propagation approach has been developed to the point where crops (i.e., ranging from 50,000 to 1,000,000) of conifer seedlings are now produced through an operational production program. Stock quality assessment conducted on the original production scale-up efforts of the early 1990s indicated that interior spruce (*Picea glauca* (Moench) Voss x *Picea engelmannii* Parry ex. Engelm.) somatic seedlings were smaller and had variable performance in comparison to zygotic seedlings (Grossnickle and Major, 1994, Can. J. For. Res. 24:1385-1396). This presentation revisits the issue of somatic versus zygotic seedling performance. In addition, this presentation reviews the variation in performance attributes observed among genotypes. Somatic seedlings were produced as an operational unit with an effective population size that met BC Ministry of Forests deployment guidelines (i.e., 34 genotypes from 12 families). A genetically improved seedlot from the same central region of British Columbia where seedlings were planted was used to produce zygotic seedlings for comparison purposes. Both somatic and zygotic seedlings were grown under a standard container nursery cultural regime. A performance potential testing approach assessed the morphological and physiological characteristics of somatic and zygotic interior spruce seedlings (Grossnickle et al., 1991, New For. 5:77-91; Folk and Grossnickle, 1997, New. For. 13:121-138). Somatic and zygotic seedlings met BC Ministry of Forests morphological specifications (i.e., height and diameter) required for seedling size. Shoot growth capacity was comparable for zygotic and somatic seedlings under optimum edaphic conditions. Under certain limiting edaphic conditions, zygotic had greater shoot growth capacity than somatic seedlings (i.e., low nutrients and low temperature), while in other conditions (after drought) shoot growth was comparable. Root growth capacity was higher in somatic seedlings under all tested edaphic conditions. Photosynthetic capability was comparable for zygotic and somatic seedlings under optimum edaphic conditions. Freezing tolerance declined at a comparable rate for zygotic and somatic seedlings during the shoot elongation phase. Drought tolerance was higher in somatic seedlings under dormant conditions. Drought tolerance declined during shoot elongation with comparable levels for zygotic and somatic seedlings. Results indicate that somatic and zygotic seedlings have comparable morphological development and physiological performance under a range of assessment conditions. Genotypic variation was evident in all performance potential testing conditions, with some genotypes performing better and others worse than the zygotic seedlot. The need for improved understanding of ecosystem processes and related carbon dynamics in response to changes in global climate has led to the construction of several dynamic global vegetation models (DGVM). Simulations performed with such models have generally been successful in approximating the distributions and magnitudes of key ecosystem indicators at the global scale. However, detailed validations against observations made in different ecosystems at smaller spatio-temporal scales are still highly desirable. The objectives of this paper address some of these validation requirements. First, we present and discuss results of site-based simulations of energy, water and carbon fluxes for different forest

stands in central Canada, using the Integrated BIosphere Simulator (IBIS) of Foley et al (a DGVM). Agreements between observed and simulated energy balances and CO_2 fluxes were generally very good. In a second validation exercise, the results of a national scale simulation of Canada's forests were compared with a recently compiled gridded dataset of forest biomass derived from the CFS Canadian Forest Inventory (CanFI) database. Plant functional types (PFT) used in IBIS were parameterized to more closely represent the characteristics of Canada's forest vegetation. Simulated vegetation distribution and biomass densities were found to agree with the gridded dataset better than were obtained using the global PFT parameterization.

LANDSCAPE GENETIC STRUCTURE OF *Pinus banksiana*: ALLOZYME VARIATION.

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Abstract: The extent and patterning of genetic diversity at a landscape scale (30 km x 30 km) was investigated in 82 natural *Pinus banksiana* (jack pine) stands in Wisconsin using fourteen polymorphic allozymes. Many of today's jack pine forests originated following fire or agricultural abandonment creating a forest mosaic fragmented by past land use. Most measures of genetic diversity and overall allelic frequencies varied little among these stands, and genetic distances were small (averaging 0.008). Genetic differentiation among-stands is limited but significant (F_{ST} = 0.022) with stands formerly in agricultural use characterized by lower levels of differentiation. Autocorrelation analysis provides evidence for subtle population genetic structuring at a scale of 8 to 15 km. We recommend that public and industrial land managers maintain some naturally-regenerated jack pine stands at a landscape scale corresponding to major soils units as a genetic conservation measure.

A CASE STUDY OF A PROVENANCE TEST USING TREND ANALYSIS WITH CORRELATED ERRORS AND SAS PROC MIXED.

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Abstract: A case study of a provenance test using trend analysis with correlated errors and SAS PROC MIXED. Cuauhtemoc Saenz-Romero, Erik V. Nordheim, Raymond P. Guries and Peter M. Crump. Can. J. For. Res. A statistical analysis was performed on data from a provenance test of *Pinus banksiana* Lamb. 1.5 year-old open-pollinated seedlings from 47 stands collected in five distinct soil-moisture classes within a pine-barren landscape, in west-central Wisconsin. A large-scale environmental gradient across the nursery bed and small-scale among-microsite variability were evident in seedling responses. We compared three analyses in terms of their capabilities for accounting for such within-experimental area variation: (A) a "standard analysis" using ANOVA for a randomized complete block design, (B) trend analysis in addition to (A), and (C) correlated errors in addition to (B). PROC GLM of the Statistical Analysis System (SAS) was used for analyses (A) and (B); PROC MIXED was necessary for analysis (C). We concluded that analysis (C) was the best option for adequately modeling the data, reducing the error variance and consequently, detecting significant differences among sets of stands grouped by soil-moisture classes. We suggest that the row and column position of each experimental unit in provenance or progeny tests with forest species be recorded in order to allow for the possibility of conducting analysis of this type. As an important caveat, we found an unexpected bimodal likelihood surface when PROC MIXED included a term for correlation among plots; this requires use of the PARMS statement when applying PROC MIXED.

FIELD RESULTS OF WHITE PINE BLISTER RUST RESISTANCE IN SUGAR PINES AND WESTERN WHITE PINE SEEDLINGS.

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PRESENTATION PROVIDED

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Abstract: Seedlings from 12 sugar pine (*Pinus lambertiana*) and 13 western white pine (*Pinus monticola*) families were planted at Happy Camp, California in 1996, for field validation of families artificially screened for white pine blister rust (*Cronartium ribicola*). 1-0 container stock from a mixture of resistant and non-resistant families was planted in 12 blocks in a randomized complete block design. An initial assessment was done in early summer 1999, in which height, number and type of cankers (normal, bark reaction, partial bark reaction or blight) was recorded. These results indicated moderate levels of blister rust infection, with sugar pine found to have a significantly higher percentage of trees infected (both active and inactive cankers) and significantly more stem infections per infected tree than western white pine (based on all trees, including healthy). Height differed significantly between species, and among families within a species, but the number of cankers per tree was not significantly different between families at this age. An unexpected result from this assessment is the very high percentage of infections that are bark reactions (completely inactivated infections), despite the fact that only some of the families of both species were selected this mechanism. In addition, the results indicated that there was an association between species and canker type for normal, bark reaction and partial bark reaction type cankers, with SP having a greater number of bark reactions than expected, and WWP having a greater number of normal and partial bark reactions than expected. The reason for this high level of bark reaction is unknown at this time. A subsequent assessment is scheduled for summer/fall 2000 to track the progression of blister rust infection in the individual families, and contrast differences in infection, and subsequent mortality between the two species. In addition, it will show whether the observed bark reactions have remained inactive, and the current status of infection scored in 1999 as partial bark reaction.

LANDSCAPE GENETIC STRUCTURE OF *Pinus banksiana*: SEEDLING TRAITS.

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Abstract: The extent and patterning of genetic diversity at a landscape scale (30 km x 30 km) was investigated using seedlings from 47 stands of *Pinus banksiana* Lamb, collected in Jackson County, Wisconsin, USA. Seedlings grown for six months in a greenhouse were evaluated for the number of cotyledons, the length of the longest cotyledon, the number of early needle fascicles, seedling height, timing of bud set, and the dry weight of roots, foliage, stem and total seedling, shoot:root ratio and foliage:root ratio. A pronounced genetic structure exists for most traits, with stands showing significant differentiation at geographic distances up to 25 km. Seedlings originating from trees growing on sandy sites were larger than those from sandy-loam sites. The scale and pattern of differentiation for several traits parallels the scale and pattern of soil variation on the landscape, supporting the hypothesis that stand genetic differentiation corresponds to a gradient of environmental differences. The results could be useful in a program of genetic resource management.

EL MEJORAMIENTO GENÉTICO FORESTAL Y SU APLICACIÓN EN MÉXICO.

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Resumen: Con el propósito de tener un registro del origen geográfico de la semilla recolectada de las diversas especies forestales utilizadas en los programas de reforestación, el Dr. Thompson Conkle ha identificado diferentes zonas de semillas en México, de acuerdo a los lineamientos utilizados por el Servicio Forestal del departamento de Agricultura de los Estados Unidos (USDA Forest Service), en los cuales se considera de particular importancia que la semilla debe ser recolectada dentro de los 160 Km al sur o norte del sitio de plantación y diferir en la elevación del sitio en menos de 365 m cuya intención es reducir los riesgos de fracaso mediante el establecimiento de material genético adaptado localmente. Sin embargo, es importante mencionar que no se puede hacer una zonificación real sin el establecimiento previo de ensayos de especies y procedencias por lo cual en México, y particularmente en el estado de Veracruz, a través del programa de "Mejoramiento Genético Forestal" se han establecido ensayos de procedencias/progenie, de progenie y de especies que abarcan las siguientes: *Pinus caribaea* con 5 procedencias de Honduras; *Pinus oocarpa* con 3 procedencias de Guatemala y 1 de México; *Pinus maximinoi* con 5 procedencias de México y 3 de Honduras, *Pinus greggii* con 3 procedencias de México; *Liquidambar styraciflua* con 5 procedencias de México, 4 de Honduras, una de Guatemala y una de Nicaragua; *Pinus patula* con progenie procedente de huertos semilleros de primera y segunda generación de selección; y en cuanto al ensayo de especies se tiene el de *Pinus cembroides* subsp. *orizabensis* y *Pinus*. En total se tiene bajo prueba 30 procedencias y 259 familias. Dichos ensayos se han establecido abarcando un rango que va de los 210 hasta los 2720 msnm. Con los resultados de estas pruebas, podemos determinar las mejores fuentes parentales de reproducción de cada especie en el área de influencia altitudinal y longitudinal de su establecimiento para una estrategia de multiplicación sexual y asexual según sea el caso y la pertinencia, a partir de las cuales se puede iniciar un proceso que permita dar certidumbre al establecimiento de plantaciones comerciales con altos rendimientos según la evaluación de la pruebas antes citadas así como el establecimiento y manejo de bancos clonales como fuente de generación y aplicación del conocimiento, y de esta manera, fortalecer la cultura silvícola que se merece el país como depositario de casí 3000 especies de árboles componentes de su flora.

POLIMORFISMO BIOQUÍMICO EN SEMILLAS DE GENOTIPOS ELITES DE *Pinus greggii* Engelm, EN VERACRUZ, MÉXICO.

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RESUMEN: Se realizó en el Instituto de Genética Forestal de la Universidad Veracruzana un estudio del polimorfismo bioquímico presente en muestras de semillas de árboles seleccionados fenotípicamente para las características: rectitud del fuste, poda natural y calidad de la copa en *P. greggii* Engelm, provenientes de un rodal natural situado en la localidad de "Carrizal Chiquito", municipio de Zacualpan,Ver., México, situada en un rango altitudinal de 1,600 a 1,250 msnm con el fin describir y analizar la variación bioquímica presente en dicha población. Se utilizó la técnica de SDS-PAGE y PAGE en sistemas discontínuos de láminas verticales de geles de poliacrilamida (8.5-5%) para el estudio de la variación en la composición de proteínas totales e isoenzimas Esterasas y Fosfatasas Ácidas de cada genotipo en estudio. Las variantes polimórficas detectadas fueron previamente codificados con valores 0 y 1 antes de ser procesados por Análisis Factorial de Correspondencias Simples. Los resultados obtenidos revelaron la presencia de 9 bandas distintiva de proteínas totales bien delimitadas en dos regiones electroforéticas: PT1 y PT2. Un marcado polimorfismo fue observado asimismo en la composición de isoenzimas Esterasas (6 bandas polimórficas) lo que contrastó con el menor polimorfismo observado en la composición de isoenzimas Fosfatasas Acidas (1 banda polimórfica).Los resultados del Análisis Factorial de correspondencias permitió agrupar los genotipos y las variantes polimórficas detectadas. Se discuten los resultados obtenidos en función de la posición del rodal natural como el extremo más sur del rango de distribución natural de la especie y su posible implicación por la alta capacidad de esta especie para formar híbridos con la especie de *Pinus patula* dominante en la mencionada región. Por todo ello esta población tiene potencial de producción de progenies altamente variables que pueden ser vocacionadas a través de sus paquetes de variación en distintos tipos de ambientes a fin de conciliar la erosión genética de las especies con la erosión de los sitios naturales. Con ello se brindaría una respuesta científico técnica al alto grado de erosión de los suelos que se presenta en las distintas latitudes y altitudes del mundo.

FOREST TREE PHYSIOLOGY

FISIOLOGÍA DE ÁRBOLES FORESTALES

INTERSPECIFIC DIFFERENCES IN RATES OF BASE CATION IMMOBILIZATION IN THE STEM OF SOME HARDWOODS OF EASTERN CANADA ARE LARGELY AGE- OR SIZE- DEPENDENT.

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PRESENTATION PROVIDED

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Abstract: Large amounts of nutrients are immobilized in woody tissues as forests proceed towards late successional stages. The objective of this study was to compare concentrations, contents and rates of base cation immobilization of the stem of some common hardwoods of eastern Canada (sugar and red maple, beech, basswood, white ash and red oak. The study site was located on the island of Montreal in southern Quebec (45°25'N, 73°57'W, 30 m above sea level). Nineteen trees ranging from 20 to 40 cm in diameter were harvested. Stem volume, wood density, stem tissue concentrations in K, Ca and Mg, and the area covered by the projection of the tree crown on the ground were measured. Tree nutrient contents were determined and allometric equations between tree nutrient content and DBH were established. Between 20 and 25 trees per species were sampled for age and diameter. Except for the low Mg concentration in red oak, interspecific differences in tissue concentrations were generally small. White ash for K, sugar maple for Ca, and sugar maple and beech for Mg were highest in content in the 40-cm diameter class. Stem Mg content was lowest in red oak across diameter classes. Highest rates of immobilization for white ash and basswood were measured in young trees whereas sugar maple generally had among the fastest rates of immobilization when trees were both the largest and the oldest. Our study suggests that tree species growing in mixed stands are likely to develop different patterns of base cation immobilization over time that may contribute to an efficient utilization of site nutrients throughout stand development.

USE OF GROUND PENETRATING RADAR TO STUDY TREE ROOTS IN THE SOUTHEASTERN UNITED STATES.

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Abstract: Tree roots have been observed by technicians using ground-penetrating radar (GPR) to image sub-surface geophysical features or artifacts. For some time, roots were considered unwanted noise and were not the focus of GPR studies. Recently GPR was used to map coarse roots (>3 cm) of a 50-year old *Quercus petraea* using non-invasive means (Hruska *et al* 1999). The objectives of this study are to expand on the work of Hruska *et al* (1999) and assess the feasibility of using GPR for similar work in the southeastern United States. The radar unit used in this study was the Subsurface Interface Radar System (SIR) 2000 with 1.5 gHz and 400 mHz antennae. Study sites were selected in the Southern Piedmont, Carolina Sandhills, and Atlantic Coast Flatwoods to assess the feasibility of GPR over a broad range of soil conditions. Studies commenced to determine the best antennae, ability to resolve roots and buried organic debris, assess root size and gauge the practicality of using GPR at each site. In the Carolina Sandhills, (16) 1 x 1 meter plots were scanned with the 1.5 gHz antennae using overlapping grids. The plots were later excavated, large roots mapped, and all roots classified by size and oven dried. Roots as small as 0.5 cm were detected with GPR. Sandy soils gave the best resolution, while high moisture and high clay content seriously degraded resolution and observation depth. We were able to size roots (0.5 to 5 cm) that were oriented perpendicular to the radar sweep (r^2 = 0.89 P =0.0001). Preliminary work using image analysis software to relate size/magnitude of radar parabolas to actual root biomass has been less promising (r^2 = 0.43 P = 0.0998). Orientation and geometry of the reflective surface seems to have greater influence on parabola dimensions than root size.

DEPTH OF SENSOR PLACEMENT AND TREE SIZE AFFECT SAP FLUX DENSITY MEASUREMENTS OF LOBLOLLY PINE.

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Abstract: To correctly estimate canopy transpiration using (as production of) sap flux density (SFD) and sapwood area, the variation of SFD at different radial positions and in different sizes of trees were examined with constant heat sensors. The study was conducted in an 18-year-old loblolly pine stand located on the Kisatchie National Forest in Central Louisiana. Ten trees that ranged in stem diameter from 12 to 30 cm were chosen for measuring SFD. Heated and unheated thermocouple pairs were inserted at 3 to 7 radial depths within each tree from the outer to inner sapwood. The heated sensor was heated at the inner most 2 cm of its depth (0-2, 2-4, 4-6, 6-8, 8-10, 10-12, and 12-14 cm) according to the diameter of each sample tree. Data was automatically scanned every 30 minutes. At the maximum flux, we observed that SFD was significantly different among radial positions and among tree sizes during the midday (11:00-14:00). Trees of the maximum size studied had the greatest radial difference in SFD. SFD's at the 0-2cm depth and 2-4cm depth were significantly higher than other radial positions. SFD was reduced from 45% to 72% from the 2-4, to the 12-14 cm depth, compared to SFD at the 0-2cm depth. Medium and small trees studied showed only a significant SFD change in the outer most sapwood compared to other radial positions. Reductions in SFD with depth were great in larger trees. To model tree water loss, total tree SFD measurements must account for changes in radial SFD and tree sizes.

INFLUENCE OF INTENSIVE MANAGEMENT ON CANOPY TRANSPIRATION IN LOBLOLLY PINE.

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Abstract: Because of the predicted increase in consumption of pulpwood and other wood resources over the next half century, forest sustainability has become a great concern to most ecologists and forest industries today. Many suggest that this demand can be met by planting trees on small intensively managed plantations. To better understand the potential of intensive management in maximizing productivity, we examined the influence of (i) complete weed control,(ii) weed control and irrigation, and (iii) weed control and irrigation with a fertilizer solution (fertigation) on diurnal and seasonal variation in leaf and canopy physiology of 5-yr-old loblolly pine (*Pinus taeda* L). Diurnal patterns of stomatal conductance (g_s) and leaf water potential (Ψ_L) were measured four times during the 1999 growing season. Hourly measurements of photosynthetically active radiation, air temperature, vapor pressure deficit, sap flow (l hr^{-1}) and whole tree transpiration rate (E) were monitored for one year. Sap flow or E at maximum g_s, after which g_s exhibited a diurnal decline, did not differ with treatment. Treatment did not influence E_{crit}, defined as E corresponding to the Ψ_L at which the slope of the relationship between Ψ_L and E deviated from linear, and average E_{crit} was 1.2 mmol m^{-2} s^{-1}. In contrast, Ψ_L at E_{crit} was lower in the control treatment (-1.61 versus –1.28 and –1.21 MPa in the control, irrigation and fertigation treatments, respectively). Although total water loss was higher in trees supplemented with nutrients and water, maximum E relative to canopy leaf area was similar between treatments. We conclude that the critical minimum leaf water potential was increased by irrigation, but the maximum rate of E, after which stomata limit water loss to avoid cavitation, in 5 yr-old loblolly pine was unaffected by nutrient and water availability.

EFFECTS OF JIFFY FORESTRY PEAT PELLETS ON ROOTING AND SUBSEQUENT FIELD PERFORMANCE OF STEM CUTTINGS OF LOBLOLLY PINE.

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Abstract: Experiments conducted in January (hardwood cuttings) and June (softwood cuttings) 1998 compared rooting and root dry weight (DW) of stem cuttings of three full-sib families of loblolly pine (*Pinus taeda* L.) rooted in Jiffy forestry peat pellets and Ray Leach Super Cells. Ray Leach Super Cells (vol.=162 cm^3) served as the control and contained a medium of 2 peat : 3 perlite (v/v). Pellet sizes used were 25-65, 30-65, 36-65, 36-75, 42-65, 42-80, and 50-95 (dry diam.– expanded height in mm). Cuttings were taken from hedged stock plants and rooted for 12 weeks under mist in a humidity-controlled greenhouse. Following evaluation for rooting in the June experiment, approximately 500 rooted cuttings in pellets and Ray Leach Super Cells were field planted in eastern Georgia in December 1998 to study the effect of pellet size and cutting development on first-year field growth. Rooting percentages in January for hardwood cuttings rooted in pellet sizes 42-80 (36%) and 50-95 (57%) were less than the control (83%). Root DW for each pellet size was less than the control. Rooting percentage in June for softwood cuttings rooted in pellet size 36-65 (77%) was greater than the control (64%) whereas rooting percentages for cuttings rooted in pellet sizes 42-80 (50%) and 50-95 (52%) were less than the control. Root DWs for cuttings in pellet sizes 25-65, 30-65, 36-65, and 42-65 were less than the control. Field performance data will be presented.

RELATIONSHIP BETWEEN HYDRAULIC PATHWAY LENGTH AND FOLIAR $\delta^{13}C$ IN LONGLEAF PINE.

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Abstract: Reductions in ANPP due to age/size effects, and the mechanisms controlling forest productivity are of interest to foresters, scientists, and industrialists. Increased knowledge of the mechanisms contributing to age/size related changes in productivity will improve forestland management practices and define the relationship between form and function. The goal of this project was to increase understanding of age/size related changes in productivity by examining branch morphology and leaf physiology of different size *Pinus palustris*. We tested the hypothesis that increasing length of the hydraulic pathway results in increased hydraulic resistance and decreased leaf carbon gain. We used $\delta^{13}C$ as an integrative temporal measure of stomatal conductance and photosynthetic activity. Total hydraulic pathway lengths (THPL - xylem length from the stump to each individual tuft) ranged from 3.8-21.8 m and tree diameters measured 3.5-30 cm. Twenty-two to 65 tufts were sampled per large/old tree (THPL 14-22 m) and a total of 28 tufts were pooled from small/young trees (THPL 3.5-9 m). A curvilinear model with log transformed THPL, grouping by size class (large/old and small/young trees), and individual tree intercept terms explained 81% of the variation in $\delta^{13}C$. Foliage $\delta^{13}C$ for large trees ranged from -25.4 to -28.6$^{o}/_{oo}$ and -26.4 to -29.7 $^{o}/_{oo}$ for the smaller trees and $\delta^{13}C$ increased with increasing THPL for both size classes. A significant relationship between nitrogen and branch length was not detected, which indicated that differences in $\delta^{13}C$ between tufts were not confounded by microclimate. Although cause and effect were not tested, correlation between $\delta^{13}C$ and the length of the hydraulic pathway indicated that hydraulic limitation is important in understanding age/size related change in productivity of longleaf pine.

BREEDING FOR STRESS TOLERANCE

CRUZAMIENTOS PARA TOLERANCIA AL ESTRÉS

GENETIC VARIATION IN DROUGHT HARDINESS OF COASTAL DOUGLAS-FIR SEEDLINGS. T.S. Anekonda, M.C. Lomas, and W.T. Adams

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Abstract: Genetics of drought hardiness traits and their interrelationships were investigated in 39 full-sib families of coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco) seedlings grown in raised nursery beds. The experimental design was a split plot replicated in five blocks. Main plots consisted of control (well-watered) and drought treatments applied in the second and third growing seasons, with families in 4-tree row sub-plots. Drought hardiness traits were percent shoot damage and percent xylem cavitation (non-functioning tracheids in each annual growth ring as detected by safranin dye perfusion) measured at the end of each growing season, and 3rd-year diameter increment and hydraulic conductivity (the quantity of water transported through a given length of stem under a constant pressure) at the end of third season. Height and diameter in the control treatment were used to assess growth potential in the absence of drought. Mean shoot damage in the third season (32%; severe drought) was twice that in second season, when only a moderate drought was applied. Families differed significantly in nearly all hardiness traits, although the genetic determination (family variance / phenotypic variance) for hardiness traits was about one-half as great as for growth potential traits. Genetic correlations between drought hardiness traits in the same year were high (average r_g =|0.97|), and were moderate between the traits measured in different years (average r_g = |0.49|), despite the large difference in severity of the drought. Growth potential was essentially uncorrelated with drought hardiness (average r_g=0.06 in year 2 and -0.13 in year 3) in both growing seasons. Much potential exists for identifying drought-hardy families at seedling stage and using this information for deployment or breeding purposes. In addition, drought hardiness at the seedling stage does not appear to be related to inherent growth potential under favorable moisture regimes.

GROWTH EFFICIENCIES OF DIVERSE *Pinus taeda* FAMILIES AS AFFECTED BY GENETICS OF THE ROOT SYSTEM.

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Abstract: Production of stemwood depends on photoassimilation in leaves, which in turn depends on resource supply from roots. The rate at which stemwood is produced relative to leaf area is important since it expresses the efficiency of stem production. An important question thus becomes: What factors inside the tree influence the functioning of the photosynthetic leaf area? Since such factors may originate from the roots as well as within the leaves, our approach seeks to alleviate the confounding effects of root and shoot processes. The main objectives are to: 1) evaluate genetic effects of roots on processes conducted in the leaves, such as CO_2 fixation and carbon allocation, and 2) determine whether root systems, by physiologically affecting leaf functions, can substantially impact growth efficiency. We used a novel grafting method with loblolly pine seedlings from diverse provenances to evaluate rootstock effects on stem growth efficiency. Seedlings of fast- and slow-growing families were grafted at 12 weeks of age in all possible combinations, and planted on an infertile site in a split-plot layout with half of the plots fertilized periodically. Tree height, volume, and biomass accumulation were measured over two growing seasons. Rootstock effects on stem growth efficiency were detected in the fertilized treatment. Rootstocks of selected families were associated with changes in photosynthetic gas exchange in leaves of other selected families. It is proposed that, in these families, differences in growth efficiency are partly caused by differences in genetic properties of root systems.

NORMS OF REACTION OF STABLE AND UNSTABLE DOUGLAS-FIR GENOTYPES ACROSS TEMPERATURE AND MOISTURE REGIMES: IMPLICATIONS FOR BREEDING AND CLIMATE CHANGE.

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Abstract: This project was undertaken to determine: 1) if genotype-by-environment interaction (g x e) observed across coastal Douglas-fir field progeny test sites could be reproduced using experimental seedling test environments; 2) if families that are 'stable' and 'unstable' in the field can be correctly identified in seedling experiments; and 3) what the relative roles of soil moisture and temperature are in inducing g x e. On the basis of 12-year stem volume of the progeny of 372 parents crossed in 62 six parent half-diallels and planted on 12 field test sites in British Columbia, pairs of coastal Douglas-fir parents were selected with similar breeding values but contrasting stabilities based on relative contributions to family-by-site variance. Seedlings from two or three full-sib families of each of the 16 parents (45 families total) were grown in outdoor, raised nursery beds under four treatments: 1) ambient soil temperature, well-watered; 2) ambient soil temperature, moderate drought (predawn xylem water potential ≥-1.2 mPa); 3) warm soil (ambient + 3 to 4^{o}C), well-watered; and 4) warm soil, moderate drought. The norms of reaction for growth (total amount and rate of height growth, and total diameter growth) of stable and unstable families varied significantly ($p<0.01$) among the four treatments. The average response to increased soil temperature was positive and significant ($p<0.001$), but stable and unstable families differed markedly in their reaction to temperature (stability class-by-temperature interaction; $p<0.05$). Stable and unstable families responded similarly to soil moisture, with significant reductions in growth due to drought ($p<0.001$); but there was no stability class-by-moisture interaction. Norms of reaction of stable and unstable families did not differ for timing of bud set or fall cold hardiness. We conclude that changes in temperature may produce greater g x e in the performance of select Douglas-fir genotypes than changes in moisture, and that selecting and deploying genotypes with a mixture of norms of reaction for temperature may be an appropriate strategy for addressing future climatic uncertainty.

TROPICAL SILVICULTURE

SILVICULTURA TROPICAL

REGENERATION OPTIONS FOR RAPID ESTABLISHMENT OF *Pinus greggii* SEEDLINGS.

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Abstract: One of the most important problems for reforestation programs in Mexico is the low seedling survival after outplanting. Factors directly involved with this problem include the group of cultural practices applied to the seedlings during the nursery production process. Two experiments, a greenhouse and an outplanting trial, were carried out at Fabian Garcia Science Center at New Mexico State University. The objective of this research was to compare the effect of different cultural practices in nursery growth and outplanting performance of *Pinus greggii* seedlings grown under the traditional polybag production system used in Mexico and an alternative containerized production system. The cultural practices evaluated in this research were chemical root pruning, sources of fertilization, top pruning, and container size. The results from the application of these practices in the nursery indicated that chemical root pruning improves most morphological characteristics of *Pinus greggii* seedlings. The major impact of this practice was reflected in the root system because seedlings had increased root:shoot balance and more fibrous root systems. In addition, chemical root pruning either eliminates or significantly decreases root spiraling and root egression from polybags. Fertilization was necessary to produce high quality seedlings, however, there was no significant differences between the soluble fertilizer applied through the irrigation system and the slow release fertilizer applied to the media at sowing time. Top pruning was effective in controlling height of seedlings but also decreased the final root collar diameter. Finally, container size significantly affected some of the morphological characteristics of the seedlings. In general, the greater the container, the larger the seedling within the five different container sizes evaluated. The outplanting trial showed that seedlings that were chemically pruned had better growth increments after eight months in the field. Top pruned seedlings completely recovered by the end of the experiment and were growing as fast as non-pruned seedlings. Seedlings produced in polybags had significantly higher survival than seedlings produced in styroblocks after eight months in the field. Regarding container size, seedlings produced in larger container performed better than those produced in smaller containers. Results from this research indicated that chemical root pruning is a simple cultural practice that can be applied in the nurseries to improve the quality of the seedlings and eliminate the problems traditionally associated with the polybag nursery production system. In addition, seedlings with a better root system will have a better opportunity to survive after outplanting resulting in great benefits for reforestation programs.

ASPECTOS ECOLOGICOS Y DE DENSIDAD DE LA REGENERACION DE *Picea* EN NUEVO LEON, MÉXICO.

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RESUMEN. Se realizó un estudio del género *Picea* del Estado de Nuevo León, con el objetivo de describir las condiciones de autoecología de este género. En el presente trabajo se presentan exclusivamente los resultados de la regeneración. Se estudió el género en tres localidades: La Marta, Rayones; La Encantada, Zaragoza; y La Trinidad, Montemorelos. En cada localidad se establecieron dos sitios permanentes de muestreo. Se utilizaron sitios de 80 m^2 para evaluar la densidad (número de individuos/ha) de todas las especies leñosas, menores de 5 cm de diámetro normal, consideradas como regeneración. Se obtuvo la densidad a nivel de localidad, así como densidad total y relativa por género y por categoría de altura en cada género. *Picea engelmannii* var. *mexicana* se presenta en la localidad La Marta, en ladera alta de montaña, con clima templado, en exposición Norte, con una fuerte pendiente. *P. martinezzii* se presenta en las localidades La Encantada y La Trinidad, en la primera se localiza en una cañada donde existe mayor húmedad y menor temperatura, la exposición es Norte, pendiente moderada, suelo rico en materia orgánica y alto contenido de arcilla. La localidad La Trinidad se presenta en una falla geológica de la montaña que le hace parecer como un cañón, en donde también se favorece la mayor humedad y menor temperatura, la exposición que predomina es zenital. La mayor densidad de regeneración (38562 individuos/ha), incluyendo todas las especies leñosas, se presentó en La Encantada. La densidad del género *Picea* fue mayor en La Marta (688 individuos/ha), después en la Encantada (500 individuos/ha); y por último en La Trinidad (188 individuos/ha). La menor densidad de *Picea* en La Trinidad es probable se deba a la falta de protección en esta área, ya que incluso se observó dañó por ramoneo del ganado.

NURSERY CULTURAL PRACTICES AFFECT EARLY SURVIVAL AND GROWTH OF TROPICAL HARDWOODS FOLLOWING OUTPLANTING. R.A. Cuevas Rangel, J.G. Mexal, P. Negreros Castillo and C. Parraguirre Lezama

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Abstract: Caoba (*Swietenia macrophylla)* and cedro rojo *(Cedrela odorata)* are valuable tropical hardwoods distributed throughout Central and Southern Mexico. About 10,000 m^3 are harvested annually, which represents 70% reduction of harvested volume from fifty years ago *(Cuevas-Lopez, 1947)*. Poor survival of plantings carried out by communities is one reason for reduced harvests. The objective of this study was to evaluate nursery cultural practices and their effect on survival and growth in the field. Three different production systems were evaluated at the INIFAP Bacalar Research Station in Quintana Roo Mexico: 1) caoba seedlings grown in polybags with soil, 2) cedro seedlings grown as bareroot seedlings, and 3) both species grown at New Mexico State University in 164ml Ray Leach tubes containing peat moss and vermiculite. The treatments consisted of seed orientation (for caoba) and fertilization with urea and triple super phosphate for both species. Randomly selected seedlings were measured for growth parameters and foliar and soil nutrient analysis. In the nursery, polybag-grown caoba seed orientation had no significant effect on seedling morphology. Fertilization increased growth, however there was a strong block effect with increasing shade influencing foliage color and seedling size. For bareroot-grown cedro seedlings, fertilization had no effect on seedling size but there was a strong growing density effect confounding any response. At the outplanting site, neither fertilization nor stocktype had a significant effect on survival of caoba, but fertilization did increase height by 25% and diameter by 60%. Fertilization of cedro had no effect on field survival or growth. For both species, there was a strong interaction between initial seedling diameter and survival at 28 months, suggesting a minimum seedling diameter of 5mm at time of outplanting for optimum survival.

PRODUCCIÓN DE SEMILLAS DEL GÉNERO PINUS EN HUERTOS Y RODALES SEMILLEROS DE SMURFIT CARTÓN DE COLOMBIA.

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Resumen: Con el fin de producir semilla genéticamente mejorada para sus programas de reforestación, Smurfit Cartón de Colombia (SCC) ha establecido 80 ha entre huertos y rodales semilleros correspondientes a 10 especies de coníferas y latifoliadas. Entre ellas el *P. oocarpa*, *P. maximinoi* y *P. tecunumanii* ocupan el 18% del total plantado en áreas de producción de semilla, ubicados entre los 2° 30' y 3° 49' latitud norte y entre los 1550 y 1800 metros de elevación. El objetivo de este informe es presentar la producción de semilla alcanzada por dichas especies a lo largo del tiempo, así como los resultados obtenidos en el último muestreo de semillas a partir de polinización abierta realizado durante 1999, en respuesta a factores fisiológicos y prácticas culturales para inducir floración. En el rodal semillero de *P. oocarpa* la producción anual de semilla es de 8 kg/ha, lo que contrasta con la abundante presencia de conos en los árboles del rodal. Los valores promedio de semillas llenas y totales por cono fueron de 21 y 33 respectivamente, con un potencial de producción de semillas de 139. En el huerto clonal de *P. maximinoi* la producción total de semilla alcanzó un máximo de 1.2 kg/ha/año; con valores promedio de semillas llenas y totales por cono de 15 y 24 y un potencial de producción de 135 semillas. La producción total de semilla para el *P. tecunumanii* se evalúo en dos huertos semilleros, y en un rodal, encontrandosen valores de 1, 0.5 y 1.5 kg/ha/año respectivamente. El muestreo de semillas en estas tres áreas de producción indicó valores promedios en un rango de 8 a 26 semillas llenas por cono y de 20 a 40 semillas totales, con un potencial de producción oscilando entre 121 y 150 semillas. Aunque el valor total de semilla encontrado en las diferentes especies está muy por debajo del potencial de producción de semilla calculado, se observan incrementos importantes tanto en la producción total de semilla como en el número de semillas llenas y totales por cono, debido especialmente a factores como edad y prácticas de manejo implementadas, ya que otras condiciones ecológicas que están directamente relacionadas con la producción de semilla, aún no han sido evaluadas.

CAUSES AND CONSEQUENCES OF SHOOT BORER (*Hypsipyla grandella*) ATTACK IN A MAHOGANY PROVENANCE STUDY IN PUERTO RICO.

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Abstract: Both the causes and consequences of shoot borer attack in mahogany have been the source of much controversy. A provenance study begun in the 1960s by the USDA Forest Service of different populations and species of mahogany was used to address these issues. Seed was harvested from a series of populations in Central America and the Caribbean and planted in Puerto Rico and the U. S. Virgin Islands, across an array of environments ranging from dry to wet forest. Trees were periodically measured from 1965 to 1993. Canopy cover at the site of a test plantation appeared to have more influence on shoot borer attack than life zone or soil type. Attack rates varied greatly between 1967 and 1971, from an overall mean of .36 (s. d. 0.48) attacks per tree in 1969 to a low of .036 (s. d. 0.19) attacks per tree in 1970. Tree height accounted for at most 12% of the variation in attack, and tree growth rate accounted for very little. The relationship between height or growth rate and attack varied widely between years and across sites and genetic sources. Shoot borer attack between 1967 and 1971 had minimal effect on subsequent height growth, height in 1979, and branching, and accounted for 11% of the variation in height of lowest fork and 8% of the variation in tree form in 1986. Pruning appeared to mitigate the effects of attack at least partially. We concluded that genetic variation in susceptibility and tolerance in this trial was either minimal or unstable, with more variation attributable to environmental effects. Future efforts may be better concentrated on appropriate site selection and silivicultural management of the shoot borer. We proposed a model integrating different factors that affect shoot borer attack by their impact on shoot borer demographics and tree attractiveness.

PREDICCIÓN DEL RENDIMIENTO Y TURNOS DE ROTACIÓN PARA PLANTACIONES DE CAOBA EN QUINTANA ROO, MÉXICO. Xavier García Cuevas.

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Resumen: **En el manejo de recursos forestales, el crecimiento y rendimiento son de vital interés para la planeación de actividades. Para ello, la distribución de diámetros como atributos de un rodal, es fundamental para la predicción del rendimiento maderable a través del tiempo, ya que las dimensiones de los árboles, determinan en gran medida el precio de mercado de la madera, su destino, las adaptaciones tecnológicas de la industria y la ganancia que de ella se pueda obtener. En un régimen de plantación y corta total, la principal decisión que se debe de realizar, es la de estimar el tiempo en que la masa alcanza la condición de madurez. A este periodo de tiempo se le conoce como turno. Algunas consideraciones que hay que hacer para la definición del turno son: que la mayoría de los árboles alcancen la mínima dimensión cosechable, que hayan alcanzado los máximos ritmos de crecimiento o que maximicen los rendimientos económicos. En el Campo Experimental "San Felipe Bacalar", Quintana Roo, México, se elaboró un modelo de predicción para plantaciones de caoba, con el objetivo de modelar la distribución diamétrica, predecir la distribución del rendimiento volumétrico a diferentes edades y fijar turnos de corta. Se utilizó información de 4306 árboles de uno hasta 34 años de edad, provenientes de plantaciones de densidad variable. Se estimaron los parámetros de la distribución diamétrica de cada plantación mediante la función de distribución de probabilidades Weibull. Se ajustaron modelos de regresión para estimar o recobrar los parámetros Weibull a edades proyectadas. Para el cálculo de la distribución de frecuencias por categoría diamétrica, se integra la función Weibull tomando en cuenta los límites inferior y superior de cada categoría. Las probabilidades para cada categoría diamétrica se multiplican por el número de árboles *"N"* para tener la frecuencia de árboles por categoría y se integran otras relaciones funcionales y se proyecta el rendimiento. Con las proyecciones se construyen las tablas de rendimiento volumétrico promedio y distribución de productos cualquier edad deseada. En estas tablas se tabulan las categorías diamétricas, número de árboles por hectárea, el diámetro cuadrático, la altura total el área basal y volumen por unidad de superficie para las edades deseadas. Este estudio sugiere que a la edad de 30 años, se esperaría tener plantaciones con 481 árboles por hectárea, diámetro cuadrático de 29.78 cm, altura promedio de 15.20 m, un área basal por de 21.5965 m^2/ha y volumen de 339.0133 m^3/ha. El turno industrial se fija en 30 años, cuando se tiene el suficiente volumen (167.7108 m^3/ha, que equivale al 49.47% del volumen total) de árboles mayores de 30 cm, requeridos por la industria. Para determinar la edad exacta del turno técnico, se tiene que satisfacer la condición de igualdad de ICA = IMA, lo cual se determina en 26 años. La madurez financiera es determinada cuando el crecimiento corriente expresado en porcentaje, se iguala a una tasa de descuento de mercado y utilizando una tasa de descuento de 14%, lo anterior ocurre a los 30 años.**

El Compendio forestal: Un sistema de apoyo a la toma de decision …. Jacques Trencia.

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La toma de decisiones aprovechando las fuentes más recientes de informaciones constituye un desafio en el manejo forestal. La disponibilidad inmediata de fuentes reconocidas de conocimientos suele ser un elemento esential para los científicos del campo forestal. Se ilustra este concepto con un ejemplo abarcando un rango ancho de varios tipos de informaciones.

El *Compendio Forestal* aprovecha el concepto tradicional de monografías sobre especies usando las informaciones las más recienes y completas en un diseño multi media. Se combina textos detallados por expertos sobre especies forestales tratando de características biológicas y silvícolas e incluyiendo ilustraciones, mapas, un sistema de informaciones geográficas, una base de datos taxonómicos sobre más de 20,000 especies, un glosario multilingue sobre dasonomía y diciplines relacionadas, bibliografías, resúmenes de publicaciones científicas, un registro de provedores de semillas, estadísticas de dasonomía sobre países y documentos seleccionados de varias organisaciones internacionales. Además, el Compendio incluye un sistema de selección de especies para usos en dasonomía y en sistemas agroforestales. El módulo global incluye también informaciones detalladas sobre 1,200 especies de bosques tropicales y templados así como informaciones principales sobre 22,000 especies.

El diseño del programa de computo usa la tecnología de base de datos relacionadas, vínculos flexibles, una capacidad de anotación por el usuario, sitemas de informaciónes geográfica y taxonómica.con una arquitectura abierta facilitando connexiones con sistemas externos. El *Compendio forestal* disponible en forma de CD-ROM con vínculos a la red electrónica mundial ha sido desarollado como parte del programa de compendios de CAB International de una duración de 3 años aprovechando el apoyo de un consorsio de desarollo internacional incluyendo varias organisaciones nacionales e internacionales. La sustentabilidad del sistema y la actualisación del sistema son elementos claves de la planeación del proyecto.

ADAPTATION & CLIMATE CHANGE

ADAPTACIÓN Y CAMBIO CLIMÁTICO

GENECOLOGY AND ADAPTATION OF DOUGLAS-FIR TO CLIMATE CHANGE.

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Abstract: Results from a common garden study of coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii*) from western Oregon and Washington were used to explore the relationship between genetic variation and recent climates of seed sources. Models developed from canonical correlation analysis were used to create maps of current geographic genetic variation using geographic information systems (GIS). Additional maps were created to show the values of traits representing genotypes that would be best adapted to changed climates given climate predictions for the years 2030 and 2095 from two widely-accepted climate models. Differences between current and future genetic maps represent maladaptation as a consequence of climate change assuming that current populations are maximally adapted to recent local climates. Relative risk of maladaptation was measured as the proportion of individuals within the native population that do not overlap with the population that would be best adapted to the site. The results indicate that by 2030 native populations will have a relative risk of maladaptation of 0.27 to 0.30. These values are within the acceptable levels of risk for seed transfer from earlier studies. By 2095, the risk of maladaptation increases to 0.54 or 0.70, depending on the model. Values of 0.70 may be considered high; nevertheless, 30 percent of the population will overlap with a population that may be considered best adapted to the future climate. The present population appears to have enough genetic variation present that it may be expected to evolve into a new optimum through natural selection or migration. Current populations, however, may be less productive than potential best adapted populations, and productivity may be enhanced by moving populations from current warm to cooler sites (e.g., moving populations from low to high elevations). GIS was used to indicate current native populations that may be expected to be best adapted to particular sites in the future.

ADAPTIVE PHYSIOLOGICAL AND MORPHOLOGICAL RESPONSE OF RED SPRUCE, BLACK SPRUCE AND THEIR HYBRIDS.

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Abstract: Across northern parts of its geographic range, red spruce (*Picea rubens* Sarg.) lives in sympatry with the transcontinental black spruce (*Picea mariana* (Mill.) B.S.P.). The two species appear closely related as they can be artificially hybridized (Manley and Ledig 1979) and are similar in morphology (Manley 1971) as well as isozyme (Eckert 1989) and molecular marker (Bobola et al. 1992, Perron et al. 1995) profiles. Estimates of the extent of hybridization and/or introgression range from medium (Bobola et al. 1996a, Morgenstern and Farrar 1964, Manley 1972, Khalil 1987, Fowler *et al*. 1988) to low (Gordon 1976, Manley and Ledig 1979). Hybrids, and introgressed individuals exist in nature. However, the two species have contrasting ecological characteristics and roles; red spruce is shade tolerant, late successional species largely confined to mesic sites while black spruce is an intolerant, early successional species often found on extreme sites, both very wet and very dry. In addition, because of past forest practices, red spruce has been in decline over the majority of its range. It has been estimated that there are now currently 1/5 to 1/10 the number of red spruce compared to pre-European colonization. Red spruce cones were collected in the fall 1996 from the provinces of Ontario, New Brunswick and Nova Scotia. This material was grown with black spruce collected from the same areas. In addition, hybrids from controlled crosses created at the Acadia Forest Experiment Station, were grown together in Fredericton, New Brunswick, Canada (46° N, 66° 15' W). During 1998 and 1999, we conducted measurements to explore physiological response of red spruce, black spruce and their hybrids. Summary results from growth and adaptive physiological response will be reported.

EFFECTS OF CLIMATE ON WEEKLY DIAMETER GROWTH OF 9 BALCYPRESS (*Taxodium distichum* (L.) Rich) PROVENANCES.

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Abstract: Long-term acclimation of a species to local environmental conditions leads to genetic adaptations that allow trees to optimize growth within the normal range of climatic variation that they are likely to experience. Evidence of global warming has led to concerns over how trees might respond. While, provenance tests have traditionally been used to assess the genetic potential of trees grown from seed collected from different geographic locations, researchers have recently suggested that provenance tests may be used to predict how local populations of trees may respond to a changing global climate. The objectives of this study were to examine how diameter growth of 9 provenances of baldcypress (*Taxodium distichum* (L.) Rich) trees might vary in response to climate change. We installed dendrometer bands on 600 19-year old trees in the winter of 1999. Timing of leaf expansion was recorded. Band changes were recorded on a weekly basis. Correlation analysis of data showed significant differences among provenances in time of leaf expansion and weekly growth rates. Provenances also showed differential responses to climate variables. Regression of climate variables with weekly growth yielded an R^2 of ~.42 when the full growing season was examined. However, when the growth period was divided into four periods: growth initiation, increasing period of maximum growth, decreasing period of maximum growth and growth cessation, comparison of climate parameters with weekly growth explained 75-98% of the growth variation. Assessing potential climate change effects will require more scrutiny of growth responses. We will discuss potential problem of dealing with seasonal data.

DIVERSITY AMONG F1 PROGENY ALLOWS RAPID SPECIES ADAPTATION TO CLIMATIC TEMPERATURE CHANGE.

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Abstract: Inheritance of growth rate responses to temperature is an important determinant of how ectothermic species' geographic distributions may change in response to climate change. However, variability among progeny in the growth rate vs. temperature responses has been difficult to define because of the impracticality of obtaining quantitative measurements of this characteristic for large numbers of individual progeny. In this study, growth rate-temperature responses among the F1 progeny of inter- and intraspecies crosses of eucalypts were determined from metabolic rate measurements and calculation of the rate of storage of chemical energy by the reaction: photosynthate $\rightarrow$ structural biomass (i.e. growth rate) as a function of temperature. The F1 progeny of all inter and intraspecies crosses of eucalypts examined have large variation in metabolic rate and growth rate. Viable growth temperature ranges for individual progeny may be broader or narrower than the parent plants, with optima shifted to either higher or lower temperatures. Because plant growth rate response to temperature is a primary determinant of the fitness of genotypes for growth in a specific environment, selection among the widely divergent F1 progeny by extant environmental temperature conditions provides a means to rapidly shift species growth rate responses to changing temperature conditions.

AIR POLLUTION EFFECTS ON WINTER ADAPTATION IN YELLOW BIRCH.

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Abstract: Early spring growth gives birches a competitive advantage during their establishment after forest disturbances. This is achieved by the use of previous years wood to conduct the water to the developing leaves. This strategy, however, is risky as birch wood was shown to become air filled during the winter freeze-thaw cycles, requiring refilling by way of root pressure development in the spring. This risky strategy requiring healthy roots has served birches well in the past, as their inherited adaptability has evolved to cope with the "normals" in climate and environmental variation. Limitations to this adaptation were only apparent in response to rare extreme events such as the wide range birch decline of the 1930's-1950's. Global change, however, has increased the number of interactive stresses such as oxidative air pollutants, nitrogen and acid deposition, which can change root and shoot frost hardiness, root/shoot biomass ratios and reduce the carbon resources of the plant. These effects can predispose the plants to winter damage caused by freeze thaw cycles. These predispositions together with the predicted global warming, which is likely to increase winter temperatures, frequency of thaws, and removal of insulating snow cover, may well push birches beyond their adaptive limits producing large-scale declines. Such declines not only represent a loss in resource and carbon storage, but will have consequences to forest regeneration and species composition as well as habitat. This paper will integrate both experimental and field approaches in the development of a biophysical / physiological model for a tree decline which includes exposure to ozone or excess nitrogen as a factor in predisposition of yellow birch to spring dieback and decline. Data will be presented that indicate that yellow birch seedlings treated with the excess nitrate fertilizer lost their stem hydraulic conductivity at shorter thaws durations than those provided with the lower level of the same fertilizers. The higher level of fertilizer also accelerate the thaw-induced dehardening in stem segments. Preliminary data from a summer ozone fumigation/winter thaw experiment indicate effects of the ozone on photo synthesis, growth, and root to shoot biomass ratios. The possible implications of these effects are illustrated in the birch decline model.

POSTERS

CARTELES

COMPARISON AND STANDARDIZATION OF FOUR SOIL CO_2 EVOLUTION MEASUREMENT TECHNIQUES UNDER LABORATORY AND FIELD CONDITIONS.

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Abstract: Accurate carbon budget models require quantification of component processes including soil CO_2 efflux. Larger scale modeling efforts typically utilize data collected from different experiments, often using different techniques. Appropriate use of data sets require a knowledge of the particular biases of each system in reference to a "ground truth". I compared two commercially available soil respiration systems, the Li-Cor 6400-09 and the PP Systems SRC-1 (both closed chamber designs) and two custom designed systems. The custom systems studied were the A.C.E.S (automated carbon efflux system) which utilized an open chamber design and a closed method that uses the Li-6262 IRGA. In the field, I observed differences among the techniques as high as 50%. To make analytical assessments of the measurement techniques, artificial efflux tanks, in which the CO_2 efflux could be controlled and used as a standard were developed. These efflux generators were built from large high-density polyethylene tanks 93L x 52W x 52H (cm). Soil medium (0.1 m^3) was suspended over a pressure equilibrated footspace equipped with mixing fans. Standard gases were circulated through the footspace creating a diffusion gradient across the soil medium. Two types of soil media with different diffusive properties (gravel and sand) were studied. I found that each measurement technique had a bias that could be corrected for, but the direction and magnitude of the correction differed. When these calibrations were used to correct field data, I was better able to assess the amount of variation in the biological system.

POTENTIAL RELATIONSHIP BETWEEN 11-YEAR SUNSPOT CYCLE AND TREE-RING CHRONOLOGY OF TWO HARDWOODS OF EASTERN CANADA.

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Abstract: Conflicting evidence has been reported in recent years concerning relationships between 11–year sunspot cycle and tree ring chronology. The objective of this study was to determine if 1. tree ring chronologies of hardwoods of eastern Canada have periodicities; these periodicities are the same for trees of the same species or between species; and these periodicites are related to the 11–year sunspot cycle. Analyses on tree ring chronologies were done on the six oldest hardwoods stored in our data set of more than 100 trees. Dendrochonolgies ranged fom 1835-1997 to 1988-1997 and were from sugar maple (Acer saccharum Marsh.) and American beech (Fagus grandifolia Ehrh.). Sunspot data were from the Sunspot Index Data Center, Belgium. Fourier time-series analysis were performed on raw and transformed data. The transformation consisted of several passes of moving average/median smoothing followed by differencing (X=X-X(lag)). Four out of six trees showed significant periodicities ranging from 9.8 to 11.1 years. Cross-spectral computation with sunspot numbers revealed that tree ring periodicities were associated with sun spot numbers, squared coherency ranging from 0.46 to 0.78. Our results suggest that the fluctuation in sun activity provide the base line for the rate of tree growth in long-lived hardwoods of eastern Canada. Both the effects of internal and external factors are likely superimposed on that base line to produce common chaotic tree-ring chronologies.

SITE PREPARATION TILLAGE IMPROVES LOBLOLLY PINE SEEDLING (*Pinus taeda* L.) GROWTH IN THE PIEDMONT AND UPPER COASTAL PLAIN OF THE SOUTHEASTERN UNITED STATES. M. J. Wheeler, R. E. Will, D. Markewitz, D. M. Shirley, M. A. Jacobson

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Abstract: The effects of machine planting, disking, bedding and bedding + ripping on the growth and physiology of loblolly pine seedlings (*Pinus taeda* L.) were assessed for a range of sites on the piedmont and upper coastal plain of Georgia to determine the mechanisms that drive stand growth differences that result from site preparation. Growth results after the second and third growing seasons were similar. After the third growing season, the bed + rip, bed, and disk treatment seedlings were significantly larger than the machine and no-till treatment seedlings. However, a significant site x treatment interaction occurred because the effect of disking varied by site. Most of the seedling mortality occurred during the first growing season, with the disk treatment having the least mortality and the no till treatment the most. Tillage treatments did not affect biomass partitioning when corrected for tree size. Foliar nitrogen concentration measured during the third growing season was not affected by the tillage treatments. Available soil nitrogen was not related to increased seedling growth as initial ammonium extracted from the soil on the no-till treatment plots was significantly greater than the other treatments, and no treatment differences were found for the initial nitrate extracted or total nitrogen mineralized. Bulk density and soil moisture was lower on the beds and in the disk plots. Therefore, soil nitrogen availability, plant nitrogen concentrations, and biomass partitioning did not appear to drive the tillage mediated growth differences. Rather improved soil physical conditions resulted in greater exploitation of soil volume and hence, larger seedlings.

ESTIMATES OF WATER USE BY NATIVE VEGETATION: AN IMPORTANT COMPONENT IN EVALUATING THE EFFECTIVENESS OF PHYTOREMEDIATION.

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Abstract: Successful evaluation of phytoremediation requires an accurate assessment of water uptake by plants. Vegetation on a site may be exerting considerable influence over the hydrologic regime; thus, it may play an important role in phytoremediation. We measured evapotranspiration (Et) and tranpiration (E) on a phytoremediation site at the Naval Training Center (NTC), Orlando, Florida. Overstory transpiration was estimated by measuring sapflow from nine trees in the summer and fall 1998, and spring 1999. Only major canopy species on the site were sampled. We used the heat pulse technique which involves inserting heated and unheated paired thermocouple probes in the xylem of individual trees. Understory transpiration was estimated by taking leaf level stomatal conductance (gl) and transpiration measurements with a Steady-State Porometer on 21 of the dominant understory species. Leaf water-relations were measured two to three times during the day and averaged to provide a daily mean. Percent cover and leaf-level transpiration measurements were used to provide an index of water use for each understory species. In the overstory, averaged across species, sapflow was highest in July and lowest in November. Overall, Cinnamomum camphora used the most water followed by Pinus palustris and Pinus elliotii. Individual tree regression models of mean hourly sapflow vs. mean hourly climate explained 6% to 78% of the variation in sapflow rate depending on species. Solar radiation and temperature were the most important climate variable for predicting sapflow rate. The most abundant understory species based on percent cover were Pentadon sp., Serenoa repens, Osmunda cinnamomea, and Polystichum sp. In contrast, the species with the highest gl and E were Lantana camara, Urena lobata, Vitis sp., and Callicarpa america. Interception loss was estimated to be 31% based on the 10 storm events sampled during the period of this study.

INFLUENCE OF INTENSIVE MANAGEMENT ON NET ECOSYSTEM PRODUCTIVITY OF LOBLOLLY PINE (*Pinus taeda*).

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Abstract: In light of concerns about potential global climate change associated with increasing atmospheric CO_2, it is important to identify sources and sinks of atmospheric carbon and the contribution of intensively managed plantations to global carbon sequestration. Therefore, our objective is to examine the influence of four treatments (weed control, weed control plus irrigation, weed control and irrigation with liquid fertilizer [fertigation], and weed control with fertigation and pest control) on above- and belowground biomass, soil CO_2 flux, and dark respiration of root, stem, and leaf in a six-year-old loblolly pine (*Pinus taeda*) plantation over two years. We will present preliminary data on the influence of intensive management on the spatial distribution of root mass, soil CO_2 flux and foliar respiration. Data will be coupled with aboveground biomass and tissue respiration to separate autotrophic and heterotrophic components of soil CO_2 flux and to assess the ratio of carbon assimilated by photosynthesis to that lost via respiration. These data will be used to quantify carbon sources and sinks in an intensively managed system. Results will be used to assess the potential for intensively managed systems to sequester atmospheric carbon and to better understand the influence of resource augmentation on productivity of loblolly pine.

HIGH LEVELS OF GENETIC DIFFERENTIATION AMONG POPULATIONS OF MEXICAN CONIFERS.

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Abstract: Conifers of boreal and north temperate North America, Europe, and Asia are characterized by moderate to high levels of genic diversity for molecular markers such as isozymes, although there are exceptions. Most of this diversity is present within populations, and differences among populations constitute a small percentage of the total. We reviewed the emerging literature on Mexican conifers to determine whether these generalizations can be extended to them as well. All of our data refer to isozyme diversity, and the taxa include spruces, firs, and pines. Levels of diversity are generally as high as those in species from northern temperate latitudes, but levels of differentiation can be several times higher in Mexican conifers. México's extremes in topography and associated climate mean that many species occur as insular populations. That is, populations exist in pockets of favorable habitat that are separated by many kilometers, often of arid desert. Migration among pockets is restricted, and populations are either small or have experienced bottlenecks as their habitat shrunk during climate change. This favors genetic drift or differentiation by selection. Drift and selection in isolation can lead to speciation, which may explain why México is a secondary center of diversity for pines.

WATER AND CARBON RELATIONS OF *Pinus elliottii* FLATWOODS SUBJECTED TO SEVERE DROUGHT.

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PRESENTATION PROVIDED

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Abstract: Pine flatwoods are the most extensive type of terrestrial ecosystem in Florida, occupying about 50% of the state's land area. Flatwoods characteristically are located in low-lying areas, have level topography and relatively poorly-drained, acidic, sandy soil. This research centers on a 10-year-old *Pinus elliottii* (slash pine) plantation growing on a flatwoods site 20 km northeast of Gainesville, Florida. This site normally receives over 1300 mm of rain annually, evenly distributed throughout the year. Starting in fall of 1998, the region entered a series of droughts that subjected vegetation to early growing season (January - May) precipitation almost 60% below normal. Previous research has suggested that water limitations seldom if ever limit carbon gain in these systems. The objective of this study was to characterize tree physiological responses to these presumably severe water deficits, and to determine the existence and mechanism of any limitations to carbon gain resulting from those water deficits. The water and carbon relations of *P. elliottii* trees were monitored periodically from January-May, 2000, using a variety of methods. Diurnal patterns of light-saturated net photosynthesis, stomatal conductance, leaf internal CO_2 concentration and parameters related to the maximum rate of Rubisco carboxylation (V_{cmax}) and light-saturated electron transport (J_{max}) were measured with a Li-6400 portable photosynthesis system. Pre-dawn and diurnal leaf water potential was measured with a pressure chamber. Tree sap flow was measured using Granier-type heat dissipation probes installed in trees across the range of diameters present in the stand. Results of the research will be discussed within the context of previous research in these systems made under less limiting soil water conditions.

GENE CONSERVATION OF PACIFIC NORTHWEST CONIFERS: *IN SITU* AND *EX SITU* ANALYSES.

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Abstract: The Pacific Northwest Forest Tree Gene Conservation Group is an ad hoc group of forest geneticists representing government, university and private interests whose aim is to ensure that the adaptation and evolutionary potential of important tree species in the region are maintained. As part of this effort, we are analyzing the spatial distribution of conserved genetic resources in eight conifer species in western Oregon and Washington. The eight species were chosen based on their ecological and economic importance, and because they have been most subject to genetic manipulation. Genetic resources present both at their original location (*in situ*) and at some other location (*ex situ*) are being evaluated. We used a GIS-based "gap analysis" approach to determine the extent and spatial distribution of genetic resources conserved *in situ*. The first step was to develop high-resolution GIS coverages showing the distribution of tree species across the landscape. These coverages were built from models of potential natural vegetation. Coverages of reserves were also created and overlaid onto the tree distributions to determine the locations of protected populations of trees. The populations were then stratified into presumably unique genetic units using a system of seed zones and ecoregions. The final analysis showed the extent and distribution of protected populations. This approach provides more detailed information on the gene resource status of tree species *in situ* than any other approach taken to date. We have also summarized *ex situ* genetic resources for each species. These resources include seed stores, provenance and progeny tests, seed orchards, and clone banks both in western Oregon and Washington and in other countries when the germplasm originated in western Oregon and Washington. This summary provides land managers with accurate information required for the development of policy and management decisions about additional gene conservation measurements that may be warranted.

MICROELECTRODE TECHNOLOGY FOR MEASURING XYLEM SAP CO_2 CONCENTRATIONS.

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Abstract: We explored the use of micro-carbon dioxide electrodes (Microelectrodes, Inc., Bedford, New Hampshire, USA) for direct measurement of xylem sap CO_2 concentrations. These electrodes are constructed of glass with a replaceable 3 mm diameter Teflon membrane tip that is filled with electrolyte solution. We tested the electrodes to determine their characteristics and suitability for this application. Electrodes were calibrated in water and air. Gas at known CO_2 concentrations (2%, 10%, 15%) was bubbled through water in a sealed beaker. Stable electrode response to a change in CO_2 concentration was achieved in 10 to 20 minutes and was curvilinear with CO_2 concentration. We used response data to develop regression equations for converting mV output to percent CO_2. Electrodes were calibrated in humidified air in a similar manner. We then tested electrode response to temperature. We placed the calibration apparatus in a controlled environment chamber and recorded response of the electrodes to varying temperatures (15°, 25°, 35° C) at the three gas concentrations. We developed an equation to correct for differences in electrode response at varying temperatures. Electrode response drifts over time (several days to weeks) and eventually degrades to an unacceptable level. In most cases an electrode can be recalibrated several times, but sometimes the membrane must be replaced after just a few days of continuous use. After completing our calibration experiments, we placed electrodes in stems of yellow-poplar (*Liriodendron tulipifera* L.), white oak (*Quercus alba* L.), and loblolly pine (*Pinus taeda* L.) at a field site near Athens, Georgia, USA. We recorded CO_2 concentrations in the range of 2% to 10% and determined that concentration varied diurnally. These results suggest that microelectrodes have advantages over other methods for measuring stem CO_2 concentration (Levy 1999). Microelectrodes provide real-time output, are sensitive enough to detect diurnal fluctuations in CO_2 concentrations, and can easily be placed at different depths and heights in the stem. Our results indicate that microelectrodes are suitable for measuring xylem CO_2 concentrations in tree stems.

REGULATION OF ECOSYSEM FUNCTIONS ACROSS COMPLEX ENVIRONMENTAL GRADIENTS IN LONGLEAF PINE (*Pinus palustris*)-WIREGRASS (A*ristida stricta*) WOODLANDS.

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Abstract: Understanding controls on productivity across landscapes is an important area of ecological inquiry. Longleaf pine-wiregrass (Pinus palustris Mill-Aristida stricta Michx.) savannas occupy sites ranging from deep, xeric sandhills to the edge of wetlands. Aboveground and belowground net primary productivity (ANPP, BNPP) of the overstory and understory were determined across this complex environmental gradient for three replicate sites of three site types (xeric, intermediate and wet-mesic). Soil moisture (at 30 and 90 cm) and N-mineralization (in situ buried bag incubations) was measured through an annual cycle for three years. Soil CO2 efflux and related environmental variables were measured for one year of the study. ANPP more than doubled across the environmental gradient. ANPP was positively correlated with soil moisture and negatively correlated to N-mineralization (see poster by Wilson et al.). Temporal variation in overstory ANPP (averaged across sites) ranged from 1.8-4.2 Mg ha-1 yr-1; spatial variation in ANPP (averaged through time) ranged from 1.9-4.3 Mg ha-1 yr-1 and varied with site (p=0.0023). BNPP fine root estimates depended on the method used. Methods unable to separate simultaneous growth and mortality of fine roots underestimated BNPP by approximately an order of magnitude from minirhizotron measurements. C allocation across productivity gradients varied similarly among methods but appeared to be relatively constant when minirhizotron estimates are used. Soil CO2 flux varied positively with NPP patterns across the gradient (ANPP r2=0.40, p=0.067; BNPP r2=0.32, p=0.11; NPP r2=0.44; p=0.049). Soil temperature and moisture appear to be major controls on soil CO2 flux. Finally, frequent fire appears to increase belowground dynamics through CO2 flux, relative root standing crop, and BNPP. We also present a new experiment that incorporates resource additions to allow for investigations into multiple resource limitations and how these limitations vary depending on gradient position and their impact on ecosystem function.

OVERSTORY STRUCTURE AND REGENERATION PROCESSES IN LONGLEAF PINE-WIREGRASS FORESTS. **Robert J. Mitchell[1], Brian J. Palik[2], Robert H. Jones[3], Mou Pu[4], Stacy Hurst[1], Stephen D. Pecot[1], Michael A. Battaglia[4], and Glen L. Stevens[3]**

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Abstract: Silvicultural methods used to meet objectives of ecosystem management often include green tree retention, or a reserve shelterwood, in order to maintain components of mature stand structure. The competitive environments and mechanisms that influence regeneration in such systems differ substantially from those under even-aged management. We initiated a study in a 65-year-old longleaf pine forest to address the effects of residual overstory structure and competing herbaceous vegetation on survival and growth of longleaf pine seedlings. Stands were harvested to similar residual basal areas using single-tree selection, small group (~0.25 ac) selection, and large group (~0.5 ac) selection. An uncut control stand was used as a reference. Twenty-five subplots encompassing the range of overstory abundance index (OAI) were installed. Ten one-year-old containerized longleaf pine seedlings were planted at 2 quadrants (2 by 2-ft spacing) per subplot, one side receiving a glyphosate application to remove the understory. Soil resources and light availability were quantified over a two-year period, as well as seedling survival, size, and growth. Trench plots were also installed across a range of OAI. The overstory and understory facilitated survival of longleaf pine seedlings but competed with them relative to seedling growth. Seedling survival increased positively with OAI and in the presence of understory. Microclimate changes, i.e., lower soil temperature and relative humidity, in the shade appeared to result in facilitation rather than increased soil moisture during a severe drought. Seedling growth was negatively influenced by OAI largely through attenuation of light by the understory. Soil N was increased at low OAI but only when the understory was absent. Root gaps created through overstory removal appear to be filled quickly by understory plant communities. Finally, trenched subplots preventing overstory root encroachment resulted in a substantial hardwood response which negatively affected growth and survival of longleaf pine seedlings.

CARBON – FINE ROOT ALLOCATION AND TRANSFER AT ECOSYSTEM SCALES (C-FATES).

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Abstract: Accurately quantifying fine root dynamics, particularly C allocation to fine root tissues, is pivotal to understanding forest structure and function. Previous attempts at estimating belowground production utilized 1) indirect methods lacking the ability to account for continuous rates of growth, death, or herbivory attributed to fine roots or 2) nutrient balances with unsubstantiated assumptions. Recent methods, i.e., minirhizotron imaging, allow for direct observation of root genesis, growth, and mortality. Direct observation allows for a more quantitative assessment of critical controls on belowground C allocation. Carbon allocation to fine roots and their controls has been addressed; however, generally accepted explanations have not been presented. We present a conceptual C-FATES (Carbon-Fine root Allocation and Transfer at Ecosystem Scales) model that models C allocation to fine roots while accounting for simultaneous rates of production, mortality, and herbivory. The study took place in a 15-year-old longleaf pine plantation. Three treatments were randomly assigned in a multi-factorial design: fertilization addition to increase root respiration; biocide additions to limit herbivory by soil insects and nematodes; and foliage scorch to reduce carbon flux belowground. For direct observations of root turnover rates, minirhizotron tubes were used. Nematode assessments and grub populations were collected to observe differences across treatments. Soil larvae populations numbered around 6.05 kg ha-1 and 10.40 kg ha-1 for the two collection periods. Nematode types included Criconemoides, Xiphinema, Meloidogyne, and Pratylenchus; however, numbers were considerably low before and after biocide additions with maximum levels of 22 Criconemoides individuals per 100 cc of soil. Soil larvae populations were not affected by the recommended biocide additions of 22.71 liters per acre. Root N concentrations were not significantly different across fertilization treatments. Future work will quantify C allocation patterns as fertilization continues and is influenced by the foliage scorch treatment to reduce C source strength.

ENVIRONMENTAL CONTROLS ON LEAF AND CONOPY CONDUCTANCE OF LONGLEAF PINE (*Pinus palustris* Mill.).

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Abstract: Longleaf pine (Pinus palustris Mill.) savannas dominated the Atlantic and Gulf Coastal Plains of the Southeastern United States prior to European settlement. Within what remains of its historic range, longleaf pine is widely distributed from xeric sandhills to poorly drained flatwoods adjacent to wetlands. Soil water availability appears to be the primary driver of net primary productivity along this gradient, but little is known about the role of soil moisture in regulating biosphere-atmosphere energy exchange. Furthermore, little work towards modeling atmospheric and soil moisture controls on water flux has been done in this system. We initiated a study at the Jones Ecological Research Center that will investigate atmospheric and soil moisture controls on leaf and canopy conductance of natural longleaf pine stands. We selected sites representing the extremes of soil moisture conditions on which longleaf pine occurs at the Jones Center. We are estimating canopy conductance from sapflow measurements and leaf-to-air vapor pressure deficit for selected individuals on each site, and we are measuring leaf conductance and water potential on a subsample of trees accessible by canopy access towers. Additionally, we are measuring temporal variation in atmospheric demand and soil moisture content to determine the response of canopy conductance to increasing water deficit and to determine if that response differs according to site. Preliminary results from a comparison of stable carbon isotope ratios suggest that water use strategy and stomatal response to water stress differ markedly according to site. Relationships between soil moisture content, leaf water potential, and leaf conductance will be presented, and drought effects on stand-level canopy conductance will be discussed. Relevance to climate change models and limitations of the methods will also be discussed.

ASSESSING THE PATTERNS AND CONTROLS OF FOLIAR LITTER DECOMPOSITION LONGLEAF PINE-WIREGRASS ECOSYSTEMS.

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Abstract: Prescribed burning is an important management tool in longleaf pine-wiregrass ecosystems. This recurrent disturbance may have a substantial impact on nutrient cycles, particularly N, and thus the long-term productivity of these forests. To more accurately assess and predict burning impacts, it is important to gain an improved understanding of the factors regulating the mass and nutrient concentration of fine fuels in the understory. The primary objectives of this study were to assess the patterns and controls of biologically mediated foliar litter decomposition and develop mathematical models to predict litter mass loss and nutrient cycling dynamics in these ecosystems. In Fall 1995, freshly senesced litter from seven species, representing a broad range in tissue substrate quality, were collected, placed in mesh bags, and incubated in the field. Litter bags were placed directly on the forest floor and in elevated positions to simulate wiregrass structure. Periodically, samples were retrieved and analyzed for dry mass and chemical composition. After two years, species mass loss patterns exhibited the standard exponential decay function, and the decay constants were most strongly correlated with the initial P concentration of the tissues ($R^2 = .89$). Mass loss rates of the elevated litter were approximately one half of the values measured for corresponding forest floor tissues. While most tissue types initially immobilized N, all species exhibited a net N release by the end of the first year. Also, forest floor tissues exhibited significant inverse linear relationships between N concentration and percent mass remaining (R^2 values from .70 - .99). These decomposition results were coupled N flux data from associated studies to assess the potential impact of different burning regimes on the N balance of these ecosystems and to identify important questions for future research.

NITROGEN DYNAMICS IN A LONGLEAF PINE-WIREGRASS WOODLAND.

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Abstract: In June 1995, we initiated a study to assess the patterns and controls on N mineralization across a longleaf pine-wiregrass dominated landscape, and relate them to observed net primary productivity (NPP) patterns over a burn cycle. Xeric sites exhibited the greatest mineralization rates as determined using buried bag incubations in the top 10 cm of soil. Net N mineralization rates were inversely correlated with both soil moisture and aboveground NPP. Higher N availability patterns on the xeric site were due to higher levels of nitrification, while N flux in the intermediate and wet-mesic sites were dominated exclusively by ammonium-N. Nitrification rates declined with time since fire, and ammonium-N production remained relatively stable over the same period. Overall, data suggest that soil temperature and organic matter quality differences among sites may be important drivers of both temporal and spatial patterns. Microbial biomass N (MBN) exhibited an initial increase immediately following prescribed burning and was generally higher in the wet-mesic site. Low rates of N mineralization were not sufficient to account for ANPP N demand; however, initial results suggest that substantial mineralization in deeper portions of the soil could supply this demand. This could be due to the edaphic characteristics of this ecosystem and the influence of fire in increasing the importance of root turnover to the soil detritus pool. Mineralization paralleled root distribution patterns down to 1 m depth. Further investigation into the complex controls on microbial dynamics and their interaction with belowground litter inputs in the context of N cycling are needed.

TREE RADIAL GROWTH AND UNDERSTORY VEGETATIVE PRODUCTION IN A 30-YEAR-OLD THINNED BOTTOMLAND OAK PLANTATION.

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Abstract: The establishment of various forest incentive and forest reserve programs in the U.S. such as, the Conservation Reserve Program and the Wetlands Reserve Program have led to millions of hectares being planted in oak plantations. Many of these plantations will soon reach an age where they could benefit from thinning and other management practices designed to increase growth and yield responses. Unfortunately, very few studies have dealt strictly with growth responses of even-aged oak plantations to thinning. Additionally, oak plantations provide significant habitat for wildlife, but few studies have looked at the response of understory vegetation to thinning in closed-canopy bottomland oak plantations. The objectives of this study were to evaluate the responses of tree radial growth and understory vegetative production to different levels of operational thinning in a bottomland oak plantation. This study was conducted in a 30-year-old cherrybark oak (*Quercus pagoda* Raf.) plantation located at Red River Wildlife Management Area, Concordia Parish, Louisiana, USA. We established fifteen treatment plots consisting of 20.4- by 81.6-meter measurement plots with buffers of 20 meters on all sides. Treatment plots were blocked by initial stocking (three plots per block) and assigned a thinning treatment: uncut control, light thinning (70-75% initial stocking), or heavy thinning (45-50% initial stocking). Understory vegetative production was evaluated using biomass clipping and Aldous deer browse surveys conducted at twenty points within each treatment plot. ANOVA showed no significant differences in first year radial growth among thinning treatments (95% confidence level). However, there were highly significant differences in understory vegetative production among thinning treatments ($p=0.0005$). So, while thinning intensity did not have a significant effect on radial growth the first season following thinning, it had a highly significant effect on understory vegetative production. Other effects of thinning will be discussed as well.

ROOTS CAN DRIVE GROWTH OF TREE SEEDLINGS. **James E. Grissom and Steven E. McKeand**
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PRESENTATION PROVIDED

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Abstract: Processes occurring in the leaves are important in determining whole-tree growth, but the importance of processes occurring in the roots is less clear. Water and nutrient uptake are critical functions of root systems, but the genetic variation in root traits and the impact on whole-tree growth is not well understood. A major obstacle is that genetic effects of roots are integrally confounded with effects of leaves and other plant parts. Our main objective was to evaluate genetic effects of roots upon tree growth by alleviating the confounding effects of root and shoot processes. One approach is to assemble a population of grafted plants of known genetic origins. We used a novel grafting technique with loblolly pine (*Pinus taeda* L.) seedlings of contrasting growth habits to assess rootstock effects on tree growth and biomass allocation. Seedlings of fast- and slow-growing provenances were grafted reciprocally in all possible combinations. Seedlings were planted on an infertile site in a split-plot design with half of the plots fertilized periodically. After two growing seasons, rootstock effects on tree growth were large in the fertilized treatment. The roots of the fast-growing provenance were able to drastically increase the aboveground biomass of the constituent slow-growing provenance. Physiological mechanisms by which the roots of the fast-growing provenance boost tree growth appear to involve more efficient use of water and enhanced uptake of mineral nutrients. These results show that genetic factors of tree roots can substantially influence the physiology and growth of tree seedlings.

FINE ROOT GROWTH IN LOBLOLLY PINE SUBJECTED TO FERTILIZATION AND CO_2 TREATMENTS.

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PRESENTATION PROVIDED

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Abstract: Loblolly pine (Pinus taeda L.) is a rapidly growing conifer that occupies approximately 30 million acres in the southeastern United States (USDA Forest Service 1988). Studies with loblolly pine have shown increased net photosynthesis and growth response to CO_2 enrichment (Sionit et al. 1985, Groninger et al. 1995, Murthy et al. 1995, Teskey 1995). These aboveground physiological responses of trees will impact carbon allocation and resource availability for belowground growth. The primary objectives of this study were to quantify root growth (rates, longevity and distribution) under elevated CO_2 conditions, and to examine interactions between site fertility and CO_2 each season. Using mini-rhizotron tubes and root ingress cores, loblolly pine root growth, longevity and distribution were evaluated under trees exposed to elevated CO_2 levels in whole tree open-top chambers. Root ingress cores were harvested every four months for two years, to enable quantification of root length, weight, and C and N contents. A more complete harvest was made at experiment end. It appeared that allocation was shifted from belowground to aboveground tissue, with increases in aboveground biomass and decreases in some root components in elevated CO_2 compared to controls. Elevated CO2 treatments generally increased root C concentration and altered root size distribution. Fertilizer treatments also increased root C concentrations and generally decreased fine root growth. Changes in root density, root length density, and biomass, by root component and treatment interaction, will be discussed.

HERBACEOUS FLORA AS INDICATORS OF SUGAR MAPLE SITE QUALITY.

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Abstract: Sugar maple is a keystone species in the northeastern United States and eastern Canada. The species has been declining across the unglaciated Allegheny Plateau in northern Pennsylvania since the 1980s. Throughout its northern range, health and growth of sugar maple have been associated with supplies of base cations, particularly Mg and Ca. Research in northern Pennsylvania and southern New York indicates that sites vulnerable to sugar maple decline are those with low foliar Mg and Ca and ≥2 moderate to severe defoliations in the past 10 years. Geology and soils maps can provide the general location of base cation-poor sites, but site-specific indicators of good sugar maple site quality are lacking. A preliminary qualitative reconnaissance of more than 80 stands in PA, NY, VT, and NH in 1997 and 1998 resulted in a working hypothesis that herbaceous plant communities might provide such a site-specific tool. The qualitative reconnaissance showed that species such as wild leeks (*Allium tricoccum*), blue cohosh (*Caulophyllum thalictroides*), maiden-hair fern (*Adiantum pedatum*), and hepatica (*Hepatica acutiloba*) were routinely associated with healthy stands of sugar maple. In 1999 and 2000 quantitative surveys of the herbaceous plants in 89 stands in PA, NY, VT and NH were conducted. These northern hardwood stands were identified previously in a regional sugar maple health assessment and were used to examine foliar and soil nutrition, radial growth, stand structure and species composition and stand health. Herbaceous inventories were conducted during May and July 1999 in the PA and NY stands and during July 1999 and May 2000 in the VT and NH stands. In each stand, twenty-five 1-m^2 plots were established on a systematic grid within a 50 by 20 m area. In each 1-m^2 plot, all species present were identified and the percent cover was estimated (1, 2, 3, 4, and 5% and by 5% increments to 100%). About 300 species were identified in the 46 PA and NY stands, and over 230 species in the 43 VT and NH stands. After all 25 plots in a stand were sampled, a random search was conducted to identify additional species within the 0.4 ha area that enclosed the 1000 m^2 area. Presence-absence, abundance, frequency, and importance data from these stands are being used in association with foliar and soil nutrition in an indicator species analysis. We envision the use of site-specific herbaceous indicator species in association with forest health monitoring to enable land managers to make timely decisions about insect suppression efforts or other management options.

THE EFFECT OF FERTILIZATION ON GAS EXCHANGE AND GROWTH OF MATURE LONGLEAF PINE. Anderson, P.H., and K.H. Johnsen

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Abstract: Longleaf pine, (*Pinus palustris*), is a dominant tree found on the coastal plain throughout the southeastern US. Stand level fertilization of pine species is being used to increase productivity for both the wood products and pine straw industries. However, there are indications that longleaf responds differently to fertilization than loblolly pine. The study was conducted in Scotland County, NC on a 15-year old loblolly pine plantation, which contains small numbers of volunteer longleaf. At age 8, we imposed a fertilization treatment in which fertilizer was applied at an "optimal" level, measured as 1.3 % N in the loblolly foliage. Gas exchange measures were taken bi-monthly over the course of a year from June 24, 1999 through June 2000 on 24 trees total. Growth of 20 trees per treatment was measured yearly beginning in 1992. Net photosynthesis and stomatal conductance were significantly increased in fertilized trees on September 23, 1999. On all other measurement days net photosynthesis and stomatal conductance in controls were either similar or higher than fertilized trees and was significantly greater on May 4, 2000. Mean net photosynthesis and stomatal conductance throughout the study was significantly greater in control than fertilized trees. Diameter growth over the entire experiment was increased 10.6% by fertilization, although not statistically significant while height and height to live crown were significantly increased. During the 1999 growing season diameter increment growth was significantly greater in the control trees and differences in height increment and height to live crown between treatments disappeared. This suggests that initial increases in growth due to fertilization are being limited as the study progresses and can be partly attributed to increased gas exchange and carbon assimilation. Results may be partially explained by competition effects with loblolly pine, which has responded positively (volume growth = 2.5 x controls) to fertilization.

MANAGEMENT IMPLICATIONS OF WHITE PINE BLISTER RUST INFECTION AND MORTALITY THROUGH AGE 15 IN SUGAR PINE IN SOUTHWESTERN OREGON.

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PRESENTATION PROVIDED

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Abstract: Six plantations of sugar pine (*Pinus lambertiana*) were established in the early 1980's in southwest Oregon with seedlings from 53 families previously screened for white pine blister rust (*Cronartium ribicola*) resistance. These sites were established to validate the screening and to monitor rust infection, virulence, and mortality over time. Not all families were planted on all sites, and a subset of 25 families represented at all six sites are discussed here. The six sites were selected to cover a range of blister rust hazards and all trees were inspected and measured for height, presence and location of infection, and type and severity of damage at age 5, 10 and 15. In addition, at age 15 the number of cankers per tree was counted, as well as the height of the highest canker. Blister rust infection varied significantly by site at all ages, with the widest spread in site means being at age 10 (15.9 to 95.0%). Infection percentages on all sites increased dramatically between age 10 and 15, and at age 15 ranged from 77.7 to 99.1%. At age 15, percent mortality by site ranged from 41.2 to 91.2%. The mean number of cankers per tree on all living trees varied widely by site from 1.3 to 10.8, although due to high mortality on some sites, these means are based on widely differing numbers of trees per site (82 to 507). Mean height of the highest canker ranges from 59.8 to 144.5cm with 88% of all cankers below 2.0 meters. Infection levels at age 15 on 6 additional families known to have a single dominant major gene for resistance (MGR) range from 44.4 to 57.2%. It appears that there is little or no evidence that a strain of rust with virulence to MGR in sugar pine is present on these sites at this time and this will continue to be monitored in the future. The viability of planting sugar pine in southwest Oregon will depend on several factors, including rust hazard, effectiveness of silvicultural treatments, type and durability of resistance, and development of virulence in the rust population.

GENETIC DIVERSITY AND RESTORATION OF A DISJUNCT PITCH PINE POPULATION IN VERMONT, U.S.A.

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Abstract: Pitch pine (*Pinus rigida* Mill) in northern Vermont (VT) U.S.A. represent marginal populations that, because of their potential genetic uniqueness, may be valuable for the future evolution of the species. Development pressures threaten the survival of the species in this area. Within Camp Johnson (VT Army National Guard compound), resides one of the last relatively large populations of pitch pine; however, primarily because of the lack of periodic fires necessary for seedling establishment, there is little pitch pine regeneration in this stand. Establishment of regeneration via planting could be problematic because seedlings from outside the area may not be adapted to northern VT and the introduction of outside germplasm could compromise the genetic uniqueness of the existing population. Objectives were to: 1) evaluate the genetic diversity of pitch pine at Camp Johnson; 2) estimate the genetic uniqueness of that population compared to other marginal and central populations; 3) estimate current levels of inbreeding; and 4) provide a genetic perspective to a restoration plan. Genetic assessments using starch gel electrophoresis indicate that relatively large differences in gene frequency exist among pitch pine populations and that the Camp Johnson population is genetically unique. Thus, if seedlings from outside Camp Johnson were used for restoration, gene frequencies would be altered in subsequent generations and the future adaptation and evolution of this population could be jeopardized. Because there was no evidence of low genetic variability or higher than normal levels of inbreeding, and because germination is adequate in Camp Johnson pitch pine, we recommended that germ plasm from Camp Johnson be used to restore pitch pine here. Restoration was initiated in 1998. Seedlings grown from Camp Johnson pitch pine seed were outplanted after several controlled burns to prepare the seedbed. Seedling survival is periodically assessed and additional plantings are planned.

CALCIUM DEPLETION: A THREAT TO FOREST HEALTH AND SUSTAINABILITY?

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Abstract: Recent evidence indicates that numerous anthropogenic factors can deplete Ca, an essential plant nutrient, from forest systems. Available Ca is important to membrane structure and function, and serves as a second messenger in the perception and transduction of environmental stimuli and stress signals. In its' messenger role, Ca movement across membranes initiates plant response and defense systems to an array of environmental stresses including temperature perturbations, drought, salt, fungal pathogens, and insects. We have demonstrated that acid deposition directly leaches plasma membrane-associated Ca (mCa) from red spruce (*Picea rubens*) mesophyll cells. This loss of mCa destabilizes cells and increases their susceptibility to the freezing injury responsible for red spruce decline in the northeastern U.S. Our data now indicate that acid-induced perturbations of mCa and membrane stability can also occur in other tree species (e.g, eastern hemlock (*Tsuga canadensis*) and balsam fir (*Abies balsamea*)), and that soil-based treatments can independently limit mCa accrual and alter membrane integrity. These findings suggest that mCa disruptions may be more pervasive than the direct acid-induced foliar alterations already noted for red spruce. We hypothesize that anthropogenic disruptions of biologically available Ca impair the ability of trees to recognize and respond to environmental stress, predisposing forests to decline. Although this hypothesis is not centered on any one species or decline, we are intrigued about the potential predisposing influences of Ca perturbation on the well-documented decline of sugar maple (*Acer saccharum*). Several environmental factors (notably drought, insect defoliation, and freezing injury) as well as nutritional deficiencies (especially Ca) have been implicated with maple decline. Considering the importance of Ca in plant responses to stresses associated with maple decline, it is plausible that disruptions of Ca have compromised the ability of sugar maple forests to respond to secondary stressors that would otherwise pose no catastrophic threat.

UN ÍNDICE DE HUMEDAD Y TEMPERATURA DEL SUELO CORRELACIONADO CON LA SOBREVIVENCIA DE PLÁNTULAS. Miguel Angel Capó Arteaga

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Resumen: Uno de los mayores retos es el diseño de parámetros que nos permitan aumentar nuestra capacidad de diagnosticar o predecir que tipo de ambientes son favorables para la productividad vegetal. En el campo de la investigación forestal se requiere clasificar rodales según el riesgo que representan para el establecimiento de plantaciones forestales. Capó (1987) y Capó y Newton (1991) propusieron un índice de condiciones del suelo reportaron una alta correlación entre el índice y la sobrevivencia de cinco especies de coníferas en el sureste de Oregon. Las mediciones que se requiere para obtener los datos se hacen colocando un bloque de yeso a 45 cm de profundidad y midiendo la resistencia eléctrica de los bloques mediante un aparato tipo Boyoucos. La temperatura se midió a 30 cm de profundidad con un termómetro de suelo. En el caso de los resultados reportados por Capó y Newton (1991) el promedio de los índices obtenidos de las mediciones mensuales de los meses Mayo a Septiembre mostraron la más alta correlación con la sobrevivencia, excepto para la especie *Pinus ponderosa* que fue bastante insensible al estrés hídrico y térmico. En una plantación de *Pinus* en la Sierra Madre Oriental, en Arteaga, Coahuila obtuvimos datos para la construcción del índice de condiciones del suelo del primer año de plantado y la correlación con la sobrevivencia del segundo año de cuatro especies y con la sobrevivencia promedio.

Conclusiones.

1) Deben desarrollarse esfuerzos encaminados a facilitar el diagnóstico de los sitios forestales y predecir la sobrevivencia de la regeneración, sea natural o inducida.

2) El uso de un índice que combine la disponibilidad de humedad y la temperatura del suelo ofrece amplias perspectivas de aplicación en el campo de la Ecología Vegetal y la Silvicultura. El efecto de la eliminación de la vegetación competidora, en términos de humedad del suelo, puede ser detectado con este método sencillo y fácil de aplicar.

ESTADO ACTUAL DEL BOSQUE DE *Pinus maximartinezii*, UN PIÑONERO EN PELIGRO DE EXTINCIÓN. Miguel Angel Capó Arteaga[1] y Edmundo Lara Rodríguez

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Resumen: *Pinus maximartinezii* es una especie endémica de Juchipila, Zacatecas, México, que se distribuye en un área no mayor de 10 km^2 entre los 21° 20' y 21° 23' Latitud Norte y los 103° 12' y 103° 15' Longitud Oeste. El suelo, de textura gruesa y pH ácido, es de origen ígneo. El clima es continental con lluvias en verano. La precipitación fluctúa entre 750 y 900 mm anuales. La temperatura media anual es de 18°C. Con el propósito de conocer la estructura y distribución de los rodales de esta especie, durante 1995 se realizó un inventario en 415 ha, ubicando 54 sitios circulares de muestreo de 1000 m^2 cada uno. Se identificaron cuatro rodales. En el poster se muestra la densidad media de árboles para cada rodal. El número de árboles con conos maduros y el número de conos por árbol se presentan también. Sólo el 20.4% de los árboles presentan conos maduros. El número de conos por árbol es de 4.6, y cada cono produce en promedio 100 gr de semilla. La densidad de la regeneración natural (árboles menores de 130 cm) es baja pues apenas es de 333 individuos por hectárea en promedio, pero tres de los rodales tienen menos de 220 individuos/ha. La colecta de semilla.

EVALUACIÓN TEMPRANA DE PROCEDENCIAS-PROGENIES EN CAOBA (*Swietenia macrophylla* King).

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Resumen: En México y América Latina la caoba (*Swietenia macrophylla* King), es la especie forestal económicamente más importante. En los últimos años, las existencias reales de esta especie han disminuido considerablemente. Lo anterior ha inducido el interés por su aprovechamiento, cultivo y preservación. Sin embargo, la mayoría de los viveros forestales que apoyan los Programas de Producción Masiva de Plantas de caoba y cedro (*Cedrela odorata*), utilizan semillas de origen desconocido. Los resultados que se presentan son parte de un Proyecto de Colaboración que tiene la finalidad el estudio y preservación de los recursos genéticos, entre ello, la caoba. Se colectaron semillas de 100 árboles localizados en la Península de Yucatán, agrupados en 5 procedencias. Cada procedencia tuvo entre 6 y 51 familias. El transplante se realizó en bolsas de polietileno negro. Se establecieron ensayos en 3 diferentes sitios. En campo, las plantas se establecieron en un diseño experimental bloques completos al azar con 5 repeticiones. El número de familias plantadas en cada sitio varió entre 47 y 56, con 36 familias presentes en los tres sitios. Se registraron mediciones y observaciones de altura total, tasa de crecimiento en altura, ataque de *Hypsipyla grandella*, ramificación y vigor de las plantas. A nivel de Procedencias se utilizó la técnica de Promedios ajustados para un diseño experimental desbalanceado o comparación de rangos múltiples de Promedios y la Prueba de Rangos múltiples de Duncan. Las mismas técnicas se utilizaron para las 30 familias en los tres sitios. El tamaño y la tasa de crecimiento de las plantas fue similar en las 5 procedencias y en los tres sitios, aún cuando la plantación del sitio San Felipe Bacalar se estableció un año después que los otros. En la mayoría de las variables estudiadas, en cada sitio, no hubo diferencias significativas entre procedencias y entre familias dentro de procedencias. En el análisis con la Prueba de Duncan, tampoco se encontró un patrón definido entre las procedencias y en las 30 familias.

INFLUENCIA DEL FENOMENO CLIMATICO "EL NIÑO" (ENSO) EN LAS PERTURBACIONES NATURALES A LOS BOSQUES.

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INTRODUCCION. Los problemas ambientales en México han derivado del subdesarrollo económico y una deficiente administración gubernamental. Las actividades antropógenas han conducido al empobrecimimiento del medio y por consiguiente a una depauperización económica. En general, cualquier actividad humana que disminuya la cantidad de ozono de la estratósfera puede tener efectos de largo alcance sobre el clima y la existencia de las especies. La Oscilación del Sur y "El Niño" son parte de un mismo fenómeno con interacción entre atmósfera y Oceáno Pacífico, su explicación más pausible física y dinámicamente son las formas de inestabilidad en esta interacción.

ANTECEDENTES. Las oscilaciones son moduladas por las estaciones del año, siendo mayores en el verano y menores en invierno. A su vez por oscilaciones interanuales sin tener un periodo regular; su estudio se realiza basándose leyes de la física de la atmósfera y el oceáno y los modelos de circulación general (GCM). Los cambios anuales que produce el clima como condiciones extremas (periodos de secas con cosechas pobres, hambrunas y migraciones masivas) así mismo, la silvicultura se ve afectada.

RESULTADOS. En los últimos 30 años la variabilidad interanual esta relacionada con "El Niño"(eg. El Huracán Paulina), está se conoce desde el siglo pasado como un periódo de 2 a 4 años al que se le denomina "Oscilación del Sur". La cantidad de energía calorífica aumenta en el Pacífico Central ocurriendo un corrimiento de los patrones de lluvia; pude alterar el clima en regiones distantes como Perú, E.U., Sudáfrica, Brasil con sequías intensas impactando la actividad silvícola y agrícola, y en Australia e India con la ganadería. La preocupación de tal fenómeno estriba en una afectación mayor por explosión demográfica que obliga a asentamientos en zonas de alto riesgo, este fenómeno no tiene una periodicidad por lo tanto se complica su predicción. Sus impactos tienen grandes repercuciones, las lluvias se debilitan durante los veranos y la sequía aparece en la Costa Oeste de México; se presentan sequías , incendios, pérdida de cosechas, e l último evento (97-98) con daños por 8 millones de pesos, además se presenta el "efecto cascada", ya que los procesos de extracción de recursos ocasiona fallas del mercado, lo que tiende a una tala clandestina de árboles, pérdida de biodiversidad y por lo tanto deterioro ambiental, cuyo costo no se contempla dentro de los esquemas económicos.

CONCLUSIONES. Los factores determinantes del impacto térmico del "Niño" que aumenta la temperatura y la precipitación son: variación en la cantidad de energía solar que llega a la Tierra y su incidencia sobre la superficie, en las propiedades del aire y en la rotación ésta sobre un plano inclinado. México ha tomado acciones preventivas debido al aumento de interés por productores silvícolas, aseguradoras, compañías generadoras de energía y sociedad civil, comenzando a trabajar en esquemas de pronóstico a largo plazo aplicando el principio de precautoriedad.

ESTRUCTURA ARBÓREA DE UN BOSQUE SECUNDARIO TROPICAL EN EL SUR DE YUCATÁN Y SU POTENCIAL DE MANEJO. Centeno Erguera, Librado Roberto y Rivera Leyva, Refugio

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Resumen: Los bosques secundarios surgen por la perturbación de la vegetación tanto por el hombre como por la naturaleza. En el estado de Yucatán estos bosques representan una proporción creciente del recurso forestal. Es imprescindible entonces, determinar el potencial de dichos bosques para la producción forestal y su incorporación al desarrollo local y/o regional. Se caracterizó la estructura arbórea de un rodal de bosque secundario de aproximadamente 20 años de edad y derivado de una selva mediana subcaducifolia. La estructura arbórea de este rodal está determinada por 6 categorías diamétricas (individuos < 7.5 cm de DAP), un área basal de 23 m^2, y volúmenes total, comercial y aprovechable de 130, 73 y 8 m^3 por hectárea, respectivamente. De un total de 1,679 individuos arbóreos registrados, más del 65 % se concentra en la categoría de 10 cm y solamente el 0.2 % (3 individuos) en la categoría mayor (35 cm.). Las especies con mayor aportación son: *Lysiloma latisiliquum*, *Bursera simaruba*, *Piscidia communis*, *Diospyros anisandra* y *Thouinia pausidentata*. Estas cinco especies, que juntas representan el 58 % de individuos por hectárea, aportan el 74, 76 y 75 % del área basal y volúmenes total y comercial, respectivamente. El volumen aprovechable está concentrado en *L. latisiliquum*, en individuos con DAP mínimo de 25 cm. Se concluye que este rodal de bosque secundario presenta características adecuadas para un manejo forestal intensivo y ofrece un alto potencial para la producción maderable.

STIMULATION OF ROOT AND SHOOT GROWTH BY SALICILYC ACID IN *Pinus patula* Schl. Et Cham.

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Abstract: Salicilyc acid (SA) is phenolic compound recently recognized as plant growth regulator involved in many physiological processes such as thermogenesis in *Arum* lilies inflorescence, inhibition of ethylene synthesis, disease resistance, etc. (Raskin, 1995). Some effects of application of SA have shown diverse responses including seed germination; reducing transpiration in leaves and epidermal strips, increasing the pod number and yield in mung beans, etc. (Raskin, 1995). In our laboratory, Gutiérrez-Coronado et al. (1998) found that SA sprayed on leaves increases significantly the root growth in soybean plants, and Gutiérrez-Rodríguez et al,. 1999, found that SA stimulated root growth in carrot, radish, and beet plants. Its important to know if SA stimulated root growth in ligneous species such as *Pinus patula* Schl. Et Cham, one specie extensivily planted in parks, gardens and forests of México (Perry, 1991). The experiment was carried out with seedlings 3 months-old of *P. patula* under greenhouse conditions. Salicilyc acid was sprayed every month on shoots in concentrations from 10^{-10} M to 10^{-4} M. After 9 month, the seedlings were hervested root length, root fresh weight, root dry weigth, shoot height, shoot diameter, shoot fresh weight, and shoot dry weight were determinad. The results indicated that SA alters the growth of roots and shoots, and a sgnificant increase in all the parameters measured were found in seedlings sprayed with 10^{-10} M to 10^{-6} M of SA in comparison with the control treatment. SA increased root length as much as 31% and an increase of 56% for shoot hieght. Other studies related to root stimulation have found that SA in combination with indoleacetic acid (IAA) stimulated adventitious root initiation in mung beans (Ling, 1995).

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LAS ORQUÍDEAS SILVESTRES EN CAMPECHE. Antonio Sánchez Martínez y Joann M. Andrews

El estado de Campeche es el estado mexicano con la mayor cantidad de su territorio en estatus de protegido, con más del 30% lo que significa poco más de un millón de kilómetros cuadrados. Sin embargo, también es de los estados cuya flora es menos conocida y estudiada. Las orquídeas silvestres en Campeche son aproximadamente 100 especies, lo cual representa aproximadamente el 10% de las que vegetan en México. Sin embargo, no existe una lista completa garantizada, por lo que resulta vital tenerla, toda vez que el recurso natural del estado se encuentra bajo constante presión y sujeto a múltiples siniestros, naturales o antropocéntricos, como incendios y huracanes. Dichos siniestros provocan la destrucción de miles de hectáreas arboladas cada año, poniendo en grave riesgo la diversidad florística del Estado. Por lo anterior se hace necesario tener el conocimiento de las especies que actualmente habitan en el Estado, para así poder realizar un plan de manejo y conservación de las mismas; además de establecer programas de rescate para aquellas especies que se encuentren amenazadas o en peligro de extinción. Los principales resultados que se tienen después de tres años son los siguientes: se han encontrado 78 especies, incluyendo terrestres, epífitas y semiacuáticas. Además se tienen los reportes de la existencia de por lo menos otras 20, lo cual nos hace llegar a la conclusión de que ha aumentado la cantidad de orquídeas que vegetan naturalmente en Campeche. Entre las especies encontradas, se tienen a nuevos reportes para el estado, tales como *Prosthechea radiata* y *Cyrtopodium macrocarpum*, también se tienen nuevas especies tales como *Lophiaris andrewsiae, Habenaria pringlei* y *Epidendrum martinezii*. Se ha podido observar que la parte sur y sureste del Estado es la más rica en cantidad de especies, las cuales son encontradas tanto en la selva mediana subperennifolia como en la selva baja subcaducifolia. Entre los géneros con mayor cantidad de especies se encuentran *Encyclia*, *Epidendrum* y *Habenaria*; la especie de más difícil localización es *Psygmorchis pusilla* y la más ampliamente distribuida es *Catasetum integerrimum;* se tienen diversas especies con flores minúsculas de los géneros *Pleurothallis*, *Stelis* y *Trichosalpinx*. La especie con la inflorescencia más grande es *Rhyncholaelia digbyana*, cuyas flores alcanzan hasta 20 cm de diámetro. En este trabajo se presente un resumen macro del libro *Las orquídeas de Campeche*, en el cual se presentan a las primeras 57 especies, con su descripción botánica, mapas de distribución nacional y estatal, dibujos de las plantas y sus partes, así como una fotografía de la inflorescenia. Se proporciona, asimismo, una introducción donde se abunda sobre la situación geográfica y ecológica del estado, así como conclusiones finales y la lista completa de las especies que vegetan en Campeche.


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