camcore

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NC STATE UNIVERSITY

2011 Annual Report

2011 CAMCORE ANNUAL REPORT

International Tree Breeding and Conservation

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EXECUTIVE SUMMARY

1. In 2011, two new industrial members joined Camcore: Suzano Pulp and Paper (Brazil) and Proteak (Mexico). This brings the Camcore membership to 30 active, 4 associate, and 7 honorary members.
2. Camcore continues to expand its work with eucalypts. In addition to the work with *E. urophylla* and *E. pellita,* currently there are established 13 provenance/progeny tests of *E. dorrigoensis*, 27 tests of the Temperate-Subtropical and Tropical Camcore-CSIRO species/provenance series, and 18 tests of the Temperate-Subtropical Species Benchmark trials.
3. In 2011, fourteen Camcore members agreed to participate in a cooperative eucalypt hybrid breeding project. The goal will be to produce full-sib families of a wide array of hybrids using tropical, subtropical, temperate and cold-tolerant eucalypt species.
4. Preliminary results from research on wood properties variation in *E. urophylla* show substantial variation in density and pulp yield at both the island and provenance levels. There is a strong unfavorable relationship between density and pulp yield: high density is associated with low pulp yield. There appears to be no strong relationship between growth and wood properties.
5. In 2011, Camcore completed new multiple-site BLUP analyses of four of its major pine species: *P. tecunumanii, P. maximinoi, P. patula,* and *P. greggii.* All of these species have significant commercial potential. Second-generation progeny tests of these and other species are growing well, and there is opportunity to make significant genetic gain in volume growth.
6. There are now a total of 62 pine hybrid trials that have been planted in seven countries. Observations and some early measurements (3 years) indicate that some hybrids will surpass current commercial species in growth rates.
7. Successful site explorations and seed collections of hemlock (*Tsuga* spp.) were completed in 2011, despite setbacks in Vermont and New Jersey due to flood damage from hurricane Irene. Camcore and state and federal cooperators explored 75 eastern hemlock populations across 16 states, and made collections from 21 of the best sites.
8. Conservation work also continued on table mountain pine, another endangered species in the USA. In 2011, collections were made from 97 trees in 13 populations from the northern part of the species range.
9. Research on artificial frost-tolerance screening of *P. patula x P. tecunumanii* hybrids was completed. The laboratory methods can distinguish variation in frost tolerance at the species, provenance, and within-species levels, and appear to be well correlated with field results. Hybrids of *P. patula x P. tecunumanii* show a wide variation in frost tolerance, ranging from *P. patula*-like (relatively toleranat) to *P. tecunumanii*-like (very susceptible).
10. Good progress was made in testing whether NIR scans of foliage can be useful for identifying pine hybrids. Preliminary results with foliage from verified pine hybrids and their parental species were encouraging.
11. Camcore staff completed or were involved in numerous special and collaborative projects in 2011. These projects included the use of new software for species/site matching of "obscure" eucalypt species, literature reviews of water use in forest plantations and breeding for drought tolerance, a survey of best practices for plantation forestry of pines, eucalypts and gmelina, the impacts of climate change on pine plantation distribution (with researchers from CIAT), and an insect and fungi survey in the forests in Guatemala (with researchers from FABI-Univ. of Pretoria).
12. In 2011, Camcore staff authored or co-authored 13 peer-reviewed publication, 4 internal reports, and 6 presentations and posters at scientific meetings (including one keynote address).
13. In February 2013, Camcore will co-host a IUFRO meeting on Breeding and Genetic Resources of the southern US and Mexican pines (including *P. radiata*) in Jacksonville, Florida.

RESUMEN EJECUTIVO (Español)

1. En el 2011, dos nuevos miembros de la industria se afiliaron a Camcore: Suzano Pulpa y Papel (Brasil) y Proteak (México). Esto hace que la membrecía de Camcore sea ahora de 30 miembros activos, 4 asociados, y 7 honorarios.

2. Camcore continúa expandiendo su trabajo con eucaliptos. Adicionalmente a nuestro trabajo con *E. urophylla* y *E. pellita,* actualmente hay establecidos 13 ensayos de procedencia/progenie de E. dorrigoensis, 27 ensayos de la serie de especies/procedencias templado-subtropical y tropical Camcore-CSIRO, y 18 ensayos comparativos de especies templadas-subtropicales.

3. En el 2011, catorce miembros de Camcore acordaron participar en un proyecto cooperativo de cruces híbridos de eucalipto. La meta será producir familias de hermanos completos de una amplia gama de híbridos usando especies de eucaliptos tropicales, subtropicales, templadas y resistentes al frío.

4. Resultados preliminares de investigación de la variación en las propiedades de la madera de *E. urophylla* muestran variación sustancial en densidad y rendimiento en pulpa tanto al nivel de isla como al nivel de procedencia. Hay una fuerte relación no favorable entre densidad y rendimiento en pulpa (alta densidad está asociada con bajo rendimiento en pulpa). Parece que no hay una relación fuerte entre el crecimiento y las propiedades de la madera.

5. En el 2011, Camcore completó un nuevo análisis BLUP en múltiples sitios de cuatro de sus mayores especies de pino *P. tecunumanii, P. maximinoi, P. patula,* y *P. greggii.* Todas estas especies tienen un potencial comercial significativo. Los ensayos de progenie de segunda generación de estas (y otras especies) están creciendo bien y existe la oportunidad de obtener una ganancia genética significativa en crecimiento en volumen.

6. Hay ahora un total de 62 estudios de híbridos de pino que han sido plantados en siete países. Las observaciones y algunas mediciones tempranas (tres años) indican que algunos híbridos sobrepasarán a las actuales especies comerciales en las tasas de crecimiento.

7. Exitosas exploraciones de sitio y colectas de semillas de abeto (*Tsuga* spp) fueron realizadas en el 2011 a pesar de los contratiempos en Vermont y New Jersey debido a las inundaciones ocasionadas por el huracán Irene. Camcore y cooperadores del estado y federales exploraron 75 poblaciones del abeto del este a través de 16 estados, e hicieron colectas en 21 de los mejores sitios.

8. El trabajo de conservación también continuó en el pino de la montaña de la mesa (table mountain pine en inglés) otra especie en peligro en los Estados Unidos. En el 2011, colectas de 97 árboles fueron realizadas en 13 poblaciones de la parte norte del rango de la especie.

9. Se completó la investigación sobre la resistencia a las heladas en forma artificial en híbridos de *P. patula x P. tecunumanii.* Los métodos de laboratorio pueden distinguir la variación en resistencia a las heladas a nivel de la especie, la procedencia y dentro de la especie y parecen bien correlacionados con los resultados de campo. Los híbridos de *P. patula x P. tecunumanii* muestran una gran variación en resistencia a las heladas, fluctuando entre valores similares a los del *P. patula* (relativamente tolerantes) y valores similares a los del *P. tecunumanii* (muy susceptible).

10. Se progresó bastante al ensayar si la utilización del NIR puede ser útil para la identificación de híbridos de pino. Los resultados preliminares con follaje de híbridos de pino verificados y sus especies padres fueron alentadores.

11. El personal de Camcore completó o estuvo involucrado en muchos proyectos especiales y colaborativos en el 2011. Estos proyectos incluyeron el uso de nuevo software para determinar la correspondencia especie/sitio de especies de eucaliptos poco conocidas, revisión de literatura sobre el uso del agua en plantaciones forestales y mejoramiento para la tolerancia a la sequía, una encuesta sobre las mejores prácticas en plantaciones forestales de pinos, eucaliptos y gmelina, el impacto del cambio climático en la distribución de las plantaciones de pino (con investigadores del CIAT), y un levantamiento de insectos y hongos presentes en los bosques de Guatemala (con investigadores de FABI, Universidad de Pretoria).

12. En el 2011, el personal de Camcore fue autor y coautor de 13 publicaciones científicas revisadas por expertos, 4 informes internos, y 6 presentaciones y posters en encuentros científicos (incluyendo una presentación magistral de apertura).

13. En Febrero del 2013, Camcore será coanfitrión de una reunión de IUFRO sobre mejoramiento y recursos genéticos de los pinos del sur de los Estados Unidos y México (incluyendo *P. radiata*) en Jacksonville, Florida.

RESUMO EXECUTIVO (Português)

1. Em 2011, dois novos membros industriais juntaram-se a Camcore: Suzano Papel e Celulose (Brasil) e Proteak (México). Isso traz o número de participantes ativos para 30, com 4 associados, e 7 membros honorários.

2. Camcore continua a expandir o seu trabalho com eucaliptos. Além de nosso trabalho com *E. urophylla* e *E. pellita*, nós estabelecemos 13 testes de progênie / proveniência de *E. dorrigoensis*, 27 testes com a série Camcore-CSIRO de clima temperado, subtropical e tropical, e 18 testes com testes de benchmark de clima temperado e subtropicais.

3. Em 2011, quatorze membros Camcore concordaram em participar de uma cooperativa do projeto de melhoramento de eucalipto híbrido. O objetivo será produzir famílias de irmãos completos de uma ampla gama de híbridos utilizando especies de eucalyptus tropicais, subtropicais, temperadas e tolerantes a frio.

4. Resultados preliminares na pesquisa sobre a variação nas propriedades da madeira em *E. urophylla* apresentou variação significativa na densidade e rendimento em polpa, tanto no nível da ilha quanto no de proveniência. Há uma forte relação desfavorável entre densidade e rendimento de polpa: alta densidade está associada com baixo rendimento de polpa. Não parece haver nenhuma relação forte entre o crescimento das árvores e as propriedades da madeira.

5. Em 2011, a Camcore completou novas análises de BLUP de vários sites de quatro das suas principais espécies de pinheiros: *P. tecunumanii, P. maximinoi, P. patula* e *P. greggii.* Todas estas espécies têm potencial comercial significativo. Testes de segunda geração de progênie destas e outras espécies estão crescendo bem, e há oportunidades para significativos ganhos genéticos em volume.

6. Existe um total de 62 ensaios de pinheiros híbridos plantados em sete países. Observações e algumas medidas iniciais (3 anos) indicam que alguns híbridos ultrapassarão atuais espécies comerciais em taxas de crescimento

7. Explorações de site e coleção de sementes de hemlock (*Tsuga* spp.) foram concluídas com sucesso em 2011, apesar de contratempos em Vermont e Nova Jersey devido a danos causados pelas inundações do furacão Irene. Camcore e cooperadores estaduais e federais exploraram 75 populações de hemlock do leste em todos os 16 estados, e fez coleta de 21 dos melhores sites.

8. Trabalhos de conservação também continuou no “Table Mountain Pine”, outra espécie em perigo nos EUA. Em 2011, foram realizadas coletas em 97 árvores em 13 populações do norte da faixa em que a espécie se concetra.

9. Pesquisa sobre o rastreio de híbridos *P. patula* x *P. tecunumanii* tolerante ao geada artificial foi concluída. Os métodos laboratoriais podem distinguir variação na tolerância a geada nas do nivel de espécies, proveniência, e dentro espécies, e parecem estar bem correlacionados com resultados de campo. Híbridos de *P. patula x P. tecunumanii* mostraram uma grande variação na tolerância a geada, indo de *P. patula*-como (relativamente tolerante) para *P. tecunumanii*-como (muito suscetíveis).

10. Foram feitos bons progressos com respeito ao use de NIR em folhagem para identificação de híbridos de pinheiros. Resultados preliminares com folhagem de híbridos de pinheiros e suas espécies parentais são encorajadores.

11. O pessoal da Camcore concluiram ou estavam envolvidos em vários projetos de colaboração especial em 2011. Esses projetos incluíram o uso de um novo software para a identificação de sites para espécies de eucalipto "obscuro", revisões de literatura sobre o uso da água em plantações florestais e cruzamentos para tolerância à seca, um levantamento das melhores práticas para a plantação de pinheiros, eucaliptos e gmelina, os impactos das mudanças climáticas sobre a distribuição de plantação de pinus (com pesquisadores do CIAT), e pesquisa sobre insetos e fungos nas florestas da Guatemala (com pesquisadores da FABI-Univ. de Pretoria).

12. Em 2011, a equipe Camcore teve autoria ou co-autoria em 13 publicações (peer-reviewed), 4 relatórios internos, e 6 apresentações e posteres em reuniões científicas (incluindo um discurso de abertura).

13. Em fevereiro de 2013, Camcore co-sediará uma reunião da IUFRO em Melhoramento e Recursos Genéticos de pinheiros do sul dos EUA e do México (incluindo *P. radiata*) em Jacksonville, Florida.

RINGKASAN EKSEKUTIF (Bahasa Indonesia)

1. Di tahun 2011, dua anggota baru dari industri bergabung Camcore: Suzano Pulp and Paper (Brasil) dan Proteak (Mexico). Dengan demikian, keanggotaan Camcore menjadi 30 anggota aktif, 4 anggota tidak penuh, dan 7 anggota kehormatan.

2. Camcore terus meluaskan kegiatannya dengan kayu putih. Sebagai tambahan dari kegiatan dengan *E. urophylla* dan *E. pellita*, kami telah melaksanakan 13 uji asal-usul/keturunan dari *E. dorrigoensis,* 27 uji spesies/seri asal-usul iklim sedang, sub tropis, dan tropis milik Camcore-CSIRO, serta 18 uji percobaan spesies benchmark untuk iklim sedang, sub tropis.

3. Di tahun 2011, empatbelas anggota Camcore sepakat untuk berpartisipasi dalam proyek kerjasama untuk pembiakan kayu putih hibrida. Tujuannya adalah untuk menghasilkan keluarga kandung penuh (full-sib families) dari hibrida yang tersebar luas menggunakan spesies kayu putih iklim tropis, sub tropis, temperate dan tahan-dingin.

4. Hasil awal dari riset keragaman sifat kayu di *E. urophylla* menunjukkan keragaman nyata dalam kepadatan dan hasil pulpa pada kedua pulau dan tingkat asal-usul. Ada hubungan ketidaksesuaian yang kuat antara kepadatan dan hasil pulpa: kepadatan tinggi dihubungkan dengan rendahnya hasil pulpa.

5. Di tahun 2011, Camcore menyelesaikan analisa BLUP di berbagai-lapangan baru terhadap empat dari spesies pinus utamanya: *P. tecunumanii, P. maximinoi, P. patula*, and *P. greggii*. Semua spesies tersebut memiliki potensi komersial yang berarti. Uji keturunan generasi kedua dari spesies tadi dan yang lain berkembang dengan baik, dan ada peluang untuk membuat perolehan genetik yang berarti dari segi pertumbuhan isi.

6. Sekarang ada sejumlah 62 uji pinus hibrida yang telah ditanam di tujuh negara. Pengamatan dan beberapa pengukuran awal (3 tahun) menunjukkan bahwa beberapa hibrida akan melebihi spesies komersial yang ada dalam hal laju pertumbuhannya.

7. Penjajagan tapak yang berhasil dan pengumpulan biji hemlock *(Tsuga spp.)* telah diselesaikan di tahun 2011, walaupun ada kemunduran di Vermont dan New Jersey yang disebabkan oleh kerusakan banjir dari badai Irene. Camcore dan pemerintahan state dan federal yg bekerjasama menjajagi 75 populasi eastern hemlock di 16 state, dan mengumpulkan 21 dari tapak terbaik.

8. Kegiatan konservasi juga berlanjut untuk pinus gunung meja, salahsatu spesies terancam di AS. Di tahun 2011, pengumpulan dilakukan terhadap 97 pohon di 13 populasi dari wilayah spesies bagian utara.

9. Riset untuk pemilihan tahan-beku buatan dari hibrida *P. patula x P. tecunumanii* telah diselesaikan. Metoda laboratorium dapat membedakan keragaman dalam ketahanan beku pada spesies, asal-usul, dan tingkat di dalam-spesies, dan tampaknya berhubungan erat dengan hasil lapangan.

10. Kemajuan telah dibuat dalam meneliti apakah pemeriksaan daun secara elektronis NIR dapat bermanfaat untuk mengenali pinus hibrida. Hasil awal dengan daun dari hibrida pinus yang telah diperiksa dan spesies tetua mereka adalah menjanjikan.

11. Pegawai Camcore menyelesaikan atau terlibat di sejumlah proyek khusus dan bersifat kerjasama di tahun 2011. Proyek-proyek tersebut meliputi penggunaan piranti lunak baru bagi spesies/tapak yang cocok dari spesies kayu putih "samar-samar", tinjauan pustaka dari penggunaan air di perkebunan kayu dan pembiakan untuk tahan kekeringan, suatu survai tentang 'best practice' dari perkebunan pinus, kayu putih, dan jati putih, dampak perubahan iklim terhadap penyebaran perkebunan pinus (dengan peneliti dari CIAT), dan suatu survai serangga dan jamur di hutan Guatemala (dengan peneliti dari FABI – Universitas Pretoria).

12. Di tahun 2011, pegawai Camcore menulis atau ikut menulis 13 publikasi peer-reviewed, 4 laporan internal, dan 6 presentasi dan poster di pertemuan ilmiah (termasuk satu pidato utama).

13. Di bulan Pebruari 2013, Camcore akan bertindak sebagai co-host di pertemuan IUFRO tentang Pembiakan dan Sumberdaya Genetik Pinus dari bagian Selatan US dan Meksiko (termasuk *P. radiata*) di Jacksonville, Florida.

Message From the Director

We had a very successful year in Camcore. Two new industrial members joined our program, Suzano (Brazil) and ProTeak (Mexico). We finished a number of research projects that included everything from a literature review of water usage in plantations to verifying that NIR can be used to distinguish pine hybrids from parental species in field studies. Two of our graduate students, José Jiménez and Davíd Cerda successfully finished their MS projects. We hired Mr. Romeo Jump as our new seed and pollen technologist at NC State University. We received additional funding from the USDA Forest Service to continue conservation projects in the eastern US. Our regional technical meetings in Colombia, Uruguay and South Africa and our annual meeting in Australia were well attended and very productive. We began working with colleagues in the Department of Forestry and Environmental Resources at NC State University and elsewhere in the southern US to host an important IUFRO pine genetics meeting in Jacksonville, Florida in early 2013.

The trend to plant more eucalypts than pines continued across the industry in the southern hemisphere in 2011. In response to this shift, Camcore's eucalypt projects have been expanded to include eight different genetic trial series. We envison that in two years' time the number of Camcore eucalypt projects will double again. Our activities in 2012 will emphasize the accumulation of genetic bases of different eucalypt and *Corymbia* species and more intense research on flowering and cold and drought tolerance. Our eucalypt hybrid initiative is also developing well.

A number of our 2nd generation pine trials are approaching 5 years of age and a new round of selection will commence soon. One of the questions that will need to be addressed is how to handle the contamination of *Pinus patula* pollen from large plantations that surround trials and orchards of *P. tecunumanii* and *P. greggii* in some locations. Our *P. elliottii* benchmark studies are being established in southern Africa. Success has been reported by Smurfit Colombia in the air-layering of *P. maximinoi* and similar studies are also being conducted in South Africa. Future *P. maximinoi* orchards will be generated by cuttings or air-layers and not by grafts. Some of the pine hybrid trials are developing very well and initial wood quality assessments will be made with acoustic tools around 5 years of age.

Teak trials have been established by several Camcore members. We continue to search for additional genetic material to broaden existing genetic bases of the species. Our research emphasizes the promotion of early flowering and the use of improved technology to assess wood quality of standing trees.

Our emphasis has always been to conduct practical, applied research for the benefit of Camcore members. Economic analyses of different research activities initiated by members will be a common service offered by Camcore in the future. Despite a challenging economy, we continue to be optimistic about the future of forestry research in the Camcore membership. Thank you again for your support in 2011. We look forward to working with you in 2012.

Bill Dvorak, Director

A young *E. smithii* seedling that made it through a cold winter on the Northeast Cape of South Africa.

2011 Camcore Membership

Active & Associate Members

Argentina
- Alto Paraná, SA
- Bosques del Plata, SA

Australia
- CSIRO (Associate)

Brazil
- Klabin, SA
- Rigesa, Celulose, Papel e Embalagens Ltda
- Suzano Pulp and Paper

Chile
- Arauco Bioforest
- CMPC Forestal Mininco

Colombia
- Cementos Argos, SA
- Pizano/Monterrey Forestal, SA
- Reforestadora de la Costa, SA
- Smurfit Kappa Cartón de Colombia, SA

Guatemala
- Grupo DeGuate (Associate)

Indonesia
- PT Sumalindo Lestari Jaya

East Africa
- Kenya, Uganda, Tanzania

Mexico
- Forestaciones Operativas de México, SA de CV (FOMEX)
- Proteak Uno SA de CV

Mozambique
- Chikweti Forests
- Florestas de Niassa Limitada

Republic of South Africa
- Komatiland Forests, Ltd
- Merensky Pty Ltd
- Mondi South Africa
- MTO Forestry Pty Ltd
- PG Bison Holdings Pty Ltd
- Sappi Forests
- York Timbers Pty Ltd

United States of America
- Mead Westvaco (Associate)
- USDA Forest Service (Associate)

Uruguay
- Montes del Plata
- Weyerhaeuser Company

Venezuela
- PROFORCA
- Smurfit Kappa Cartón de Venezuela, SA
- Terranova de Venezuela, SA

Zimbabwe
- Border Timbers

Honorary Members

Belize
- Ministry of Natural Resources

El Salvador
- Centro Nacional de Tecnología Agropecuaria (CENTA)

Guatemala
- Instituto Nacional de Bosques (INAB)

Honduras
- Escuela Nacional de Ciencias Forestales (ESNACIFOR)

Mexico
- Instituto de Investigaciones Forestales, Universidad Veracruzana
- Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP)

Nicaragua
- Instituto Nacional Forestal (INAFOR)

The 2011 Annual Meeting in Australia

The 2011 Camcore Annual Meeting was held in Australia and hosted by our associate member, CSIRO. Jeremy Brawner, CSIRO, Queensland was the chief organizer of the event, and he was assisted by a number of his colleagues. The visit was divided into two parts: a pre-meeting tour that originated in Canberra and ended in Melbourne and the annual meeting tour that was centered in the vicinity of the Sunshine Coast area of Queensland.

The pre-conference tour was attended by 14 Camcore participants. We visited the CSIRO Seed Centre and a *E. benthamii* seed orchard in the Canberra area. We then drove southwest to Albury and visited a natural stand of *E. camaldulensis* and several seed orchards and progeny tests of different eucalypt and *Corymbia* species as well as a fish farm enterprise. Stops were also made to see various natural stands of grey gums. One of the highlights of the tour was a visit to the highland areas of Victoria to see natural stands of *E. globulus, E. nitens, E. regnans* and *E. delegatensis.* Many of the old growth forests of eucalypts there had regenerated after a fire in 1939. Along the way, the CSIRO Seed Centre staff served as excellent guides, answering our many questions about eucalypt taxonomy and biology. We want to thank David Bush and his entire staff for their wonderful organization and hospitality during the pre-conference tour.

The Camcore Annual Meeting on the Sunshine Coast, Queensland was attended by approximately 32 participants from southern and eastern Africa, Latin America and the United States. During the first day of the technical sessions, our Australian hosts gave talks on forestry in Queensland and the status of eucalypt, *Corymbia* and pine breeding programs as well as the development of new enabling technologies to assess wood quality. Invited speakers included Drs. Kevin Harding (Forestry Science, Queensland), David Lee (University of the Sunshine Coast), Dominic Kain (Foresty Plantations Queensland) and Roger Meder (CSIRO). Paul Toon (Forestry Plantations Queensland) also demonstrated a new pollinator that has been developed for pines to make the pollination process in seed orchards easier and quicker. Special guests at the technical sessions of the annual meeting included Drs. Garth Nikles and Mike Shaw, strong supporters of Camcore since the early days.

Camcore Annual Meeting participants listen to presentations about *P. elliotti x P. caribaea* hybrid breeding done by Forestry Plantations Queensland.

The field trips during the annual meeting included seeing some of David Lee's work with *Corymbia* hybrids and Dominic Kain showing us some very impressive clonal trials of the *P. elliottii x P. caribaea* hybrids. There also was a special stop at the University of the Sunshine Coast, by request of the participants, to photograph kangaroos grazing on the grass around the buildings.

During the final dinner, we presented small gifts to Jeremy Brawner and Roger Meder and their staff to thank them for an excellent trip. We also recognized Andrew Morris (Sappi) for his great job as Camcore Board Chairman over many years. We left Australia not only with better knowledge of some of the local tree species, but with a better appreciation of some of the really good research that is being done by our hosts in the region.

The 2011 Camcore Annual Meeting in Australia was well-attended, with 32 particiapants from southern and eastern Africa, Latin America, and the United States.

Regional Technical Meetings in Colombia, South Africa and Uruguay

Each year, Camcore holds regional technical meetings to discuss research opportunities and challenges. These usually include a one-day indoor session and one day of field trips. The regional meetings give the technical people in the program the opportunity to coordinate projects with colleagues and discuss ideas that someday might turn into future projects. The regional meetings are usually held in southern Africa, and southern and northern South America. In 2011, MTO (South Africa), Weyerhaeuser Uruguay and Smurfit Kappa Cartón de Colombia hosted the regional meetings in their respective areas. We thank these companies for their support and hospitality. All three meetings were well attended and gave us the opportunity to report on current projects, exchange ideas and develop plans for the future.

The 2011 Camcore Regional Technical Meeting for Southern Latin America in Uruguay.

Water Use in Plantations of Eucalypts and Pines: Breeding Opportunity or Dilemma?

In the last 5 years, Camcore members have been much more interested in finding tree species/populations/families that are well suited to dry environments. There are two reasons for this. First, the forestry land now available for planting is often marginal in some way for good tree growth. Second, global climatic fluctuations are characterized by extreme weather events that often include periods of severe drought. The genetic material that we plant must be able to withstand or adapt to these changing scenarios.

Generally, in tree breeding we try to improve drought hardiness by finding better adapted seed sources. As examples, efforts were made in the early years of Camcore to make selections in natural populations of *Pinus caribaea* var. *hondurensis* on extremely dry sites in southeastern Guatemala and Honduras for marginal dry areas in eastern Venezuela and central Brazil. In the *P. taeda* programs in the southern US, seed sources of the species from the drier regions of east Texas have often shown superior drought resistance/survival over more coastal sources when planted in marginal areas. *Eucalyptus camaldulensis* is often chosen as a parent species when hybrid progeny are desired for improved drought tolerance. The new interest in *Corymbia* species/hybrids is due to their supposed superior drought tolerance. When severe droughts do occur that include high levels of tree mortality, tree breeders usually walk through genetic field trials and assess trees as dead or alive, select the best phenotypes among the survivors, and create a "drought resistance" landrace or seed orchard that hopefully offers better protection in the future against cyclic water deficits.

In 2011, the Camcore Advisory Board asked that we conduct a literature review of the status of water usage in pines and eucalypts. What is the state of the art of scientific knowledge in this area ? In many countries, the issue of water use by tree species continue to be important. Forest plantation are often considered "water guzzlers" by the public, especially if the trees planted are exotic and fast growing. Putting the emotional arguments aside, how are the crop breeders and crop and tree physiologists addressing the issue of developing hardy varieties of trees? Are tree breeders selecting the right traits to improve drought resistance? Can drought hardiness be considered a single trait or is it an expression of multiple traits controlled by different gene actions? Can surrogate juvenile traits be assessed that correlate to drought hardiness in mature trees?

Results of our assessment were examined from a tree breeding perspective and some of the main points are summarized below.

- There have been a number of excellent reviews of water usage in tree species by physiologists over the last three decades.
- Tree species produce less surface runoff, ground water recharge and streamflow than more shallow rooted forms of vegetation such as crops, pastures and grasslands.
- However, on a biomass per unit of water utilized, pines and eucalypts appear more efficient water users than many agricultural crops.
- The research is inconclusive on whether plantations of pines and eucalypts use more water than indigenous species.
- Physiologists use a concept of water use efficiency (WUE) in their models to predict productivity. There are at least five different measures and definitions of water use efficiency (White et al. 2009). Generally, WUE is defined as the dry matter produced by the tree per unit of water transpired. In some cases, it is calculated using estimates of wood volume (minus branches and leaves) divided by m^3 of water transpired or divided by estimates of annual evapotranspiration rates. Eco-physiologists often present WUE values on a stand or clonal block basis rather than on an individual plus-tree basis.
- WUE is considered a useful parameter in tree physiology. However, the multiple definitions and range of scales that are often used by physiologists cause confusion to those outside the field.

- When tree breeders select trees that have survived droughts in genetic trials, the alleles captured are probably not those that govern WUE. However, some contend that selecting trees for high productivity in water-limited environments, in effect, is selecting for high WUE.
- Selecting individual plus-trees based on measurement of leaf-scale WUE is not practical since these values change with different tree ages, season of sampling, and soil type. However, selecting clones planted in large blocks across multiple sites that have been derived from cuttings taken from plus trees or trees derived from somatic embryos offers a viable approach to ranking genetic entries (large numbers of trees buffer environmental effects) and is currently the approach used by some physiologists.
- Some suggest that the heritability of leaf-scale WUE is high. However, since the calculation of WUE includes estimates of evapotranspiration, and breeders can not manipulate this trait easily through selection, questions remain on what actual gains could be achieved through traditional breeding. Rates of evapotranspiration might be better controlled by specific silvicultural management practices such as manipulation of crowns, thinning, pruning and fertilizer applications (Vanclay 2009, White et al 2009).

Some land management and policy decisions might impact the efficacy of tree breeding efforts for improving water use. For example, if clones of some species were developed that were 20% more efficient in water use than commercial planting stock based on field trial measurements, would commercial deployment of these more efficient clones translate into increased water flow in catchments areas? In other words, would gains in water flow be obscured by the environmental variation (soils, vegetation type, rainfall patterns) that normally surrounds catchment area assessments? If some improvement in water flow was realized by planting more water efficient trees, how much improvement in water flow is needed to cause a positive impact on water supply and be recognized as important by local municipalities? Finally, do wood physical properties of trees/clones selected for high WUE have the same wood cellular properties (cell wall size, thickness etc.) as unimproved material? These questions are important because in the next decades, tree breeding programs are going to survive or be terminated based on their ability to demonstrate real economic returns on investment. It is unclear on how the millions of dollars needed industry-wide to breed for some form of a water use trait would be measured in terms of its benefits to the public, the industry, or the environment. Results of clonal trials at one location for better water use are not necessarily transferable to another location.

The question of water use by plantation trees is important to physiologists to model productivity. It is not a major feature of most commercial tree breeding programs because of the ambiguity of what exactly to select for and how to go about it. Alternate measures of water use using heavy isotopes or C or O might prove useful in forestry. The language that tree breeders and physiologists speak is different. Lack of communication is not intentional. The water use issue will be one of the most important questions in plantation forestry in many countries in the next decades. It seems that practical, applied research, that includes an economic assessment of options, is needed more than ever regarding the water use issues in trees. Water use questions and the return on investment from breeding must be evaluated in the context of local environmental policies. Physiologists and tree breeders would benefit by working closely together.

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Developments in Camcore

Two new members joined Camcore in 2011, **Suzano** (Brazil) and **Proteak** (Mexico). Suzano is a major producer of eucalypt market pulp and bioenergy; ProTeak, as its name implies, is a teak organization that has visions of possibly expanding into eucalypts and pines. We welcome these two new members to our program! At the end of 2011, Camcore had 30 active, 4 associate and 7 honorary members that represent 21 countries.

The Camcore staff made technical visits to all but two of its active members in 2011. Below is a summary of our visits.

Argentina

Jesús Espinoza visited **Bosques del Plata (BDP)** in April. Trees from the first series of pine hybrids are developing very well at age 4 years. The *Pinus caribaea x P. tecunumanii* and *P. elliottii x P. caribaea* hybrids are showing superior growth compared to the *P. taeda* control. BDP has begun to evaluate the potential of some eucalyptus species for its forestry program. In 2011, the company established the South African Eucalyptus Benchmark Study that Camcore has been coordinating with its members since 2010. In 2012, the company will test other species from several eucalypt projects that Camcore is developing.

After Bosques del Plata, Jesús visited **Alto Paraná (APSA).** As at BDP, the hybrids of *P. caribaea x P. tecunumanii* continue to show excellent growth. The Genotype x Environment interaction test with *P. taeda* is growing very well and at age 3 years, does not show significant G x E interaction. So far, the APSA material has shown the best growth in these trials. Alto Paraná made an important contribution to the *Eucalyptus urophylla* wood project and sent samples to Camcore for analysis. Regarding eucalypt trials, APSA established the South African Eucalyptus Benchmark Study. In 2012, APSA is planning to establish trials for two more Camcore eucalypt projects: the tropical eucalypt benchmark and the drought hardy study.

Brazil

Jesús Espinoza visited **Rigesa** in April. The hybrids of *P. caribaea x P. tecunumanii* and *P. caribaea x P. oocarpa,* as well as the pure species *P. tecunumanii,* continue to show excellent growth. The company established the second series of hybrid trials with new species combinations at the end 2010; they are showing good survival and growth. They have started the expansion of the pulp mill by adding one more paper machine. This mill expansion will require a doubling of the eucalypt fiber supply in the short term. We believe the Camcore eucalypt hybrid program will be very useful to Rigesa for finding the best species-site combinations to increase not only volume, but also disease and frost resistance. In 2012, Rigesa is planning to establish several series of Camcore eucalypt trials and also to make some controlled crosses as part of the Camcore eucalypt hybrid project to assess other potential eucalypt species for its program.

Ricardo Paim and Waldemar Veiga look for early cone production in the Rigesa *P. greggii* seed orchard.

Jesús visited **Klabin PR** in June. We are very pleased that Klabin hired Fabricio Biernaski as the breeder for its pine program. The company is working to update and improve its pine breeding program. The primary focus of the visit was to explain to the new breeder what Camcore does and how we can help Klabin in different projects that involve not only new pine species, provenances and families but also studies of wood properties, NIR models, hybrids, and the development of a comprehensive conservation strategy for its species. As at Rigesa, the hybrids of *P. caribaea x P. tecunumanii* and *P. caribaea x P. oocarpa,* as well as the pure species *P. tecunumanii* continue to show excellent growth. The *P. taeda* GxE study demonstrates at an early age that the Argentinian sources have the highest growth rates (Alto Paraná ranked first and BDP ranked second). In 2012, Klabin is planning to establish the *Eucalyptus dorrigoensis* and temperate eucalypt species studies in Santa Catarina.

After working with Klabin, Jesús Espinoza traveled to **Suzano Pulp and Paper (SPP),** our new member in Brazil. The primary objective of the technical visit was to learn more about SPP to determine how Camcore can best help the company. Of key importance was to learn more about the eucalypt species and seed sources being used in Suzano's plantations and to offer some suggestions on what other species and sources they might try. Camcore will work with SPP to test a greater number of provenances of the main species as well as new species that could be very useful for its tree improvement program. One of the objectives of the breeding program in the company is to produce timber in accordance with the requirements of the mill while increasing pulp yield and reducing the quantities of chemicals used in the production of pulp and paper. In 2012, Camcore will be working with Suzano to develop new technologies to include wood property traits in the tree selection process.

Chile

Bill Dvorak visited **BioForest-Arauco** and **CMPC-Forestal Mininco**. Both companies are working diligently to establish a number of different Camcore eucalypt and pine trials. Visits were made at BioForest to see a 16-year-old *P. patula* trial and the recent hemlock *(Tsuga)* conservation planting. At CMPC-Forestal Mininco, field visits were made to see the recently planted eucalypt benchmark studies, as well as the older eucalypt trials at at Rucumanqui (formerly the location of the Shell project). There are species like *E. badjensis, E. smithii* and *E. benthamii* that show some potential as alternate species or possibly as parents in hybrid crosses.

Iván Appel of Arauco Bioforest with a 16-year-old *P. patula* in Chile.

Colombia

Jesús Espinoza visited **Smurfit Kappa Cartón de Colombia (SKCC)** in January. The company has transplanted the grafts for the *P. tecunumanii* and *P. maximinoi* indoor accelerated breeding orchards. This will help eliminate the problem of pollen contamination in the orchards as well as facilitate the pollination and collection of genetically improved seeds. Camcore is very pleased to see the improvements being made by SKCC in the rooting process of *P. maximinoi* by using air layering, after having struggled with low rooting percentage. SKCC began to make the first controlled crosses between mother trees of *Eucalyptus urophylla, E. grandis* and pollen from best selections of *E. pellita* from Refocosta. This is part of the Camcore project to produce eucalypt hybrids started this year by a group of participating members.

During the same trip to Colombia, Jesús visited our new member **Cementos Argos** to learn more about the status and future plans of their breeding and forestry programs. The company is developing its forestry project with teak *(Tectona grandis)* on the Atlantic Coast of Colombia. There

Jesús Espinoza of Camcore (center), and Fernando Fernández (left) and Alejandro Castaño (right) of Argos Cementos (Colombia) with an outstanding selection of teak.

are opportunities to improve the productivity and quality of plantations of this species through a comprehensive program of genetic improvement and intensive silvicultural management. In 2011, the company established the first two teak trials using seeds of different provenances from the seed exchange that Camcore is leading with members who plant teak commercially. We will work with Cementos Argos to develop their teak breeding program and to strengthen the company's forest plantation program.

East Africa

Gary Hodge visited **East Africa** at the end of March. The trip this year was in Kenya, and was attended by representatives of the Kenya Forest Research Institute (KEFRI) and the Tanzania Forest Research Institute (TAFORI). In addition, Flic Blakeway attended the trip as a representative of the Kalimo Trust. In 2011, KEFRI planted progeny tests of *P. maximinoi* and *P. tecunumanii* in the eastern highlands at Turbo, and a second-generation *P. caribaea* test on a low-elevation coastal site at Kwale. Cuttings of pine hybrids were sent from South Africa to Kenya, and two installations of the Camcore hybrid trial series were planted, one in the highlands, and one on the coast. We also visited sites along the coast to look at *Gmelina* and *E. grandis x E. camaldulensis* trials. Seed for the Camcore-CSIRO eucalypt species trials and the Camcore Tropical Benchmark trial was sent to East Africa in 2011, and we hope to have tests established in both Kenya and Tanzania in 2012.

Guatemala

Grupo DeGuate was visited by Juan López in June. This member, together with the National Institute of Forests of Guatemala (INAB), are part of a multidisciplinary group working on a FAO project entitled, "Country Report on the Situation of the Forest Genetic Resources". Juan gave a presentation to invited guests on the work done by Camcore during its 31 years in Guatemala and provided information on the status of pine genetic resources for this project. Grupo DeGuate is taking good care of the pine 2nd generation studies as well as the teak trials planted with seed given to INAB from Camcore.

Mexico

Juan López visited **Fomex** in the month of August. The Camcore *Eucalyptus pellita* trial visited is showing great potential at one year of age. The species is an interesting option as a parent in hybrid combination with *E. grandis, E. urophylla* and *E. urograndis*. Other species provided by Camcore, such as *E. dorrigoensis*, might be well suited for high altitudes in Mexico and other eucalypt species distributed might show promise for biomass production. More seeds of pines and *Gmelina arborea* will be sent to Fomex in 2012.

Camcore made its first technical visit to **Proteak** in 2011. The company is doing an impressive job in the establishment and maintenance of Teak plantings. Proteak is taking part in the teak seed exchange among Camcore members, broadening its genetic base through the establishment of progeny trials with families from different origins and landraces. Camcore is helping Proteak with the development of its teak breeding program, including the design and planting of clonal trials. A teak flowering induction study with hormones is being conducted at this time and results are expected in the near future.

Mozambique

In May, Jesús Espinoza visited the **Chikweti Forest** group. The company is following Camcore recommendations on species choice for the Lichinga area and is getting good results. The

Camcore 2nd generation *P. maximinoi* and *P. tecunumanii* material is doing well and will be much more productive than *P. elliottii* and *P. patula* if proper silviculture is used. The Camcore pine hybrids trials are also showing that these new genetic combinations could be very important to the company in the future, especially the hybrid *P. tecunumanii x P. caribaea.*

After the Chikweti Forest group visit, Jesús went on to **Florestas de Niassa** (FDN). As at Chikweti, the *P. maximinoi* and *P. tecunumanii* commercial material are doing well. The Camcore pine trials are also showing good growth and confirm the potential of these new species. We believe that these species and the new genetic combinations (hybrids) could be very important to the company in the future. In 2012, FDN will establish the first eucalypt trials as well as additional 2nd generation trials of *P. maximinoi* and *P. tecunumanii.*

South Africa

Gary Hodge visited South Africa in May, and spent time with **Komatiland Forests (KLF)**. KLF is making good progress on all phases of their pine improvement programs. Second-generation tests of *P. maximinoi, P. tecunumanii, and P. chiapensis* are now 3 years old, and growth measurements and Tree Sonic measurements to assess wood strength have been completed. Similar data is available for four family trials of the *P. patula x P. tecunumanii* hybrid. KLF also established a large clonally-replicated breeding seed orchard of *P. patula,* and has identified outstanding families of *P. elliottii x P. caribaea* hybrids.

On the same trip, Gary visited **York Timbers.** Since joining Camcore, York Timbers has worked hard to make contributions to the program, including establishing a Camcore Conservation Park with *P. oocarpa* and other species. Prior to joining Camcore, York did a great deal of hybrid crossing, and has some interesting crosses including *P. greggii* N x *P. maximinoi, P. greggii* S x *P. maximinoi,* and *P. greggii* S x *P. caribaea. Pinus chiapensis* is a white pine species that has very good potential as a solid timber species in the Sabie region of South Africa. In 2011 York and KLF collaborated on seed collections of *P. chiapensis* for additional second-generation progeny trials.

Lastly, on the visit in May, Gary visited **Sappi Forests.** The bulk of the visit was spent in Mpumlanga visiting Sappi's own *P. patula x P. tecunumanii* and *P. patula x P. oocarpa* family trials, Camcore hybrid trials, and discussing hybrid breeding strategy. In June 2010, this region experienced very severe freezes over a period of a number of days, and some interesting things were learned about the field frost tolerance of various hybrids. Sappi has adopted a strategy of planting unreplicated block plantings of *P. patula x P. tecunumanii* hybrids on commercial plantations. These plantings will eventually provide a useful database on the performance of the hybrid, and will be effective "advertising" among operational foresters and land managers. We also had good discussions about breeding strategies for hybrid eucalypts *(E. grandis x E. nitens,* and *E. grandis x E. urophylla).*

Vouranis Coetzee (KLF) next to a beautiful 3-year-old *P. patula x P. tecunumanii* hybrid in a trial at Spitskop, South Africa.

Gary Hodge made a second trip to South Africa in the last week of July and first week of August. On the visit to **Mondi Forests,** the bulk of the time was spent reviewing Mondi's internal breeding programs for pines and tropical and cold-tolerant eucalypts. In 2011, Mondi completed a large expansion of their research nursery, which is already yielding improvements in rooting success for the cold-tolerant eucalypts, and will also be very useful as Mondi looks to expand its testing program for pine hybrid families. The workplan for 2011-2012 calls for 9 to 20 full-sib families of 6 to 10 different hybrid combinations such as *P. patula x P. tecunumani, P. patula x P. greggii*, and *P. taeda x P. greggii*. Mondi has built capacity to do NIR screening of wood samples in support of the breeding programs, and has several thousand wood samples in the field awaiting laboratory work and NIR scanning.

Gary then visited **MTO Forestry**, where the topics of discussion included the *P. radiata* breeding strategy for the company, optimum age of selection in progeny trials, and alternative species resistant to *Fusarium.* In response to the *Fusarium* problem in the nursery at Karatara, MTO completely re-worked their water supply to avoid using *Fusarium*-contaminated water drawn from the stream passing through nearby commercial plantations of *P. radiata.* Second-generation *P. tecunumanii* and *P. maximinoi* also continue to grow well on MTO sites in the western Cape, as does the Marion County, Florida source of *P. taeda.*

Finally, Gary visited with **PG Bison (PGB)** in the western Cape. PGB has made great progress in the past two years, establishing large numbers of species trials and genetic trials in both the eastern and western Cape. On this visit, we saw a number of one-year-old trials, including species-site trials, *P. maximinoi* and *P. tecunumanii* progeny trials and hybrid trials. On some sites, there were problems with survival of *P. radiata*, the commercial species, which may have been *Fusarium* and/or drought related. These tests will be of great value in the next few years to evaluate if alternative species or hybrids can demonstrate better survival and/or growth, and therefore offer an opportunity to add diversity and reduce risk in the region.

Bill Dvorak visited **Merensky** in the Weza area in October. One of the main objectives of the visit was to meet some of the new people at the company and explain the Camcore program to them. The 2nd generation Camcore trials of *P. maximinoi* and *P. tecunumanii* at Weza are growing well as is the pine hybrid trial. Merensky is experimenting with air-layering of *P. maximinoi* on 4-year-old trees. Some of the pine hybrids are also showing promise in the Camcore trials

Julian Chan of PG Bison in a one-year-old progeny test *P. maximinoi* in the western Cape region of South Africa.

United States

MeadWestvaco, one of our associate members, actively participated in one of the Camcore eucalypt projects in 2011. The company supplied *Eucalyptus dorrigoensis* wood from South Carolina, USA for the study of combustion properties of different eucalypts for pellet production. The results of this study are presented in the species characterization section.

Uruguay

In March, Gary Hodge visited **Montes del Plata (MDP).** MDP had very good germination for the Camcore Eucalypt Species / Provenance trials, and South African Benchmark temperate eucalypt trial series, and succesully established all of these tests a few weeks after the visit. MDP also planted two Camcore progeny tests of families of *E. dorrigoensis.* This species has the potential to be very valuable for MDP. Field visits were made to a *E. dunnii* progeny test, and a one-year-old clonal hybrid trial. In the clonal hybrid trial, the commercial *E. dunnii* looked quite good, setting a rather high bar that commercial clones must surpass. By eye, some of the most impressive clones in the trial were *E. urophylla x E. maidenii.*

Gary then visited with **Weyerhaeuser,** who was germinating eucalypt seeds for the same series of eucalypt trials as was MDP (species/provenance, benchmark, and *E. dorrigoensis)*. The goal was to plant one set of trials in the north near Tacuarembo and another set in the east near Cerro Largo, and to plant in both the spring and autumn. In addition, we visited newly planted second-generation progeny tests of *P. greggii* and *P. maximinoi* in the east in the department of Cerro Largo.

In addition to the normal Camcore visit by Gary, Robert Jetton also visited Weyerhaeuser in March to work on the development of a comprehensive Forest Health Plan for the company. The visit involved field tours to observe some of the forest insect and disease problems affecting Weyerhaeuser lands in Uruguay, and a discussion of some possible research projects related to forest insect management.

Venezuela

Juan López and Jesús Espinoza visited **Smurfit Kappa Cartón de Venezuela (SKCV)** in March. They indicated a need to advance quickly with the *Eucalyptus urophylla* breeding program. To facilitate this, the SKCV research team sent measurements of their *E. urophylla* provenance/progeny trials to Camcore, and 122 trees were selected based on volume and stem quality. Camcore will continue to help SKCV with the breeding strategy of this species by providing test designs for the establishment of clonal trials on different sites, guidance in making controlled crosses in a breeding orchard, collaboration in developing hybrids with species like *E. grandis* and *E. pellita*, and analysis of wood properties.

Luciana Ingaramo and Jorge Martinez Haedo of Weyerhaeuser (Uruguay) identify damage by leaf cutter ants on a young *P. taeda*.

The PROFORCA *P. caribaea* seed orchard at Santa Cruz de Bucaral in Venezuela. From left to right, Williams Vera (PROFORCA), Juan Luis López (Camcore), Martin Gutiérrez and Jairo Morales (PROFORCA).

Jesús and Juan also visited **Terranova (Masisa),** where they made recommendations to further develop the *Pinus caribaea* tree breeding program. As part of the strategy, Terranova plans to plant additional 2nd generation progeny trials, refine the protocols for rooted cuttings in the nursery, and initiate work on top grafting. New *P. caribaea* seedlots were sent to Terranova this year to broaden the genetic base. Camcore will also help with early selections in these trials to reduce the time needed to complete the breeding cycle.

In our visit to **Proforca** we had the opportunity to talk with the new president, Mr. César Briceño, in the exit meeting at Puerto Ordaz. He mentioned the importance of Camcore to Proforca and the company's interest in providing all the support that is needed to develop collaborative projects that will make it a sustainable enterprise. Camcore is helping Proforca to develop its tree breeding program and is conducting data analysis on progeny trials to assist in the genetic rogueing of the *P. caribaea* seed orchard at Santa Cruz de Bucaral. The ranking of the families will allow Proforca to eliminate the clones with low breeding values. Proforca will start making controlled crosses among the best trees in the best families in the seed orchard for production of full-sib families. Camcore is also providing seeds of *Eucalyptus urophylla* to Proforca to establish provenance/progeny trials.

Genetic Analyses of Four Camcore Pine Species

In 2011, Camcore completed new multiple-site BLUP analyses of four of its major pine species: *P. tecunumanii* (high-elevation (HE) and low-elevation (LE)), *P. maximinoi, P. patula,* and *P. greggii* (var. *greggii* and var. *australis*). As part of that analysis, all genetic parameters for these four species were recalculated using ASREML. The results of those analyses are summarized here, and a full manuscript with detailed results will be published this year in the journal *Southern Forests*.

Materials and Methods

For all species, seed collections were made by mother tree and provenance covering essentially the entire species range. Seeds were distributed to Camcore members in Argentina, Brazil, Chile, Colombia, Venezuela, and South Africa, and were used to establish provenance/progeny tests.

Provenance/progeny tests generally contained a subset of 4 to 7 provenances and/or sources, with each provenance being represented by 8 to 15 families. Trial design was a randomized complete block, typically 9 replications and 6 trees per family planted in row plots. Spacing was approximately 3 x 3 m in all tests. Test measurements were scheduled at ages 3, 5, and 8 years. Measurements were not available at all ages for all tests. Growth traits height in meters and DBH in centimeters were taken and a volume index was calculated as follows:

$$Volume = 0.00003\ (DBH^2 * height)$$

Measurements were available for a total of 133 provenance/progeny tests of *P. tecunumanii*, 43 tests of *P. maximinoi*, 83 tests of *P. patula*, and 62 tests of *P. greggii.* Many tests included the primary commercial pine species of the country (e.g., *P. taeda* in Brazil, *P. patula* in Colombia and South Africa, and *P. radiata* in Chile). Single-site analyses were done initially, followed by multiple-site analyses of a species in a country, and then by multiple-site, multiple-country analyses of a species.

Growth Results

Pinus maximinoi and *P. tecunumanii*, the two more tropical species from this set of four, showed the fastest growth rates, and these species grew best in Colombia, followed by Brazil and South Africa (Table 1). *P. patula* and *P. greggii*, which are found higher-elevation and/or colder climates, had slower growth rates. Perhaps more importantly than the raw growth rates, however, was the superiority demonstrated by these unimproved populations over the improved commercial species of the regions (Table 1).

In Brazil, *P. maximinoi* showed the highest gain potential, with nearly 130% volume gain over *P. taeda* at age 8 years. LE *P. tecunumanii* had nearly 80% gain, and HE *P. tecunumanii* had 15.8% gain over *P. taeda* at eight years.

In Colombia, eight-year volume gains over improved *P. patula* were 32.7% for HE *P. tecunumanii,* 21.3% for LE *P. tecunumanii*, and 38.6% for *P. maximinoi.*

In South Africa, the comparison of *P. patula* with unimproved *P. tecunumanii* and *P. maximinoi* showed similar results. HE *P. tecunumanii* had 16.8% advantage in volume compared to improved *P. patula* at eight years, LE *P. tecunumanii* had 25.9% advantage in volume, and *P. maximinoi* had 42.2% volume advantage.

In South Africa, *P. greggii* var. *greggii* had less than half the volume of *P. patula* at eight years; however, unimproved *P. greggii* var. *australis* demonstrated much more potential as a commercial species. At eight years, *P. greggii* var. *australis* averaged about 17.5% less volume growth than improved *P. patula.*

Finally, in Chile, the commercial species *P. radiata* demonstrated substantial growth superiority over both *P. greggii* and *P. patula,* which had 70% to 84% less volume than *P. radiata* at eight years. The more tropical species, *P. tecunumanii* and *P. maximinoi,* were not tested in progeny trials in Chile, as they were not expected to have sufficient cold and frost tolerance to survive.

Genetic Parameters

One of the remarkable results of this study was the similarity of the genetic parameter estimates for the four different species. Despite differences in growth rates and geographic region, heritability, GxE interaction (i.e., Type B genetic correlation), and age-age genetic correlations were almost identical. Table 2 presents the average genetic parameters across all species and all countries for 3-, 5-, and 8-year volume growth. These could serve as a standard set of genetic parameter estimates for these species (and perhaps many others as well) for simulation studies or BLUP analyses. An important result was the the high age 5 - age 8 genetic correlation, on the order of rg = 0.96. Given the similar heritability, amount of GxE interaction, and levels of addtivie variance, this implies that selection at five years, or perhaps four years, would make nearly as much genetic gain as selection at age eight years, and would be optimal in terms of genetic gain per unit time.

Provenance variation was important for all species, with the difference between the best and worst provenance on the order of 30% to 40% (i.e., a range of ± 15% to ±20%) for *P. tecunumanii, P. patula,* and *P. greggii.* There was less provenance variation for *P. maximinoi*, with the difference between the best and worst provenance on the order of 20% (i.e., a range of ± 10%). New provenance BLUPs and family genetic value predictions are available from Camcore, and will be distributed on the Camcore Data CD.

Summary and Conclusions

These four pine species clearly have commercial potential in many regions around the world, and breeders should invest effort and money into improving the populations. Large genetic gains both at the provenance level and additive genetic level are possible.

Table 1. Performance of unimproved Camcore pine species in different regions. Mean survival, height, DBH, and tree volume at age 8 years, plus percent gain (Gain %) above or below primary commercial species (*P. taeda* in Brazil, *P. patula* in Colmbia and South Africa, *P. radiata* in Chile).

Country	Tests	Surv (%)	Height (m)	DBH (cm)	Volume (m^3)	Gain % Height	Gain % DBH	Gain % Volume
P. tecunumanii **(high elevation)**								
Brazil	13	87.2	14.8	18.6	0.1769	+ 10.3	- 0.6	+ 15.8
Colombia	19	85.1	14.9	21.2	0.2235	+ 4.3	+ 6.9	+ 32.7
South Africa	28	73.3	13.4	18.5	0.1496	+ 1.2	+ 7.1	+ 16.8
P. tecunumanii **(low elevation)**								
Brazil	14	87.7	15.1	18.6	0.1823	+ 21.0	+ 18.4	+ 79.9
Colombia	15	79.3	15.7	19.9	0.2080	+ 5.8	+ 3.1	+ 21.3
South Africa	14	79.4	13.0	17.8	0.1354	+ 4.4	+ 6.1	+ 25.9
P. maximinoi								
Brazil	7	67.2	15.7	19.6	0.2246	+ 24.8	+ 27.0	+ 129.5
Colombia	10	82.6	17.4	21.4	0.2668	+ 8.0	+ 12.7	+ 38.6
South Africa	15	68.9	13.7	18.3	0.1543	+ 7.5	+ 12.2	+ 42.2
P. patula								
Brazil	24	86.1	10.9	17.5	0.1175	- 10.3	- 19.4	- 35.6
Colombia	13	83.0	12.3	18.8	0.1533	- 7.5	- 4.7	- 9.7
South Africa	38	79.9	11.9	18.0	0.1269	- 3.1	- 3.1	- 8.6
P. greggii **var.** ***greggii***								
South Africa	21	82.3	8.4	14.4	0.0582	- 31.7	- 29.9	- 63.8
Chile	5	81.7	6.6	10.2	0.0271	- 35.6	- 42.5	- 75.4
P. greggii **var.** ***australis***								
Brazil	14	86.4	11.9	18.9	0.1490	- 4.3	- 17.7	- 29.4
South Africa	16	84.0	11.0	17.5	0.1118	- 6.4	- 6.9	- 17.5
Chile	5	77.5	7.9	12.3	0.0469	- 31.9	- 37.1	- 70.1

Table 2. Average genetic parameters for subtropical pine volume growth at 3, 5, and 8 years of age. Values represent averages across four species and 321 provenance/progeny tests in Brazil, Chile, Colombia, and South Africa.

Trait	Age-Age Correlations			P^2	r_{Bprov}	h^2	r_{Bg}	GCV	Vphen
	with Vol3	*with Vol5*	*with Vol8*						
vol3		0.92	0.80	0.06	0.71	0.13	0.65	21.2	3655.5
vol5	0.93		0.96	0.05	0.74	0.14	0.66	18.7	2584.8
vol8	0.83	0.94		0.04	0.72	0.15	0.71	19.0	2438.4

Second-Generation Progeny Testing

Camcore members have made great progress in establishing second-generation pine progeny tests, and we continue to see very good growth in southern Africa, southern Latin America, and Colombia. There are currently 86 second-generation tests of seven important pine species that were planted between 2004 and 2011 (Table 3). A large subset of these tests (36) were planted between 2005 and 2009, so in 2012 there will be three-year or five-year measurements available from these tests. The genetic parameter analyses completed in 2011 (see previous article) confirm that young data are well correlated with older results, so Camcore members can make early selections with confidence that good genotypes will be identified. Early selections can be grafted into clone banks or top-grafted into seed orchards, and by the time the grafts begin to produce pollen or flowers for breeding, those early selections can be confirmed with later data.

Table 3. Second-generation progeny tests of pine species planted by Camcore members as of 2011.

Species	2nd Gen Tests
P. caribaea	6
P. chiapensis	6
P. elliottii	4
P. greggii	6
P. maximinoi	25
P. patula	14
P. tecunumanii	25
Total	86

In this generation, we also have the opportunity to make genetic gains in wood properties. We have very good NIR models to predict cellulose and lignin content, and acoustic tools can be used to select for wood and fiber strength. Although some members have assessed wood properties in their own Camcore trials, this has not been a prescribed component of Camcore test measurement guidelines. With the increasing importance of wood properties in the globally marketplace, this should be a point of discussion for Camcore members in 2012.

Phillip Hongwane (KLF) with an excellent 3-year-old *P. chiapensis* at Brooklands, Mpumalanga, South Africa.

Progress in Pine Hybrid Testing

Seventeen new pine hybrid trials were planted in 2011, bringing the total to 62 pine hybrid trials that have been planted by the Camcore members from 2007 to 2011 (Table 4). This is a tremendous accomplishment, and in coming years we will be able to identify hybrids with good commercial potential in different regions of the world.

Measurements at 3 years of age of some of the first hybrid trials planted in 2007 have been analyzed by Camcore staff. Even though these are early results, it is interesting to note some of the early trends in hybrid performance. At high elevations in Colombia, *P. patula* has always been the species with the best productivity. However, hybrids derived from crosses of *P. patula* with *P. tecunumanii, P. pringlei* and *P. elliottii* exhibited better volume performance than the genetically improved pure species (Figure 1) In Paraná, Brazil, where *P. taeda* is the primary commercial species, *P. elliottii x P. caribaea* had the best growth in the trial, and *P. patula x P. elliottii* exhibited better early growth than a 2nd generation family mix of *P. taeda.* Only the trees of a superior full-sib family (TAEDA PSC) were superior to the *P. patula x P. elliottii* hybrid (Figure 2).

Some members with provenance/progeny trials of *P. leiophylla, P. pringlei, P. jaliscana* and *P. herrerae* made pollen collections in 2011 for hybrid crosses to be made in 2012. The Camcore team in Guatemala also made pollen collections of *P. tecunumanii* and *P. oocarpa* in natural stands for additional hybrid crosses. Several members continued to make hybrid crosses with *P. radiata, P.*

Table 4. Pine hybrid trials planted by Camcore members in 2011, and in total from 2007 to 2011

Region	Member	2011	Total
Argentina	BDP	1	4
	APSA	0	5
Brazil	Klabin	1	4
	Rigesa	0	4
Colombia	SKCC	1	6
South Africa	Merensky	1	4
	KLF	1	7
	Mondi	1	4
	MTO	1	4
	PG Bison	1	4
	Sappi	0	3
	York Timber	5	7
Kenya	East Africa	3	3
Zimbabwe	Border Timbers	0	1
Mozambique	Chikweti	0	1
	Flor. Niassa	1	1
TOTAL		**17**	**62**

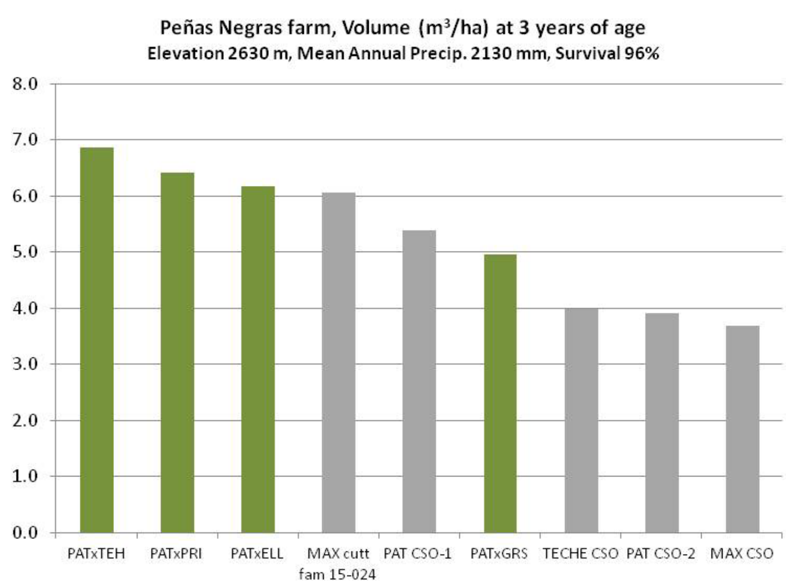


Figure 1. Volume growth in the Camcore-SKCC pine hybrid trial at Peñas Negras farm in Colombia, where *P. patula* (PAT) is the primary commercial species. .

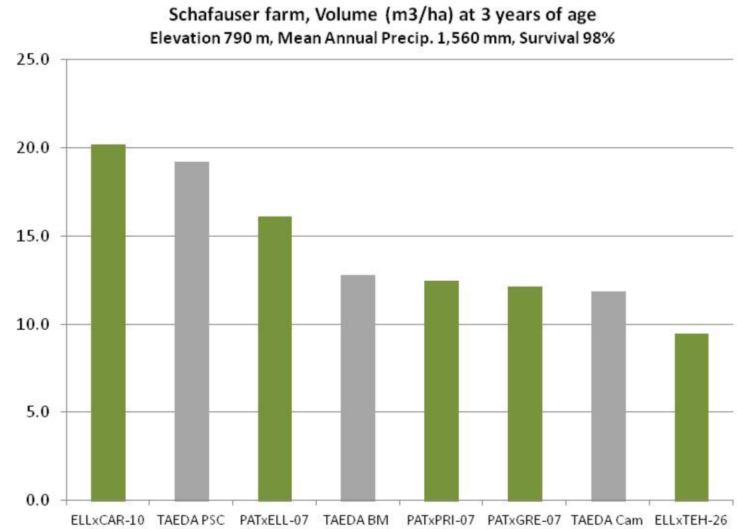


Figure 2. Volume growth in the Camcore-Rigesa pine hybrid trial at Schafauser farm in Paraná state, Brazil, where *P. taeda* (TAEDA) is the primary commercial species.

taeda and *P. maximinoi* parents as planned. Some of the crosses with *P. radiata* and *P. maximinoi* were confirmed as true hybrids by SNP markers; which opens a wide range of possibilities for many regions in plantation forestry.

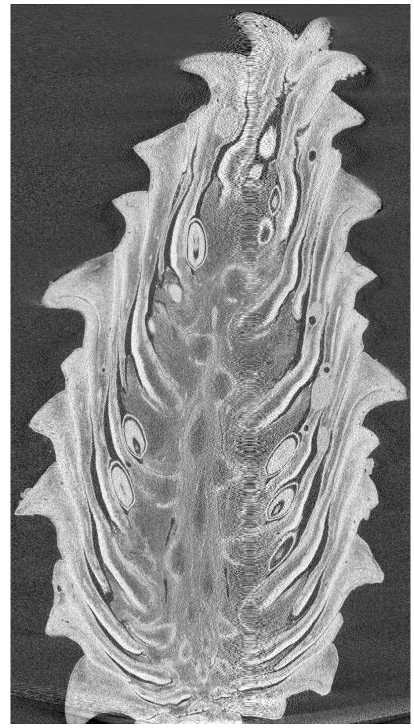
Additional hybrid seedlots of *P. greggii, P. patula* and *P. taeda* as mother trees were shipped to Camcore. DNA from seedlings of these crosses will be tested with SNP markers to verify that they are true hybrids. Previously verified hybrid seeds were sent to the regional coordinators in a third series of hybrid distributions. These will be converted into hedges for production and establishment of more field trials with rooted cuttings.

Many thanks to all members for their contributions in crossing and test establishment. We are sure that all of your hard work will generate a very rewarding payback.

Pine Hybrid Wood Quality

Juan López at Camcore continued his research on “The economics of pine hybrids with respect to pure species” in 2011. The three hybrid crosses used for the study are *P. taeda x P. tecunumanii* and *P. greggii x P. tecunumanii* from a 13-year-old trial at Mondi and a *P. patula x P. tecunumanii* hybrid in a 12-year-old trial at Sappi in South Africa. Verification of true hybridity was conducted using SNPs markers. DNA was extracted from the pine needle samples of the hybrids at the University of Pretoria and sent to Camcore in Raleigh for SNP analysis. Most of the trees sampled in the trials were confirmed as true hybrids. Measurement data of tree growth in the research trials were sent by Mondi and Sappi to Camcore for analysis. In all cases, the mean annual increment of the pine hybrids was greater than the mean annual increment of the pure species. Wood samples (cores and wedges) of the pure species and the hybrids were shipped to Camcore for chemical analyses and density measurement. A detailed analysis of chemical composition of wood was done and lignin, cellulose and hemicellulose contents were determined. Lignin and cellulose content in the hybrids is intermediate between the values for pure species in many cases and inferior in others. When pulp yield is measured in 2012, correlations with chemical composition will be determined. The wood density of the hybrids was similar to that of the pure species in all cases, with a slightly higher value for *P. taeda x P. tecunumanii* and *P. greggii x P. tecunumanii* and a slightly lower value for *P. patula x P. tecunumanii.* Ring analysis will be conducted in 2012 to explore variation of wood density from pith to bark for all the species. Fiber analyses will also be done after cooking the chips to measure fiber length, cell wall thickness, coarseness and other important properties affecting the pulp quality. The study on economic analyses should be finished in 2012 and informative publications will be produced for the benefit of Camcore members.

How can we more successfully hybridize *Pinus radiata* with other species?



Hannél Ham, instructor and Ph. D. candidate in the Department of Forest and Wood Science, Stellenbosch University, is studying the reproductive biology of *Pinus radiata,* and is partially supported by the Camcore membership. Hannel expresses thanks to all partners involved in the project, and writes the following summary.

Pinus radiata is an important plantation forest species with excellent wood properties, but is very susceptible to *Fusarium circinatum* (Pitch canker). Forestry companies worldwide have tried to artificially hybridize *P. radiata* with other *Pinus* species that have moderate to good tolerance to *F. circinatum* and to extend the geographic planting range of a "radiata type", but there appear to be reproductive barriers in *P. radiata* that hamper the production of viable seeds in a hybrid cross. Hannel's Ph. D. research project focuses on identifying and understand ing these reproductive barriers.

Seven pine species *(P. radiata, P. pringlei, P. oocarpa, P. tecunumanii* (low elevation), *P. maximinoi, P. taeda* and *P. elliottii*) form part of this study. A preliminary literature review was conducted and a questionnaire was sent to twelve pine breeding programs to obtain background information on the status of pine breeding in South Africa, Chile, Argentina and Colombia. Pollen and female flowers (before pollination) of *P. radiata* were collected in South Africa for microscopy studies and Computed Tomography scanning at Stellenbosch University (an example of a CT scan of conelet to the right). A subsequent pilot study was conducted by examining a female flower with a CT scanner just before and shortly after pollination to evaluate fertilization success.

Data loggers were placed in pollination bags in a pine seed orchard at different positions in the trees. Hourly measurements were taken of relative humidity, temperature and dew point over a period of eight weeks. From these results, it is clear that the temperatures in the bags are the highest between 8:30 am and 18:30 pm, and future studies will determine if spikes in temperatures in the bag are affecting pollen viability. More detailed studies are planned on the pollen and female flower morphology and the effect of temperature on fertilization in 2012.

Pinus elliottii Bench mark studies

In last year's Camcore annual report, we mentioned that our members in southern Africa had initiated a bench mark study with improved *P. elliottii.* The goal is to compare the growth and productivity of improved *P. elliottii* from Argentina, Australia, Zimbabwe, and the United States against locally improved selections of the species in Southern Africa. Germination of the family seed lots sown in southern Africa, by country, were as follows: Argentina 42%, Australia (bulk lot only) 78%, southern USA 79% and Zimbabwe 75%. It appears that Camcore members will collectively establish between 12 and 14 progeny trials across a number of sites that stretch from the highlands of northern Mozambique to the Cape of South Africa. The first group of trials were established in the field in late 2011 and the remainder will be planted in early 2012.

Eucalyptus dorriogoensis Provenance/Progeny Trials

A joint project with CSIRO began in 2010 with nine participating Camcore companies. Camcore collaborated with CSIRO Australia to obtain 40 open-pollinated families of *E. dorrigoensis* from four provenances with the objective of expanding the genetic base of this important species, especially for members in Chile, southern Brazil, Uruguay and South Africa. The test establishment status through 2011 is summarized in the table below.

E. dorriogoensis (6 provenances, 38 families)		
Company	**Country**	**Num. Trials**
Montes del Plata	Uruguay	3
Fomex	Mexico	1
Arauco	Chile	3
CMPC	Chile	2
Mondi	South Africa	2
Weyerhaeuser	Uruguay	2
TOTAL		**13**

Eucalyptus dorrigoensis seedlings being packed for progeny test establishment in the field by Montes del Plata, Uruguay.

Eucalyptus Species / Provenance Trials

As was reported in the 2010 Annual Report, Camcore is working on a joint project with CSIRO Australia to study several "obscure" eucalypt species with the focus on trying to identify species with cold hardiness and drought resistance. This is just one of several eucalypt projects that Camcore is developing for its members. Camcore will keep working to advance the eucalypt program by making new collections of major commercial species from natural forests, and introducing new species, provenances and families to satisfy the needs of the members. To the right is a table showing the number of eucalypt species / provenance trials established in 2011.

Temperate Series (10 species)		
Company	**Country**	**Num. Trials**
Bosques del Plata	Argentina	1
Arauco	Chile	3
CMPC	Chile	2
Mondi	South Africa	3
Klabin	Brazil	1
Montes del Plata	Uruguay	3
Weyerhaeuser	Uruguay	2
TOTAL		**15**
Subtropical Series (11 species)		
Company	**Country**	**Num. Trials**
Klabin	Brazil	1
Arauco	Chile	3
CMPC	Chile	2
Merensky	South Africa	2
Montes del Plata	Uruguay	2
Weyerhaeuser	Uruguay	2
TOTAL		**12**

Alex Medina of CMPC Forestal (Chile) with a seedling of E. dorrigoensis for a new series of Camcore provenance/progeny tests of the species.

Juan Schapovaloff of Alto Paraná (Argentina) with a beautiful 2-year-old 2nd generation *P. tecunumanii.*

Eloy Sanchez of Proteak (Mexico) with a 16-year-old selection of teak. Camcore members who grow teak are exchanging genetic material, and will be collaborating in a series of genetic trials.

Hybrid seedlings of *E. urophylla x E.pellita* produced by Smurfit Kappa Cartón de Colombia and Refocosta as part of the Camcore Eucalyptus hybrid project.

Second-generation P. *tecunumanii* seedlings being grown at a KEFRI nursery in Kenya.

Yasmin Hage of Grupo DeGuate stands in front of a 9-month-old progeny trial of teak in Escuintla, Guatemala.

Jesús Espinosa (Camcore) talks with Nora Barrios and Alba Rosales of Terranova on a visit to a typical *P. caribaea* planting site in eastern Venezuela.

Elizabeth Rojas of Smurfit Kappa Cartón de Colombia checks for flower production on a *P. maximinoi* in the company's indoor pine breeding faciltiy.

Irene Barnes and Jeff Garnas of FABI taking samples of *Dendroctonus* and *Ips* beetles in a *P. hartwegii* natural stand in Quetzaltenango, Guatemala.

Left to right: Valter Roberto Colombo, Izabel Christina Gava de Souza, João Flávio da Silva, Raimundo Nonato Medeiros and Helcio Gomes Coura of Suzano visit a 5 year-old *E. grandis x E. urophylla* clonal trial at Angatuba, SP, Brazil.

André Nel of Sappi (South Africa) in a trial of full-sib families of *P. patula x P. tecunumanii.* Field results and artificial lab freezing tests have identifed this particular cross as being very frost susceptible (see related article in this Annual Report).

Eucalyptus Benchmark and Drought Hardy Trials

In the 2010 Annual Report, we reported that Camcore had begun a series of trials using subtropical and temperate species from South Africa as part of the effort to expand our work with eucalypts and to develop cooperative projects that would benefit our members. The idea behind this series was to compare an array of commercial seedlots with local material. Improved material of *Eucalyptus nitens, E. smithii, E. macarthurii, E. dunnii,* and *E. benthamii* from Sappi and *E. saligna* from Merensky are being used in this series of trials that 14 members are establishing. The status of this project is shown in Table 5.

We have now begun a similar series of benchmark trials using tropical species of eucalypts. Seedlots of nine species from 14 sources in eight countries have been contributed to the study (Table 6), and the seed is now being distributed. We currently have plans for 34 trials of this series, and anticipate that most of the trials will be planted in 2012.

In addition to these benchmark trial series, in 2011 Camcore initiated efforts to establish a series of trials directed at testing "obscure" drought-hardy species. The tests would be planted by members with sites subject to long dry seasons and/or droughts. The species that will be included in these tests will be *E. cladocalyx, E. grisea, E. longirostrata, E. major, E. propinqua,* and *E. punctata,* and we hope to be able to evaluate their potential to withstand long dry periods. In 2011, Camcore began to distribute seed and we expect around 16 different members to establish several trials in 2012.

Table 5. Temperate-Subtropical eucalytus benchmark trials established by Camcore members.

Temperate-Subtropical Benchmark (6 species)		
Company	**Country**	**Num. Trials**
Alto Paraná	Argentina	2
Bosques del Plata	Argentina	1
Arauco	Chile	3
CMPC	Chile	4
Fomex	Mexico	1
Mondi	South Africa	2
Montes del Plata	Uruguay	2
Weyerhaeuser	Uruguay	3
TOTAL		**18**

Table 6. Species and sources to be included in the Tropical eucalyptus benchmark trial series.

Tropical Benchmark (8 species)		
Species	**Country**	**Source**
E. longirostrata	South Africa	Sappi
Corymbia henryi	South Africa	Mondi
E. brassiana	Indonesia	Sumalindo
E. camaldulensis	East Africa	East Africa
E. grandis	Brazil	IPEF
E. grandis	Colombia	SKCC
E. grandis	East Africa	East Africa
E. grandis	Mozambique	Chikweti
E. grandis	South Africa	Merensky
E. pellita	Colombia	Refocosta
E. pellita	South Africa	Sappi
E. urophylla	Brazil	IPEF
E. urophylla	Colombia	SKCC
E. urophylla	Venezuela	SKCV
E. urophylla x E. grandis	Venezuela	SKCV
E. urophylla x E. grandis	Brazil	IPEF
E. grandis x E. camaldulensis	Brazil	IPEF

Bob Purnell and Paola Molina of Weyerhaeuser, Uruguay (left, right) and Gary Hodge of Camcore (center) discuss germination of eucalypt seed for the Temperate-Subtropical Benchmark trials.

Cooperative Eucalypt Hybrid Breeding

Over the past decade, more and more forestry organizations around the world have increased their emphasis on eucalypts. In order to better serve the needs of our members, Camcore has developed a number of projects to provide new species and provenances of eucalypts, or broaden genetic bases of important commercial species.

In 2010, we began to discuss a cooperative Eucalypt Hybrid Breeding Project to further support the efforts of our eucalypt-growing members. In 2011, we finalized a work plan, and began collecting pollen for this project. The objective of this project is to produce full-sib families of a wide array of eucalypt hybrids, sharing the workload and the genetic material. A total of 14 Camcore member companies have agreed to participate: Arauco Bioforest, CMPC Forestal Mininco, FOMEX, Montes del Plata, Merensky, Mondi, Pizano, Rigesa, Sappi, Smurfit Kappa Cartón de Colombia, Smurfit Kappa Cartón de Venezuela, Suzano, Weyerhaeuser, and York.

Species involved in the crossing represent tropical, subtropical, temperate, and cold-tolerant species, and globally important species such as *E. grandis, E. urophylla, E. dunnii, E. globulus,* and *E. nitens* are prominent in the work plan (Table 7). Thus, we hope to produce some hybrids that will be of interest to every participant, regardless of geographic region or climate. We hope that each participant will end up with 20 full-sib families of four to six different hybrids that can go into field tests. For hybrids which show commercial potential, the best clones and families from this project can serve as the initial population of a plantation and breeding program.

Most of the pollen collection and crossing will be done in 2012 and 2013, but some work has already begun, and seed from *E. pellita x E.grandis, E. pellita x E. urohylla,* and *E. grandis x E. urophylla* is already in hand.

Our plans are that this will be only the first phase of hybrid eucalypt breeding. Several organizations are just beginning to develop their own eucalypt genetic resources, and along with the Camcore eucalypt material at species, provenance, and family levels, will be ready to make hybrids in a few years time. A second phase of hybrid breeding with new combinations or the best previous combinations is anticipated. Camcore has had great success with its Pine Hybrid Program, and we hope that the Eucalypt Hybrid Program will be successful also.

Table 7. Planned crosses for the Camcore Eucalypt Hybrid Breeding Project.

Female	Male
grandis	*dunnii*
dunnii	*benthamii*
grandis	*pellita*
grandis	*tereticornis*
grandis	*saligna*
grandis	*nitens*
grandis	*benthamii*
grandis	*globulus*
grandis	*smithii*
grandis	*pellita*
urophylla	*longiostrata*
urophylla	*maidenii / globulus*
globulus	*camaldulensis*
globulus	*urophylla*
nitens	*pellita*

The Sappi Forests research team in a *E. grandis x E. nitens* hybrid trial in Mpumalanga, South Africa.

Teak and Gmelina Update

As mentioned earlier in the report, Proteak (Mexico) became a new member of Camcore in 2011. Proteak will now take part in the seed exchange with other Camcore members. The company will contribute seeds from eight different provenances of teak from India as well as provide seeds of 20 selected trees from its plantations in Mexico. The research team is doing the paperwork necessary to ship the seeds to Camcore in Raleigh. Once we receive these seeds, we will assemble a new series of progeny trials to distribute among members in 2012. It will include seeds of 36 families sent to Camcore from the University of Chittagong in Bangladesh. Thanks to Dr. Mohammed Kamal Hossain who facilitated this genetic material from two seed orchards established and managed by the Bangladesh Forest Research Institute. Other seeds to be included in this set of trials will be those provided by Proteak as well as seeds received from Cementos Argos S.A. (Colombia) in 2011. Some of the families previously distributed in the first series of trials will be included in this second distribution to link trials across locations and years and facilitate the development of a single ranking of all the families in the various tests. The genetic base being compiled in the Camcore progeny tests is becoming very broad, increasing the probability of greater genetic diversity and better genetic gains. Camcore is currently looking for additional provenances and families in India, Malaysia, Thailand and other countries.

In 2011, three new teak progeny tests were planted by Camcore members, two trials by Cementos Argos S.A. (Colombia) and one test by East Africa. The total number of progeny trials planted so far is eight. Initially, Grupo DeGuate in Guatemala had planted 3 trials and Chikweti in Mozambique 2 trials.

In July 2011, Camcore and Proteak established a trial to test flower induction through the use of hormones in Nayarit, Mexico. Paclobutrazol was applied in the month of July and a second application will be done in January 2012. The purpose of the study is to learn more about the response of teak flowering to different doses of paclobutrazol in two different applications. Measurements of flowering and fruiting will be conducted for two years. The initial measurement of flowering was done in September 2011 and every 15 days thereafter until November when the flowering declined. Measurements of phenology will continue to be done every month, starting in January 2012.

Because of the high value of teak wood and the price variation due to the heartwood proportion, a study will be conducted to develop a non-destructive method to estimate heartwood/sapwood ratio at different ages in 2012. The results of the study might be used to practice early selections in genetic trials, including wood quality as selection criteria.

Progress on the teak genetic diversity study conducted at the University of Copenhagen in Denmark, to which Camcore members contributed with seeds from Colombia, Guatemala, Indonesia, Mozambique and Venezuela, has been behind schedule. Definite results of the study should be available for 2012.

Seeds of *Gmelina arborea* and *Pachira quinata* were collected and sent to Camcore by Pizano in 2011. These seeds will be forwarded to Fomex and Proteak for the establishment of second-generation progeny trials.

A first issue of the Camcore Teak and Gmelina Newsletter in English and Spanish was sent to members and other interested parties in the forestry sector in 2011. The Newsletter was well received by the public and two more issues will be written in 2012, one in February and another in August.

A financial model was developed in Camcore to estimate profitability of a Teak tree breeding program for member companies or potential new members in the program. Currently, the model defines minimum planting area per annum to justify a genetic improvement program with Camcore membership. The model is being refined to provide information on additional issues such as potential economic losses caused by delays in tree breeding programs for one or more years. The model is flexible and customizable, easily adjustable to the specific needs of the members.

2011 Seed Collections in Central America

As part of the Camcore tree breeding and conservation plan, we continue to make seed collections in natural stands of pine in Central America. During 2011, cones of *P. tecunumanii, P. maximinoi* and *P. caribaea* were collected in two populations in Guatemala and three populations in Honduras (Table 8). The cones were collected with the assistance of The National Institute of Forests (INAB) in Guatemala and The National School of Forestry Sciences (ESNACIFOR) in Honduras, which we greatly appreciate.

In our collection work, the Camcore team selects the best possible phenotypes in the natural stands, looking for healthy trees with straight stems, small branches and large volume. At the time of seed collections, the Camcore team assesses the conservation status of the natural populations using international conservation standards. Two of the populations sampled, Limón *(P. caribaea)* and Dulce Nombre de Copán *(P. maximinoi)* in Honduras, are classified as "endangered". This information is used by Camcore to guide *ex situ* conservation decisions. The seeds are sent to North Carolina State University where Camcore staff store them in the cold room at 4°C and then distribute these among active members for the establishment of genetic trials and *ex situ* conservation parks. Seeds produced by Camcore members in selected trees of genetic trials are also available to the donor countries for the establishment of 2nd generation progeny trials, also known as re-introduction trials. Several batches of seeds *P. tecunumanii, P. maximinoi, P. patula* and *P. greggii* have been delivered to government institutions in Guatemala and Mexico in the past (see 2009 Camcore annual report)

Josué David Cotzojay Chamalé, Camcore tree climber collecting seeds of *Pinus maximinoi* in Cobán, Alta Verapaz, Guatemala.

Table 8. Summary of seed collections completed in Central America and Mexico in 2011.

Country	Species	Provenance	Conservation Status	Latitude	Longitude	Trees
Guatemala	*P. tecunumanii* HE	San Jerónimo	Vulnerable	15° 00' N	90° 15' W	16
	P. maximinoi	Cobán	Vulnerable	15° 22' N	90° 23' W	17
Honduras	*P. caribaea*	Limón	Endangered	15° 51' N	85° 23' W	12
	P. maximinoi	Dulce Nombre de Copán	Endangered	14° 50' N	88° 51' W	16
	P. maximinoi	Tatumbla	Vulnerable	13° 59' N	87° 05' W	20

Pinus jaliscana and *P. oocarpa* introgression in natural stands in Mexico

Even though *P. jaliscana* and *P. oocarpa* occur sympatrically in the pine forests of western Jalisco, Mexico, and are closely related genetically, there have never been any reports of natural hybrids between the two species in the native geographic range. The absence of apparent gene exchange between *P. jaliscana* and *P. oocarpa* in Mexico seems unusual, but was thought to simply be a function of different flowering times of the two species in their native environment. Camcore established several provenance/progeny field trials of *P. jaliscana* in Argentina, Brazil, South Africa and Swaziland. In the South African trial, which was located at De Rust, Natal (29°S, 900 m altitude, 1460 mm annual precipitation), and included 57 open-pollinated families from all nine known provenances of the species, a small number of trees exhibited stiff, grey-green needles more typical of *P. oocarpa* than *P. jaliscana.* Their needle morphology was so strikingly different from "typical" *P. jaliscana,* that they were assumed to be natural hybrids between the two species.

In a joint project with Camcore and researchers at Sappi in South Africa, and with special contributions from Smurfit Kappa Cartón de Colombia, we have now conducted a botanical analysis of needles (no cones were available) in the 10-year-old study to confirm that natural hybrids between *P. jaliscana* and *P. oocarpa* occur in the Sappi field trial (Figure 3). We have also determined that Near-Infrared (NIR) technology can distinguish between dried needle samples of the pure species and putative hybrids. We will use this technology to quantify rates of *P. oocarpa* introgression in a larger sample of trees in the Sappi *P. jaliscana* trial, which in turn should give us a general estimate of the rate of introgression in natural populations of *P. jaliscana* in Mexico. The hope is that NIR can be used as a quick and inexpensive tool to identify and verify natural hybridity in research trials without the need to rely on more expensive molecular marker technology. The final report of this study will be available in 2012.

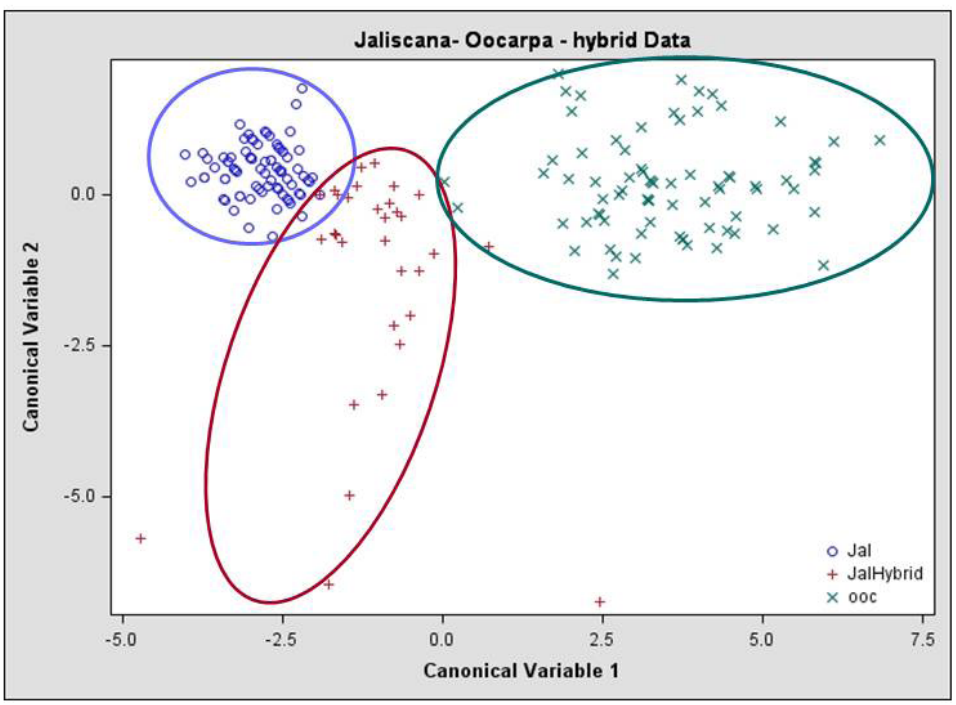


Figure 3. Separation of *P. jaliscana*, *P. oocarpa*, and the putative jaliscana x oocarpa hybrid trial using needle characteristics of 10-year-old trees in a Camcore trial established by Sappi, South Africa.

Conservation of Hemlock Species Native to the USA

Since 2003, Camcore has been working in cooperation with the USDA Forest Service (USFS) Forest Health Protection group to conserve the genetic resources of Eastern hemlock *(Tsuga canadensis)* and Carolina hemlock *(T. caroliniana)*. Both species are native to the eastern United States, and are ecologically important, but are threatened by the exotic insect pest hemlock woolly adelgid *(Adelges tsugae)*. This conservation project has been funded with approximately $800,000 awarded to Camcore in a series of grants from the USFS. The most recent of these grants, a $314,321 award made in 2009, has allowed us to expand this project beyond the southern Appalachian Mountains and focus our seed collection efforts on Eastern hemlock populations in the mid-Atlantic, northeastern, and Midwestern regions of the country.

Following a mediocre seed year in these northern regions in 2010, we had very successful site explorations and seed collections in 2011 despite setbacks in Vermont and New Jersey due to flood damage from hurricane Irene. During the summer, Camcore and our numerous state and federal cooperators explored 75 eastern hemlock populations across 16 states. Seed cones were identified on 50 sites and seed collections were completed from 21 of the best sites during the fall (Figure 4). In total, seeds were collected from 154 mother trees, 149 of which were new to the project. We also collected additional seed from 5 families that were first sampled in 2010 at Echo Lake, Wisconsin. These efforts bring our total seed collections over the nine years (2003-2011) of this project to 134 families of Carolina hemlock from 19 southern Appalachian populations, 237 families of Eastern hemlock from 35 southern populations, and 181 families from 23 northern populations.

As reported in previous Camcore Annual Reports, hemlock conservation banks have been established by Bioforest-Arauco in Chile, Rigesa in Brazil, and Camcore in North Carolina. In 2011, Carolina hemlock seeds were germinated for eventual conservation bank establishment in the Ozark Mountains of Arkansas and at the Beech Creek Seed Orchard in Murphy, NC by Weyerhaeuser USA and the USFS, respectively.

In addition to our continued efforts in seed collection and conservation bank planting, Camcore recently published, in Conservation Genetics, the results of our three-year USFS-funded study on range-wide patterns of Eastern hemlock population genetic structure and diversity across the US and Canada, and received an additional $83,316 award for a similar study with Carolina hemlock. We also had the opportunity to share the ongoing progress of our hemlock gene conservation and genetic diversity program through invited presentations by Robert Jetton and Andy Whittier at the North American Forest Insect Work Conference in Portland, OR, the Kentucky Hemlock Woolly Adelgid Symposium in Cumberland Falls, KY, The Alliance for Saving Threatened Forests Hemlock and Fir Symposium in Waynesville, NC, and the NC State University Department of Entomology.

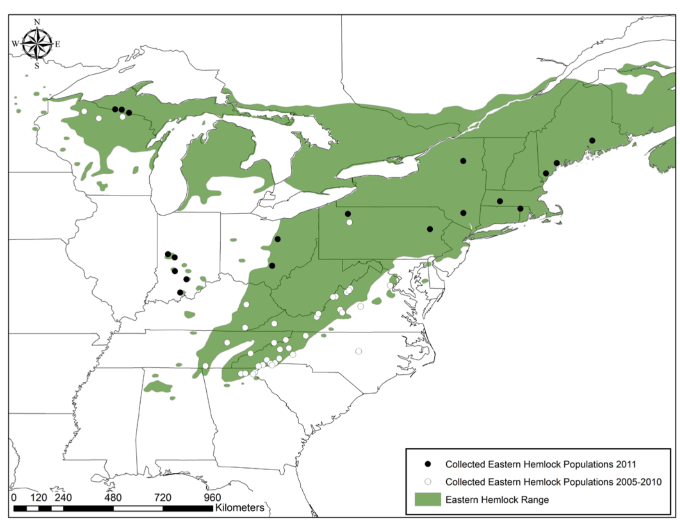


Figure 4. Map depicting the natural distribution of Eastern hemlock in the eastern United States and populations where Camcore has collected seed for ex situ gene conservation. Populations indicated with black circles were new provenance collections for 2011.

Thank You to Our Hemlock Seed Collection Collaborators

We have enjoyed a very successful year for the hemlock conservation project at Camcore. In particular, we made tremendous progress with seed collections in the northern parts of the hemlock range. This work would not have been possible without the help of our numerous state and federal cooperators who made collections on our behalf and whom we would like to acknowledge here: Collin Hobbs, Elizabeth Allaby, Thomas Amick, and Jennifer Boatz in Indiana; Allison Kanoti, Wayne Searles, Rick Dionne, Karl Buckley, and Elizabeth Lewis in Maine; Dennis Souto, Mike Bohne, Garret DuBois, and Angie Hammond in New Hampshire; Tim Frontz and Ken Edson in Pennsylvania; Ken Gooch, Melanie Joy, and Michael Andrews in Massachusetts; Charles Sullivan in Maryland; and Tim Toman and Amy Hill in West Virginia.

Conservation of Table Mountain Pine *(Pinus pungens)*

For the past two years, Camcore has been collaborating with the USDA Forest Service (USFS) to conserve the genetic resources of Table Mountain pine (TMP, *Pinus pungens*) in the eastern United States. This is a three year project funded by a $48,563 grant to Camcore from the USFS. Across its native range, spanning the Appalachian Mountains from central Pennsylvania south to northern Georgia, TMP is threatened by wildfire suppression activities and periodic outbreaks of the bark beetle *Dendroctonus frontalis.* Camcore and the USFS are working together to collect seed samples for reforestation efforts, seed orchard establishment, and long-term seed preservation.

Prior to 2011, Camcore completed seed collections from 106 TMP mother trees in 15 populations. In 2011, we focused on populations in the northern portion of the range as well as filling in gaps in the southern region that we did not get to in 2010. In total, our 2011 collections accounted for an additional 97 trees in 13 populations, bringing our total seed collections for this project to 203 mother trees in 28 populations across the range of the species (Figure 5). Twelve populations yielded collections from 10 mother trees each, while in the remaining 16 populations the number of trees sampled ranged from 1 to 8.

In 2011, we reported on this conservation effort through poster presentations at the 31st Southern Forest Tree Improvement Conference in Biloxi, MS and the 38th Natural Areas Conference in Tallahassee, FL. These presentations were made by Barbara Crane, USFS Southern Region Geneticist and our primary collaborator on this project.

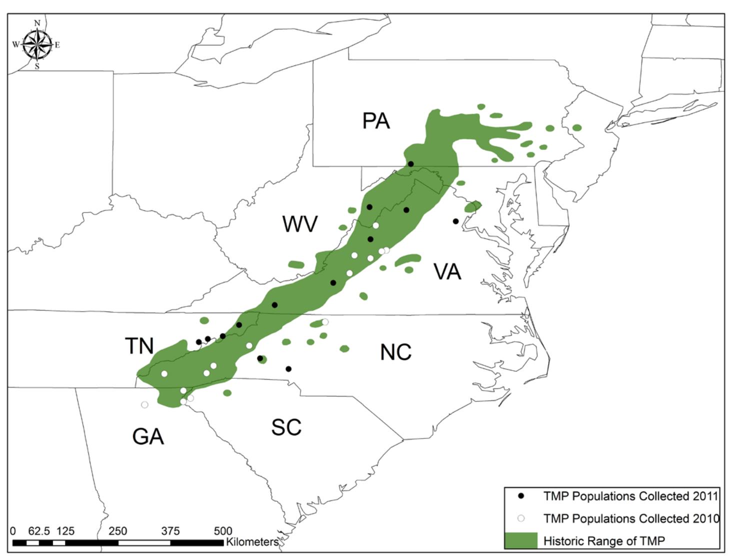


Figure 5. Map depicting the natural distribution of Table Mountain pine (TMP) in the eastern United States and populations where Camcore has collected seed for ex situ conservation. Populations indicated with black circles were new provenance collections for 2011.

Selection of Pine Provenances for Adaption to Climate Change on the Basis of Climate Analogues

Camcore continues to work with various researchers on questions of pine provenance selection and global climatic change. Christoph Leibing at the Centre for Wood Science and Technology University of Hamburg, Germany files the following short report.

In a study conducted by researchers from the International Centre for Tropical Agriculture (CIAT) in collaboration with Camcore, growth performance of plantings in Colombia, Brazil and South Africa were correlated to the degree of climatic similarity between planting sites. This computation of multivariate climatic distance was termed Analogue. Results are used to assess the suitability of seed material under changing climate of six *P. tecunumanii* provenances (Jocón, Campamento, Chempil, San Jerónimo, Mountain Pine Ridge and Chanal), and four *P. patula* provenances (Sierra Huayacocotla, Potrero de Monroy, El Cielo and Conrado Castillo).

For each provenance, climate dissimilarities based on standardized Euclidean distances were calculated and statistically related to growth performances. After validating two Analogue computation methods, gridded dissimilarity surfaces were coupled with predictions of 2030 and 2050 climate. The site classification models were able to relate climate similarity to different growth performances for five out of six *P. tecunumanii* provenances (Figure 6). Growth performances of seed sources from *P. patula* could not be related statistically significant to climate distances.

Results point towards the importance of the identification of sites with stable climates where high yields are achievable. Here the study suggests that fast-growing *P. tecunumanii* provenances can be planted that are rather narrowly matched to planting sites. On sites with climate change of uncertain direction and magnitude the choice of *P. patula* provenances, with greater tolerance towards different temperature and precipitation regimes, seems advisable. To this effect the interpretation of provenance trial data through climate similarity models enables to not only maintain plantation productivity in a rapidly changing environment, but ideally lets us improve our understanding of tree species' adaptation to a changing climate.

Co-authors on the work include: J. Signer, CIAT, Cali, Colombia; M. van Zonneveld, Bioversity International, Cali, Colombia & Ghent University, Ghent, Belgium; A. Jarvis, CIAT, Cali, Colombia and W. Dvorak, Camcore.

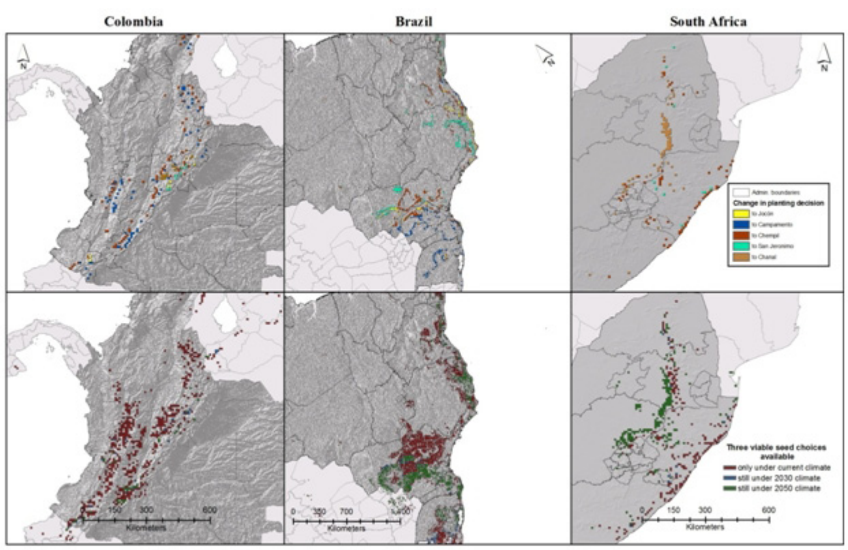


Figure 6. Maps of the results of the Analogue runs for projected climate conditions.

Note: The top three maps show where the Analogue model suggests changing the planting choice for the next rotation. The lower three maps point out where less than three of the analyzed provenances are expected to yield at least 12 m height growth at age 8. Predictions are assuming greenhouse gas emission levels following SRES A2a

Frost Tolerance of *P. patula x P. tecunumanii* Hybrids

Pine hybrids between temperate and subtropical species, such as *P. patula x P. tecunumanii* have great potential. Fast-growing subtropical pine species, like *P. tecunumanii*, are often very susceptible to frost, and hybrids will likely also have limited tolerance to frost. In the 2009 Annual Report, we presented results from an artificial freezing experiment designed to replicate field results at the species level. The hope was that similar protocols could be used to screen candidates at the within-species level (or within-hybrid variety level). David Cerda, a Fulbright Scholar and M.S. student with Camcore, conducted research on this topic using bulk seedlots of *P. patula* provenances provided by Camcore, and *P. patula x P. tecunumanii* hybrid families produced by Sappi Forests. Here we summarize the results from his M.S. research. David's full thesis can be found online at http://www.lib.ncsu.edu/.

Materials and Methods

Five *P. patula* females and four *P. tecunumanii* males were crossed in a factorial design. There was seed available from 16 (out of the possible 20) full-sib hybrid families. In addition, open-pollinated pure-species seed was available from the five *P. patula* and two of the *P. tecnumanii* parents, as well as bulk seedlots from 13 *P. patula* provenances.

Seedlings were grown in environmentally controlled chambers for 6 months, and then had a 6-week "autumn" with short photoperiods and cool temperatures. The goal was to simulate conditions in Sabie, South Africa, or Curitiba, Brazil.

Needles from each family were harvested, and put in small plastic tubes. Needles were then frozen to a target temperature (-7, -14, and -21°C), using a regime with a two-hour chilldown, 6 hours at target temperature, and 2 hours warmup to 0°C. There was also a replicate set of needles for each family that was used as an unfrozen control kept at 0°C.

Following some recovery time, the tubes were then filled with deionized-distilled water, and after 16 hours, electrical conductivity was measured. The foliage was then completely killed by heating all needles in the water-filled tubes to 85°C for two hours. Electrical conductivity was measured again for dead heat-treated samples. Damage to the tissue caused by freezing results in membrane damage and electrolyte leakage (EL) from the cells; the greater the damage, the higher the electrical conductivity. An Injury Index was calculated to compare conductivity of the frozen samples and completely killed heat-treated samples.

Results and Discussion

For the *P. patula* provenances, there were significant differences found among the 13 provenances for the -14 and -21°C treatments. Three of the provenances were var. *longipedunculata*, and as expected, these provenances had significantly higher Injury Index than the var. *patula* provenances. Provenance latitude was significiantly correlated with Injury Index ($r \approx 0.60$), as well as various climatic measures. For example, Mean Minimum Temperature in the Coldest Month was highly correlated with Injury Index ($r \approx 0.70$).

For the *P. patula x P. tecunumanii* hybrids, there were a number of interesting results. In general, at any given temperature, hybrid offspring from a particular *P. patula* mother showed higher Injury than pure-species offspring from that same mother. On average, the hybrids had Injury Index intermediate to the two parent species at -7°C, and were more similar to *P. tecunumanii* at the lower temperatures. However, some hybrid families had Injuy Index profiles very close to a typical *P. patula* (e.g., P-01 x Tec, Figure x), while other hybrid families behaved much more like *P. tecunumanii* (e.g., P-03 x Tec, Figure 7).

Results indicated that variability in the frost tolerance of the hybrid families came primarily from the *P. patula* side of the parentage, with little or no effect from the *P. tecunmanii*. This makes some sense: as a species, *P. tecunumanii* is very frost susceptible, therefore conributes little in the way of variability in frost tolerance.

Finally, an artificial screening technique is only valuable to the extent that it provides information about frost tolerance in the field. As mentioned earlier, we have some good agreement between lab results with electrolyte leakage and frost tolearnce in the field at the species/variety level. Further confirmation of the value of the lab approach used in this study comes from Sappi field trials of *P. patula x P. tecunumanii* hybrids. Hybrid families with P-05 as the maternal *P. patula* parent have demonstrated very high levels of frost-related mortality (see interior color photo in this Annual Report). This corresponds nicely with the results of this artificial freezing study where hybrid offpsring from P-05 were the most frost susceptible of the hybrid population (Figure 7).

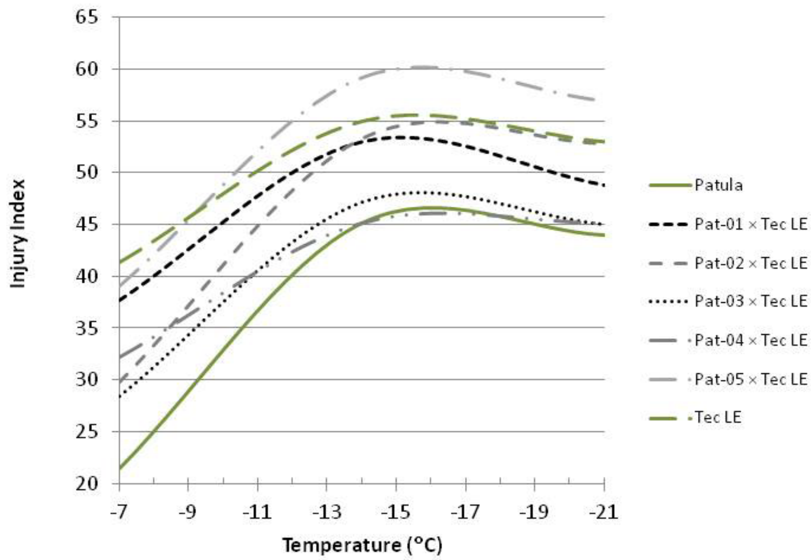


Figure 7. Frost injury index for *P. patula x P. tecunumanii* hybrid families.

Conclusions

Artificial freezing methodology appears to be useful for discriminating levels of frost tolerance at the within-species/variety level. Hybrids of *P. patula x P. tecunumanii* show Injury Index profiles intermediate between the two parent species, but there is great variability among hybrid families, and some screening of hybrid families may be necessary for operational deployment.

Species/site matching of eucalypts using Maxent®

Camcore is in the process of establishing a number of the lesser-known eucalypt species in field trials around the world (see Camcore 2010 report). To develop a better understanding of where these species might be best adapted, we are using the MaxEnt (Maximum Entrophy) model for species distribution using presence only data released by Princeton University (see http://www.cs.princeton.edu/~schapire/maxent/). MaxEnt fits a sophisticated mathematical model, somewhat akin to regression analysis, on features that are transformations of the covariates from occurrence records. The 19 environmental variables that can be included in MaxEnt models are from the world climatic data base called BioClim (http://www.worldclim.org/bioclim). The user chooses what environmental variables to include in each run. Pixels generated in the high-resolution maps are 0.9 km on a side.

Our first runs of MaxEnt were on the approximately 20 "obscure" temperate and subtropical eucalypt species obtained from the CSIRO (see internal technical reports). Collection site data were obtained from CSIRO and private collections listed in the Global Biodiversity Information Facility data base (http://data.gbif.org/species). Below is an example of a MaxEnt-generated distribution map for *Corymbia citriodora* ssp. *variegata* (Figure 8). The Maxent models gives us a starting point on where to begin establishing field trials.

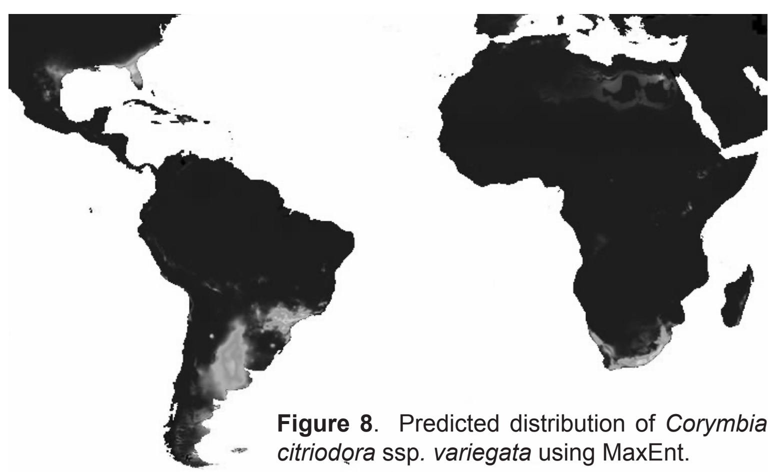


Figure 8. Predicted distribution of *Corymbia citriodora* ssp. *variegata* using MaxEnt.

Insect and Fungi Survey in Guatemala

In May, 2011, Juan López and Elmer Gutierrez from Camcore (NCSU), Jeff Garnas and Irene Barnes from FABI (University of Pretoria) and Carlos Rodas from Smurfit Kappa Cartón de Colombia made a second trip to Guatemala to complete the Insects and Fungi Survey in the natural pine forests of the country. The first trip was in October 2010. Here we summarize the final results from the collaborative project with the Guatemala National Institute of Forests (INAB), Grupo DeGuate (Camcore member in Guatemala) and the Universidad de San Carlos. We appreciate the strong support provided by the manager of INAB, Josué Iván Morales Dardón, and his team, who made the project possible. Also many thanks to Bernabé Caballero, Director of the Genetic Improvement Center & Seed Bank of Nicaragua (INAFOR), who coordinated a a one-day visit to a natural forest of *P. tecunumanii* in Yucul, Nicaragua.

The 31 years of continuous work of Camcore with the government of Guatemala facilitated the planning and execution of this project. After the survey, in which 46 different sites were visited (Figure 9), and more than 700 samples were collected, several important pathogens and insects were identified. Overall, the natural pine forests in Guatemala are exceptionally healthy with little evidence of major damage caused by insects and pathogens. Sites where pine species had been planted outside of their natural limits of environmental tolerance showed elevated signs of stress, often showing greater susceptibility to pathogens. Other sites where the forests were ineffectively managed and/or heavily utilized by the local communities showed elevated susceptibility, especially to bark beetles. In San Carlos Sija, Quetzaltenango, we found abundant evidence of an ongoing outbreak of bark beetles *(Dendroctonus adjunctus)* killing thousands of trees. Such outbreaks have long been part of the native pine ecosystem, occurring throughout the Holocene (Brunelle et al. 2001). Outbreaks have also been recorded in recent history in *Pinus hartwegii* forests in Guatemala between 1975 and 1980 (Vité 1980, Billings et al. 2004), reflecting the cyclical nature of bark beetle population fluctuations in pine forests of North and Central America. Several species of *Ips* and *Dendroctonus* beetles were present on most sites, often in association with fire or other forms of tree stress.

Figure 9. Inscet and fungi survey sites visited in Guatemala in 2010 and 2011.

Other species of insects observed were sawflies, shoot tip borers, wood- or phloem-borers and piercing-sucking insects. We found very low levels of sawfly damage in a few trees during our two visits; on only one site in 2010 (on *P. maximinoi*) and two sites in 2011 (on *P. maximinoi* and *P. caribaea*). The *P. maximinoi* visited in 2010 did not show presence of the insect in 2011, even though no control measure was applied. Two distinct forms were encountered and species determinations are underway. All individuals encountered belonged to the family *Diprionidae.* We found scattered examples of dieback of shoot tips across all species of pine throughout Guatemala. In most sites, damage levels were low. The majority of insects we found were larvae in the family *Tortricidae,* genus *Rhyacionia*. Species determinations are difficult using larval specimens and insufficient molecular data have accrued in public databases to make DNA identification an efficient tool. We also encountered high numbers of scotylid beetles in the genus *Pityophthorus* at one site in San Carlos Sija, on *P. hartwegii.* There was scattered evidence of stem-boring damage by beetles of the families *Buprestidae* and *Cerambycidae,* as is common in native pine forests. Sap-sucking insects such as aphids, leafhoppers and cicadas were in evidence at low abundance at nearly all sites.

Pathogens found during the survey were: Pitch canker *(Fusarium circinatum)*, *Dothistroma* needle blight, brown-spot needle blight, *Lophodermium* needle-cast of pine, pine cone rust, needle rust, and *Diplodia scrobiculata.* Pitch canker disease was found in 2011, in one locality in San Carlos Sija on densely planted and stressed *P. hartwegii* trees, surrounded by native forests of the same species at varying elevations. The pathogen responsible for the pitch canker, *Fusarium circinatum,* was identified based on colony morphology and DNA-based identification methods from isolates that were obtained from diseased material. The presence of *F. circinatum* in Guatemala, although a first report, is not unexpected as the pathogen is considered native to Mexico (Gordon 2006). *Dothistroma* needle blight has previously been reported from Guatemala in 1983 on trees of *P. tecunumanii* and *P. maximinoi* in Salamá, Baja Verapaz and on *P. michoacana* in El Tejar, Chimaltenango (Evans 1984). We found this pathogen at two locations in Jalapa. At a small La Soledad farm, planted *P. oocarpa* trees (at an elevation unsuitable for this species) were badly affected by the disease. Another nearby site planted with *P. tecunumanii* at La Lagunilla farm was less severely infected and symptoms were not obvious. Molecular characterization of isolates from these two sites confirmed that the species in Guatemala is *D. septosporum.* Brown-spot needle blight disease is caused by the fungal pathogen *Lecanosticta acicola* (teleomorph: *Mycosphaerella dearnessii)* that has been reported as widely distributed in the Central American areas including Guatemala, Honduras and Nicaragua (Evans 1984). The pathogen is also considered native to these regions. In our observations, no typical blight symptoms or disease outbreak were observed even where the pathogen was detected. Instead, in this environment, the pathogen appeared to be present as part of the natural microfloral community of the native forestson *P. pseudostrobus, P. tecunumanii, P. oocarpa* and *P. maximinoi.* One exception was evident, however, at a trial site in Cobán with 4-year-old *P. maximinoi.* Initial symptom development at this site was evident with yellow and brown necrotic spots occurring on green needles in October 2010. Almost every tree in the site was affected by the pathogen, albeit at low levels of intensity. *Lophodermium*-like symptoms were observed on needles from all three pine species, *P. tecunumanii, P. oocarpa* and *P. maximinoi* in almost all of the sites we visited. Morphological and molecular characterization of the different forms is underway to determine the species composition of *Lophodermium* in these pine forests. In Guatemala, *Diplodia scrobiculata* has been confirmed on *P. maximinoi* from Morazán, El Progreso. This fungus has generally been considered as a latent or weak pathogen of conifers that causes blue staining of wood (de Wet et al. 2003) with a limited distribution in Mexico, north-central United States, Southern Europe and South Africa (Burgess et al 2004). Some of the insects and fungi sampled are currently being identified using both morphological and molecular techniques.

We believe that the Camcore/FABI survey of diseases and insects in the pine forest of Guatemala has increased our knowledge about the potential for pest problems to develop in pine plantations in other areas of the tropics and subtropics in the future. Again, our survey indicates that, for the most part, the pine forests in Guatemala are very healthy. Additional funding is required to continue this joint collaborative project between NCSU and University of Pretoria in Central America.

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Eucalyptus urophylla Wood Properties: Variation Among Islands and Provenances

Camcore began collecting *Eucalyptus europhylla* in 1997, and has made seed collections from 62 provenances and 1196 mother trees covering all seven island where the species occurs naturally. Camcore members have established a total of 187 field tests in Argentina, Brazil, Colombia, Venezuela, Mexico, South Africa, Mozambique and Tanzania. The species is valuable as a hybrid partner, having good characteristics for growth, disease resistance, and rooting capacity (i.e., ease of vegetative propagation). In some regions, it also has good potential as a pure plantation species. In 2010, Camcore initiated a project to study variation in wood properties among *E. urophylla* provenances. Here we report preliminary results of that project.

Materials and Methods

Wood samples were taken in five distinct geographic regions: Argentina, Colombia, Mexico, Venezuela, and South Africa. In each region, two to four provenance/progeny tests were sampled. A provenance was represented by at least 20 trees, from as many different families as possible. A total of 2140 trees from 56 provenances were sampled at breast height. Wood samples were also taken at various heights from 45 trees to study the relationship between breast-height and whole-tree wood properties.

Gravimetric density measurements were taken on 10% of all samples. Samples were then ground into woodmeal and scanned with near-infrared spectroscopy (NIR). An NIR prediction model was then built for density. The NIR density model and existing NIR models for pulp yield were then used to predict density and pulp yield for all samples. For pulp yield, three separate and independent models (developed for *E. urophylla, E. grandis,* and *E. nitens*) were each used to predict pulp yield. Each of the models was based on approximately 100 data points, and had an $R^2 \approx 0.67$ with and SECV ranging from ±0.84% to 2.20%.

Preliminary Results and Discussion

The NIR model for density had a reasonably good fit. For density, there were 349 data points with a mean of 590 kg / m^3, and a range of 442 to 713 kg /m^3. The NIR model had an $R^2 = 0.75$ with a standard error of cross-validation (SECV) of ±33 kg/m^3.

The predictions from the three pulp yield models were all highly correlated, with R ranging 0.83 to 0.86. It seems that regardless of species, the NIR spectra are detecting similar chemical properties of the wood related to pulp yield. This gives us confidence that any of the predictive models, or some average of the three values, will give similar, and presumably reliable, rankings for pulp yield. For the purposes of this preliminary analysis, we focused on the predictions from the *E. urophylla* model which had a mean pulp yield of 44.9% and a range from 38.2% to 51.6% yield.

Breast-height wood samples give a good indication of whole-tree wood properties. Breast-height density and whole-tree density were highly correlated ($R \approx 0.90$ to 0.95), and means were also very similar, differing by less than ±2%. Breast-height and whole-tree pulp yield were also very highly correlated ($R \approx 0.95$); however, breast-height samples had about 3% to 5% lower predicted pulp yields than the whole-tree pulp yields.

There was a strong negative relationship between density and pulp yield at the island level (Figure 10). For example, Timor island had the highest pulp yield (46.2%), but the lowest density (531 kg/m^3). In contrast, Adonara island had the highest density (577 kg/m^3), but the second-lowest pulp yield (40.4%). This is an unfavorable relationship, as pulp producers want both high density and high pulp yield. This unfavorable correlation between density and pulp yield was also found at the provenance level ($R = -0.89$). On a more encouraging note, it does not appear that volume growth (in any geographic region) is strongly correlated with either density or pulp yield.

Summary

These preliminary results are based on about 60% of the planned samples. To date, samples from Colombia, Venezuela, and South Africa have been completely processed. Final provenance rankings will undoubtedly change somewhat once

the samples from Argentina and Mexico are completed. However, it seems clear that density and pulp yield are negatively correlated at the island and provenance level in *E. urophylla*. Since both of these traits are very important to pulp producers, it seems likely that tree breeders will need efficient screening tools and high selection intensities to find clones that are "correlation-breakers", having both high density and high pulp yield.

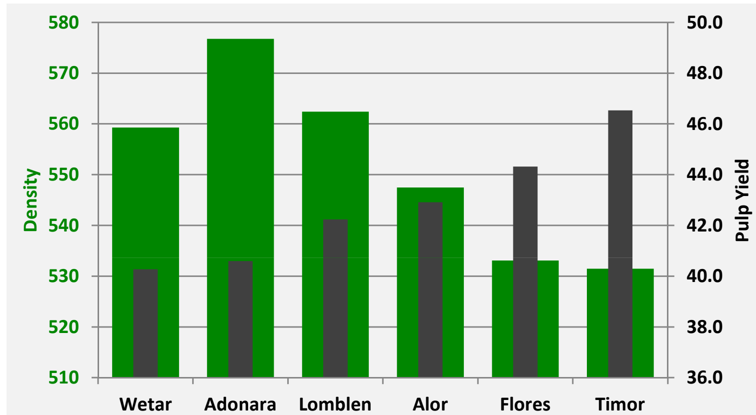

Figure 10. Density (left axis, green bars) and Pulp Yield (right axis, gray bars) for *E. urophylla* originating from six different islands. Island means are based on samples from 20 trees/provenance from five to eight provenances.

Eucalyptus Wood Pellets for Energy

Working with the NCSU Department of Forest Biomaterials (FBM), Camcore developed a project to assess the potential of eucalypt wood for producing wood pellets for biomass fuel. Wood pellets have several advantages as solid biomass fuel compared to wood chips and firewood: higher energy density, lower moisture content, and better handling properties. For these reasons, wood pellet production worldwide has been increasing substantially in recent years. The objective of this project was to produce pellets from different eucalypt species and then assess the pellets' combustion properties. The species used and the results are shown in Table 9.

From the results, we can infer that no important differences in heating value were found among eucalypt species tested in this project. This is good in that we could use any fast-growing eucalypt species for energy production using pellets. However, when the species tested in this study were compared with *E. benthamii* and *E. macarthurii* from a previous study by FBM, a large advantage in heating value was found for *E. benthamii*. Therefore, further studies are recommended to verify those results. Studies at the provenance and family level may also indicate if it is possible to obtain significant gains in heating value through breeding.

Table 9. Eucalyptus species and their combustion properties for pellet production.

Species	Provenance	Density		Volatile Matter (%)		Ash Content (%)		Fixed Carbon (%)		Heating Value	
E. dorrigoensis	South Carolina	0.58	*± 0.01*	73.46	*± 1.35*	1.62	*± 0.11*	24.92	*± 1.45*	18.8	*± 0.1*
E. pellita	Colombia	0.69	*± 0.07*	76.54	*± 0.78*	0.46	*± 0.01*	23.00	*± 0.77*	18.7	*± 0.2*
E. saligna	Uruguay	0.60	*± 0.09*	79.86	*± 6.96*	0.93	*± 0.62*	19.21	*± 6.78*	18.7	*± 0.1*
E. dorrigoensis	Uruguay	0.68	*± 0.03*	73.66	*± 1.46*	1.44	*± 0.36*	24.90	*± 1.45*	18.7	*± 0.0*
E. urophylla	Venezuela	0.69	*± 0.11*	73.98	*± 0.91*	1.25	*± 0.43*	24.77	*± 1.24*	18.6	*± 0.1*
E. urophylla	Colombia	0.58	*± 0.06*	73.82	*± 0.77*	0.99	*± 0.04*	25.19	*± 0.80*	18.4	*± 0.2*
E. nitens	Chile	0.57	*± 0.03*	75.66	*± 1.91*	0.93	*± 0.49*	23.41	*± 1.45*	18.4	*± 0.1*
E. globulus	Chile	0.65	*± 0.05*	78.66	*± 2.07*	0.54	*± 0.39*	20.80	*± 2.40*	18.4	*± 0.2*
E. grandis	South Africa	0.54	*± 0.06*	75.40	*± 3.27*	0.83	*± 0.25*	23.78	*± 3.03*	18.4	*± 0.2*
E. dunnii	South Africa	0.65	*± 0.14*	74.31	*± 1.78*	1.21	*± 0.12*	24.49	*± 1.89*	18.3	*± 0.3*
*E. macarthurii**	USA	0.54	.	82.99	*± 1.24*	3.30	*± 0.10*	13.71	*± 1.22*	18.5	.
*E. benthamii**	USA	0.55	.	81.44	*± 3.00*	3.55	*± 0.18*	15.02	*± 2.91*	19.9	.

The Pitch Canker Fungus in South Africa: Responding with Alternative Species and Hybrids

The pitch canker fungus, *Fusarium circinatum,* has severely restricted the deployment of *Pinus patula* in South Africa where it results in the mortality of seedlings in the nursery and soon after planting. Glen Mitchell (York Timbers) has been working on a PhD on this topic at the University of Pretoria, under the direction of Mike Wingfield. This article summarizes the results of a number of Glen's studies.

Infection mechanisms

It has been assumed that mortality results from nursery infection or contamination which is then transferred to the field. This was quantified by removing root tips from the nursery plants at the time of dispatch and plating these onto agar medium. The fungal cultures that developed on the agar medium were subjected to molecular laboratory techniques and it was found that *F. circinatum* could be isolated from 20 to 50% of *P. patula* seedlings leaving the nursery. This percentage was lower for other species and hybrids growing in the nursery at the same time.

In most cases the infected nursery plants could not be linked to prior wounding. Scanning electron microscope studies confirmed that the hyphal tips of germinated fungal spores could enter the plant through the stomata (Figure 11).

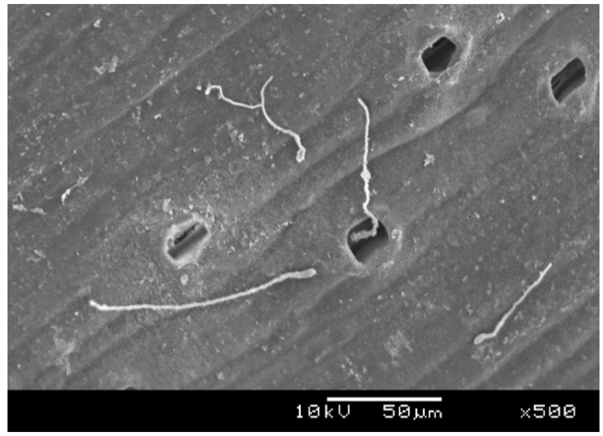

Figure 11. Scanning electron micrograph of fungal hyphae of *F. circinatum* entering stomata of pine needles.

Tolerance of alternative pines

Lab studies were done to compare tolerance of *P. patula* to that of other species and hybrids by applying a spore suspension to wounded seedlings or cuttings in a greenhouse.

Pinus elliottii is the species most often used by South African companies as an alternative to *P. patula.* However, there is evidence of genetic variation in tolerance among *P. elliottii*, and a study of 50 commercial families from South Africa indicated a wide range in tolerance with reasonable heritability ($h^2 = 0.22$).

Pinus maximinoi and *P. tecunumanii* outgrow *P. patula* on warmer sites in South Africa. Seventy three families of *P. tecunumanii* (49 from low elevation (LE) provenances and 24 from high elevation (HE) provenances) were screened. Large variation between the HE families existed with good heritability ($h^2 = 0.59$). Some of the *P. tecunumanii* HE families were similar in tolerance to the mean of *P. patula (*Figure 12). On the other hand, almost all LE families were very tolerant, so heritability was low ($h^2 = 0.01$). Similarly, very good tolerance was seen for all *P. maximinoi* families ($h^2 = 0.01$). These results indicate that families of *P. maximinoi* and *P. tecunumanii* LE need not be screened for their tolerance to *F. circinatum*.

A significant disadvantage of *P. tecunumanii* and *P. maximinoi* is the susceptibility of these two species to frost. Currently the only cold temperate species that has shown reasonable tolerance to *F. circinatum* in previous trials is *P. pseudostrobus.* Due to its poor growth, the species is not commercially grown in South Africa. Several good selections have been identified, however, and 29 families were screened for their tolerance. The results showed that all families were highly tolerant ($h^2 = 0.06$). The cold tolerance of *P. pseudostrobus*, as well as its good tolerance to *F. circinatum,* may support further breeding of the species.

Tolerance of hybrids

Through the collaborative efforts of the Camcore members, a large number of pine hybrids have been made, many in which *P. patula* is the mother parent. These hybrids, and the parental species, were screened as cuttings using the same laboratory methods as described earlier. The re-

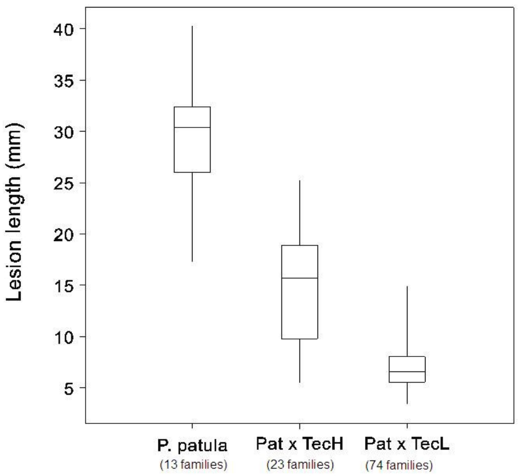

Figure 12. Box and whisker plot comparing family variation among *P. patula* and hybrids of *P. patula x P. tecunumannii* (HE and LE sources) for lesion length following inoculation with the pitch canker fungus.

sults showed that all hybrids between *P. patula* and more tolerant species were significantly more tolerant than *P. patula.*

In South Africa, *P. patula x P. tecunumanii* is gaining popularity in South Africa due to its fast growth and tolerance to *F. circinatum.* However, due to the susceptibility of *P. patula* to *F. circinatum*, and wide range in tolerance of *P. tecunumanii* HE families, it cannot be expected that all *P. patula x P. tecunumanii* families will be tolerant. To test this, 75 full-sib *P. patula x P. tecunumanii* LE families and 24 *P. patula x P. tecunumanii* HE families were screened. There was little variation between *P. patula x P. tecunumanii* LE hybrid families, while there were large differences between *P. patula x P. tecunumanii* HE families (Figure 13). The most susceptible *P. patula x P. tecunumanii* HE families were similar to the mean of the *P. patula*. Results also indicated that the variation in susceptibility of the various hybrid families was mostly due to the specific combination of the two parents.

Tolerance of *P. patula*

A trial of cuttings from 60 full-sib families of *P. patula* demonstrated that there is relatively little genetic variation in tolerance among open-pollinated families, but much genetic variation among specific full-sib crosses. In fact, some full-sib families were similar in tolerance to the *P. elliottii* seedling control.

Lab and Field Tolerance

It is uncertain if greenhouse tolerance of seedlings is related to field tolerance of older trees. To test this, 9-year-old *P. patula* and *P. elliottii* trees were inoculated by inserting agar plugs covered with *F. circinatum* into a wound on the stem. After 12 weeks, the bark was removed and the lesion length recorded. Seed collected from those trees prior to field inoculation was sown in the nursery, and later, seedlings inoculated in the greenhouse. Around 5% of the *P. patula* trees in the field were as tolerant as the *P. elliottii* trees of the same age. Furthermore, these tolerant trees produced seedlings that were similar in tolerance to *P. elliottii* seedlings in the greenhouse.

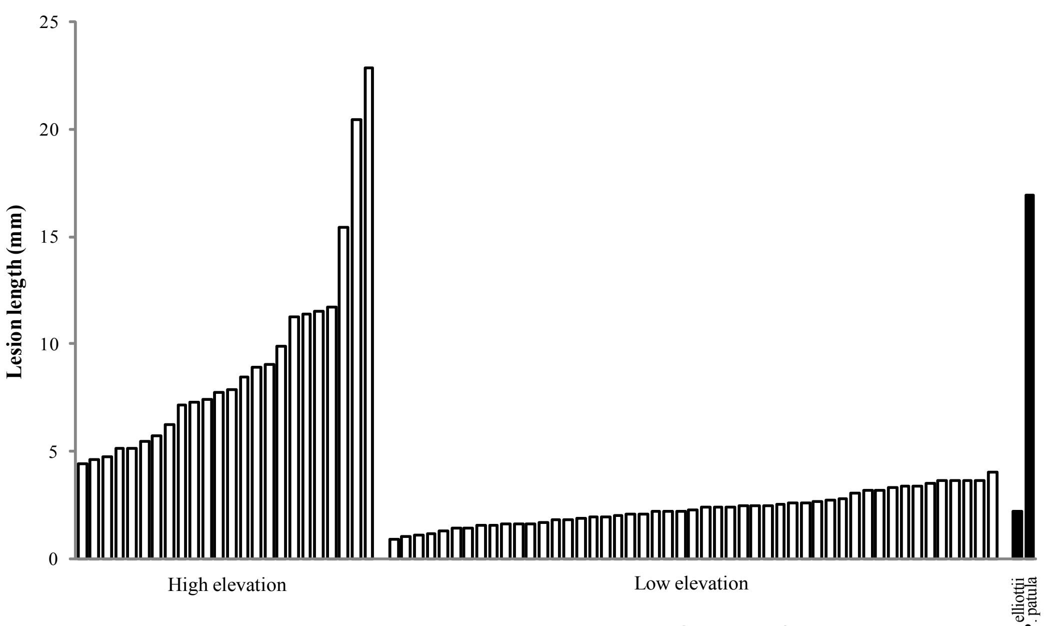

Figure 13. Variation in tolerance to pitch canker among families of *P. tecunumanii* (HE and LE).

Air Layering and Fascicle Rooting of *Pinus maximinoi*

Air-layering is a horticultural practice that has been used successfully for decades as a means of propagating some of the more difficult-to-root plants. A top branch from a selected tree is identified, the bark is removed, a rooting hormone is applied to the exposed cambium, the cambium is wrapped in moist sphagnum moss or similar rooting medium, and the branch and medium is wrapped in plastic to maintain moisture until roots form and are large enough to support the new plant. Camcore has been recommending this technique to its members for use with *P. maximinoi* since this species has a high level of grafting incompatibility, even when using root stock from the same species. Smurfit Kappa Cartón de Colombia has been working to adapt this technique to forest species (top and middle photos). Camcore is very pleased to see the improvements being made by SKCC in the rooting and propagation of improved material of *P. maximinoi* which has become one of the main species in the pine program of the company.

In addition to air-layering, several Camcore members in Argentina, Colombia, Brazil and South Africa are testing fascicle rooting as method of vegetative propagation. This involves the selection of fascicles with completely elongated needles from lower branches and placing them in a growth medium to induce callus formation and rooting (bottom photo). In some of those countries, these trials are showing promising results.

Pine Somatic Embryogenesis with Mature Embryos

In 2009, Camcore began to develop SE protocols for some tropical and subtropical pine species in a a project with Dr. Yill-Sung Park of Natural Resources Canada. Using immature seed of *P. maximinoi* and *P. tecuncumanii*, we got very encouraging results, with between 3 to 8% initiation. In 2010, we built on those results, working with Dr. Gerald Pullman of the Institue of Paper Science and Technology to test SE initiation protocols using mature seed of *P. maximinoi.* This approach would offer significant logistical advantages in a large-scale SE program. Once again, we got very encouraging results, with approximately 26% of plated embryos showing presence of embryogenic tissue after 10 weeks on initiation medium.

In 2012, we plan to continue this line of work by attempting to fully develop SE plantlets from mature seed of *P. maximinoi.* There are a number of specific questions to answer, including:

1. Can we repeat good initiation success with the same and different *P. maximinoi* seedlots?
2. Will cultures be amenable to cryogenic storage and multiple cycles of embryo development?
3. Can we germinate somatic embryos using maturation protocols used for other pine species?

The development of SE protocols will be a long process, but if we are successful, it will open the door to clonal forestry of tropical pines.

Pine Hybrid Verification with NIR

This is a multi-year Camcore project initiated in 2009 to assess if Near Infrared Spectroscopy (NIR) can be used to develop a pine hybrid verification methodology. Camcore has been working for several years to find a cost-effective method to confirm that hybrids have been successfully produced. The current methods of molecular markers such as RFLP, RAPD, SSR, etc., used to distinguish pine species have disadvantages including the need for highly skilled labor, use of hazardous chemicals, long time requirements, expensive set up costs, and occasional inaccuracies. Currently, Camcore is using SNP markers which appear to be useful and relatively cost effective; however, this still requires trained personnel to extract DNA and is time consuming. Therefore, finding a simple and fast method to verify hybrids would be beneficial to operational breeding programs.

This project has been divided into three phases. The first phase was to determine if NIR models can discriminate among all possible pairs of the 16 different species from tropical, subtropical and temperate regions using dry needle samples. There were 25 seedlings per species available. Calibration models were built using 15 seedlings from each species, and then verified using 10 additional seedlings from each species. The results from this phase were excellent. On average, across all possible pairwise combinations, 95% of the seedlings in the independent set were classified correctly by the NIR models.

Encouraged by these results, in 2010 Camcore conducted the second phase of the study to further investigate the use of NIR to verify pine hybrids using foliage samples. Because we did not have foliage samples from verified hybrids at the time, the study involved the fabrication of foliage samples of "pseudo-hybrids" by mixing foliage samples from two pure species. The samples were processed using the same methodology used in phase 1. The results were very similar to those from the first phase. The model correctly identified 95% of the "hybrid" samples as hybrids.

In 2011, Camcore began to develop the third part of this project. This phase involves testing foliage samples from true hybrids (verified using SNPs). Foliage samples from three hybrids (*P. patula x P. tecunumanii, P. patula x P. elliottii*, and *P. patula x P. taeda)* and the parental species were collected to evaluate the models used in the earlier phases. The results shown in Table xx only include the *P. patula x P. tecunumanii* hybrid and their parents because the other samples are not yet processed at the time of this report, but so far, the results are encouraging. In comparisons of the hybrid versus *P. tecunumanii*, 100% of the independent hybrid samples and 100% of the independent pure species samples were classified correctly by NIR (Table 10). For the comparison of the hybrid versus *P. patula*, the NIR was good, but not perfect, with 70% of the hybrids and 90% of the *P. patula* samples classified correctly. Only a limited number of foliage samples were available to build and test the NIR models (10 of each taxon to calibrate the model, and 10 of each taxon to validate). It seems likely that a more robust and precise model could be built with larger sample sizes.

Once the samples from the other hybrids from South Africa have been processed and analyzed, better conclusions or inferences about the efficiency of the use of NIR technique to distinguish between hybrids and their pure species can be made. The final results will be presented at the annual meeting in Chile in 2012.

Table 10. Verification of *P. patula x P. tecunumanii* HE hybrids versus a parent species using NIR.

Actual Taxon	Samples	Percentage Classified by NIR Model		
		P. pat x P. tec HE	*P. patula*	*P. tecunumanii* HE
P. pat x P. tec HE	10	100		0
P. tecunumanii HE	10	0		100
P. pat x P. tec HE	10	70	10	
P. patula	10	30	90	

Camcore To Host IUFRO Pine Breeding Meeting in 2013

Camcore will be one of the major co-sponsors of the next IUFRO Working Group meeting 2.02.20 "Breeding and Genetic Resources of the Southern US and Mexican Pines (including *Pinus radiata)*" The Conference Theme is: "Breeding for Value in a Changing World". Our goal is to bring together pine breeders from around the world to discuss various issues related to tree improvement research. The individual sessions will be:

- Quantitative Genetics and Breeding Strategies
- Molecular Genetics
- Genomic Selection & Pedigree Reconstruction
- Wood Properties
- Hybrid Breeding and Testing
- Somatic Embryogenesis & Clonal Forestry
- Reproductive Biology & Seed Orchard Management
- Population Genetics and Abiotic Stress Resistance
- Disease and Pest Resistance

Bill Dvorak is Deputy of this working group and Gary Hodge is the Chair of the technical committee for the conference. The meeting organizer is Dr. Susan Moore in the Department of Forestry & Environmental Resources, NC State University. The meeting will be held in Jacksonville, Florida, USA Feb. 3-7, 2013. The last IUFRO pine genetics meeting for the southern US pines was in the US in 2004 and for the Mexican pines was in South Africa in 2000. It is now time to discuss important issues. We hope to have good attendance by all the Camcore members that manage pine plantations. For more information, contact Bill Dvorak (dvorak@ncsu.edu) or Susan Moore (susan_moore@ncsu.edu) or visit the conference webpage at http://www.ncsu-feop.org/IUFRO.

Executive Committee Members

Andrew Morris (Sappi) stepped down as Advisory Board Chairman after nearly a decade of serving the Camcore membership. Andrew was a decisive leader who helped Camcore grow and develop during his tenure. We all appreciate Andrew's dedication to the program and especially his sense of humor. Andrew will continue to be involved in the Camcore program, but might not be able to attend all the annual meetings in the future.

Ben Pienaar (Mondi) and **Irvine Kanyemba** (Florestas de Niassa) were selected to serve on the Camcore Executive Committee beginning in 2012. Congratulations to both Ben and Irvine.

Andrew Morris (center) with Bob Purnell in a eucalyptus spacing trial in Uruguay at the 2009 Camcore Annual Meeting. Andrew has served as Camcore Advisory Board Chairman for nearly a decade.

Data Management Shortcourse in East Africa

Twenty participants gathered in Nairobi, Kenya for the 2011 Camcore Data Management Course. This annual workshop teaches research staff from member companies how to better organize and digitize data from genetic trials. The course topics include: formats for data specific to Camcore trials, trial design, and techniques for coding field measurements. The majority of class time is spent doing exercises to learn and practice intermediate and advanced computer spreadsheet techniques such as text and logical formulas, look-up functions, pivot table creation and macro recording. Camcore offers these courses in order to improve the efficiency of the members' data handling and to improve the quality of data submitted to Raleigh for statistical analysis. A number of presentations and exercises dealt with the process of validating and purifying trial measurements. The week-long class was intense, fast-paced, and challenging.

The course was sponsored by the East Africa membership and organized by Benson Kanyi of the Tree Biotechnology Programme Trust TBPT and was held at the Muguga Regional Research Centre of the Kenya Forest Research Institute (KEFRI). Participants from eight research organizations, including five from Camcore members, traveled from five countries to assemble in Nairobi.

This group set a new record for international diversity for the workshops which have been taught by Camcore data manager Willi Woodbridge since 2001. The organizations and countries represented were TBPT and KEFRI, Kenya; TAFORI and Green Resources, Tanzania; Chikweti and Florestas de Niassa, Mozambique; National Forest Authority and Ministry of Forestry and Mines, Rwanda; and the Gatsby Trust Tree Biotechnology Project of Uganda. Students from Green Resources and the Rwandan and Ugandan organizations were guests of the East Africa membership. Next year's workshop is planned for Uruguay.

Participants at the 2011 Camcore Data Management Shortcourse in East Africa.

Publications and Papers

Publications

Espinoza, J.A., Allen, H.L., McKeand, S.E., Dougherty, P.M. 2011. Stem Sinuosity in Loblolly Pine with Nitrogen and Calcium Additions. Forest Ecology and Management.. 261:1. 55-61.

Jetton, R.M., Whittier, W.A., Dvorak, W.S., Rhea, J.R. 2010. Status of Gene Conservation for Eastern and Carolina Hemlock in the Eastern United States. Proceedings of the Fifth Symposium on Hemlock Woolly Adelgid in the Eastern United States. Asheville, NC. August 17-19, 2010. USDA. pg. 93-99.

Jetton, R.M., Monahan, J.F., Hain, F.P. 2011. Laboratory studies of feeding and oviposition preference, developmental performance, and survival of the predatory beetle, Sasajiscmnus tsugae on diets of the wooly adelgids, Adelges tsugae and Adelged picae. Journal of Insect Science. 11:68 available online: insectscience.org/11.68, pg. 1-14.

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Potter, K.M., Jetton, R.M., Dvorak, W.S., Hipkins, V.D., Hargrove, W., Rhea, J.R., Whittier, W.A. 2010. Of Microsatellites, Hemlock Woolly Adelgid and Climate Change: Assessing Genetic Threats to it, Across the Range of Eastern Hemlock. Proceedings of the Fifth Symposium on Hemlock Woolly Adelgid in the Eastern United States. Asheville, NC. August 17-19, 2010. USDA. pg. 104-105.

Potter, K.M, Jetton, R.M., Dvorak, W.S., Hipkins, V.D., Rhea, J.R., Whittier, W.A. 2011. Widespread inbreeding and unexpected geographic patterns of genetic variation in eastern hemlock *(Tsuga canadensis)*, an imperiled North American conifer. Conservation Genetics. 2011 doi: 10.1007/s10592-011-0301-2

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Wee, K.S., ChunHong, L., Dvorak, W.S., Han, Y. 2011. Genetic diversity in Natural Populations of *Gmelina arborea*: implications for breeding and conservation. New Forests. doi:10.1007/s11056-011-9288-2.

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Dvorak, W.S. 2012. The Strategic Importance of AppliedTree Conservation Programs to the Forestry Industry in South Africa. In Press: Southern Forests, 2012 Vol 73(1).

Hodge, G.R. and Dvorak, W.S. 2012. Growth Potential and Genetic Parameters of Four Mesoamerican Pine Planted in the Southern Hemisphere. In Press: Southern Forests, 2012 Vol 73(1).

Hodge, G.R., Dvorak, W.S., Tighe, M.E. 2012. Comparisons between Laboratory and Field Results of Frost Tolerance of Pines from the Southern US and Mesoamerica Planted as Exotics. In Press: Southern Forests, 2012 Vol 73(1).

Mitchell, G., Wingfield, M., Hodge, G., Steenkamp, E. and Coutinho, T. 2012. Selection of *Pinus* spp. in South Africa for tolerance to infection by the pitch canker fungus. In Press: New Forests

Mitchell, R.G., M. J. Wingfield, G. R. Hodge, W. S. Dvorak and T. A. Coutinho 2012. Susceptibility of provenances and families of *Pinus maximinoi* and *Pinus tecunumanii* to frosts in South Africa. New Forests (in Press)

Internal Reports

Dvorak, W.S.. (with contributions from J.L. López and J.A. Espinoza). 2011. Best Practices Procedures for Pine, Eucalypt, Teak, and Gmelina in the Camcore Membership. 87p.

Dvorak, W.S. 2011. Water Use in Plantations of Eucalypts and Pines; A Discussion Paper from a Tree Breeding Perspective. 2011. 19 p. (Associated annotated bibliography-80 references & 56 pages).

Dvorak, W.S. 2011. An Overview of Greenhouse Experiments To Determine Drought Resistance in Forest Plantation Species:What Tree Breeders Can Learn From Crop Science. 15p. (Associated annotated bibliography-37 references &19 pages).

Dvorak, W.S. 2011. Planting Zones for "Obscure" Temperate and Subtropical Eucalypts Species Provided to Camcore Members from the CSIRO. 93p

Posters

Jetton, R.M., Crane, B.S., Whittier, W.A., Dvorak, W.S., Hipkins, V.D. Genetic Conservation of Table Mountain Pine (Pinus pungens) in the Southern Appalachian Mountains by the USDA Forest Service and Camcore. Poster presented at The Southern Forest Tree Improvement Conference. Biloxi, MS. June 13-16, 2011.

Jetton, R.M., Mayfield, A.E., Hain, F.P. Operation Adelgification: Evaluating a Rain Down Technique to Artificially Infest Seedlings with the Hemlock Woolly Adelgid. Poster presented at The 2011 North AmericanForest Insect Work Conference. Portland, OR. May 9-12, 2011.

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Hodge, G.R. Forest Genetics and Tree Improvement: Challenges and Opportunities. In Press: Proceedings of the Canadian Forest Genetics Association, Forest Gentics and Tree Improvement: New Knowledge, Challenges and Strategies. Thunder Bay, Ontario,Canada. August 16-18, 2011.

Hodge, G. R., W.S. Dvorak, J.A. Espinoza, W. Woodbridge. 2011. Provenance Variation of Eucalyptus urophylla for Physical and Chemical Wood Properties in Genetic Trials in Five Different Countries. IUFRO Conference on Improvement and Culture of Eucalypts Porto Seguro, Bahia, Brazil. (eds. J.L.de Moraes Goncalves et al. Piracicaba, ESALQ, SP, Brazil. 14-18 November. 545 p.

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Jetton, R.M., Whittier, W.A., Dvorak, W.S., Rhea, J.R. Overview of the Hemlcok Gene Conservation Program. Reclaiming Hemlcoks and Firs: A Symposium. Waynesville, NC. October 26, 2011.

Jetton, R.M., Dvorak, W.S., Hodge, G.R. 2011. The role of applied forest genetic resource conservation in the development of host resistance breeding programs: the importance of Ex Situ strategies. Oral presentation at the 2011 North American Forest Insect Work Conference. Portland, OR. May 9-12, 2011.

Other Publications of Interest

Brawner, D.J. Lee, C.M. Hardner, M.J. Dieters. 2011. Relationships between early growth and Quambalaria shoot blight tolerance in Corymbia citriodora progeny trials established in Queensland, Australia. Tree Genetics & Genomes. 7(4) 759-772

Gapare, W. J., Miloš Ivković, Gregory W. Dutkowski, David J. Spencer, Peter Buxton & Harry X. Wu. 2011. Genetic parameters and provenance variation of Pinus radiata D. Don. 'Eldridge collection' in Australia 1:growth and form traits. Tree Genetics & Genomes. DOI 10.1007/s11295-011-0449-4

Kanzler, A., K. Payn & A. Nel. 2012. Performance of two Pinus patula hybrids in Southern Africa. Southern Forests, 2012 Vol 73(1). (In Press).

Meder, R., Brawner, J., Downes, G., and Ebdon, N. 2011. Towards the in-forest assessment of Kraft pulp yield: comparing the performance of laboratory and handheld instruments and their value in screening breeding trials. Journal of Near Infrared Spectroscopy. 19 (5) 421-429

Shepherd, M., J. Bartle, D.J. Lee, J.T. Brawner, D.J. Bush, P. Turnbull, P.F. Macdonell, T.R. Brown, B. Simmons and R. Henry. 2011 Eucalypts as a biofuel feedstock. Biofuels 2(6) 639-657

Grants

This year, Camcore continued its successful partnership with the USDA Forest Service on domestic gene conservation and genetic diversity projects in the United States. Our three-year projects with hemlock *(Tsuga spp.)* and Table Mountain pine *(Pinus pungens)* have entered their final year utilizing third year funding allotments of $110,223 and $16,506, respectively. Additionally, we received USFS funding for three new projects in 2011: $163,755 for a two year project on gene conservation of Atlantic white-cedar *(Chamaecyparis thyoides)*; $83,316 for a two year study on the population genetic structure and diversity of Carolina hemlock *(T. caroliniana)*; and $45,040 for two years to study variation in adelgid susceptibility among species and families of hemlock.

Our project with FABI entitled, "Understanding pest and pathogen threats to pine under expanding global cultivation" was jointly sponsored NC State University and the University of Pretoria, and was completed in 2011. A final report submitted to the two universities, and is available on the web (http://oia.ncsu.edu/pretoria-seed-grant-status-reports).

University Committees and Service

Bill Dvorak, Professor of Forestry and Camcore Director, NC State University, served as adjunct professor in the Department of Forest and Wood Science, Stellenbosch University, South Africa. Bill gave one-week of lectures on tree improvement to 3rd year forestry students (juniors) at Stellenbosch University in October. Bill continues to serve as Associate Editor of Southern Forests (South Africa) and also is a member of the International Committee in the Department of Forestry and Environmental Resources, NC State University.

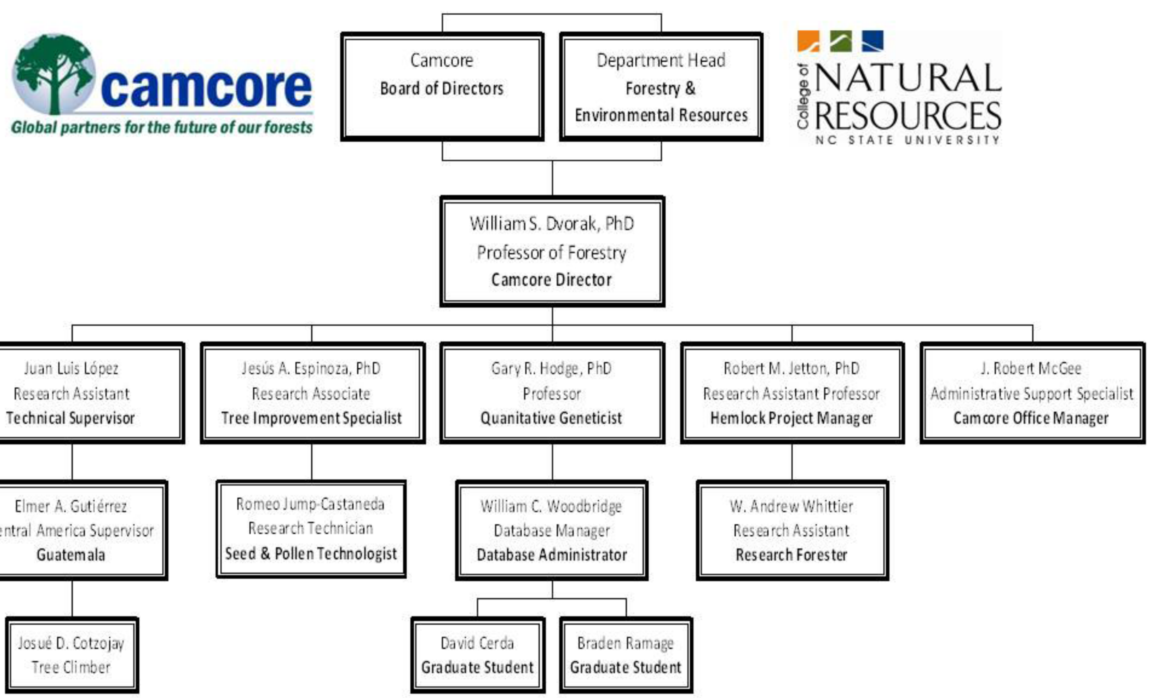
Gary Hodge, Professor of Forestry and Camcore Quantitative Geneticist, continued to serve as Associate Editor for the *Canadian Journal of Forest Research,* and reveiwed articles for *New Forests* and *Tree Genomes and Genetics.* Gary was the keynote speaker at the Canadian Forest Genetics Association Meeting in August, 2011. Gary also served on the Departmental Reappointment, Promotion and Tenure Committee.

Robert Jetton, Research Assistant Professor of Forestry & Camcore Hemlock Project Leader, was a peer reviewer for the Journal of Insect Science, Psych (entomology journal), and the Canadian Journal of Forest Research, and continues to serve as a Steering Committee member for both the USDA Forest Service Working Group on Genetics and Host Resistance in Hemlock and the Alliance for Saving Threatened Forests. Additionally, this year Robert was appointed as Associate Faculty in the NCSU Department of Entomology and was named an Associate Editor for the Journal of Insect Science in the subject areas of biogeography, community ecology, forest entomology, and invasive forest pests.

Robert McGee, Camcore Office Manager, served on the University's Group Insurance and Benefits Committee. The responsibility of the committee is to make policy recommendations to the Benefits office relative to maintaining and strengthening programs. Robert also continues to serve on the University's Transportation Appeals Hearing Board.

Willi Woodbridge served on the CNR IT Technical Advisory Committee. The group's purpose is to act as a liason between CNR IT staff and college members and to help define and plan IT projects helpful to the college.

Camcore Personnel



Graduate Programs and Training

Davíd Cerda Granados finished his MS project entitled "Geographical variation of cold hardiness in *Pinus patula* provenances and genetic inheritance of cold hardiness in *P. patula* × *P. tecunumanii* hybrids" at NC State in January 2012. Bill Dvorak and Gary Hodge were Co-chairmen of his graduate committee. David will return to Nicaragua to continue his career.

Hannél Ham continues her Ph. D. research on "Protocol for successful hybridization of *Pinus radiata* with other *Pinus* species" at Stellenbosch University. The project is under the supervision of Bill Dvorak, Arnulf Kanzler (Sappi) and Ben du Toit (Stellenbosch University).

Juan Lopéz (Camcore) had made progress on his Ph. D. research entitled, "The economic value of pine hybrids". Juan received a number of wood samples of pine hybrids from Mondi and Sappi in 2011 and is in the process of comparing pulp and paper properties of these to commercial controls. Bill Dvorak and Gary Hodge are on Juan's graduate committee.

José Jiménez Madrigal completed his MS project entitled, "Tropical pine hybrid verification using single nucleotide polymorphisms (SNPs) marker technology: case studies and applications to the forestry industry at NC State in mid-2011. Gary Hodge and Ross Whetten were Co-chairmen of his graduate committee. José has returned to Costa Rica where he will continue his research work.

Zadie Powers initiated her MS research work entitled, "Techniques for artificially infesting hemlock seedlings with the hemlock woolly adelgid (HWA). Robert Jetton (Camcore) is Chair of her committee.

Braden Ramage continues to work on his MS project entitled, "The Socioeconomic Impacts of Plantation Forestry in Rural Communities in Northern Mozambique". Bill Dvorak is Chair of his graduate committee.

Andy Whittier (Camcore) has initiated his MS research on, "Genetic/nutrient interactions and deficiency symptoms in Teak and Gmelina seedling raised in growth chambers". Gary Hodge is the Chair of Andy's graduate committee.

Jaime Zapata completed his Ph. D. work entitled, "Incorporation of molecular marker and spatial data into analysis of clonally-replicated progeny tests" at NC State in mid-2011. Ross Whetten, Fikret Isik (Co-chairmen), Steve McKeand and Gary Hodge were on his graduate committee. Jaime has returned to Chile to continue his research efforts with BioForest-Arauco.

Changes in Camcore

Eduardo Jose de Mello was named Vice-President Operations of FuturaGene in Brazil, a subsidiary of Suzano (Brazil).

Edival Zauza replaced **Joao Flavio da Silva** as the main contact for Camcore at Suzano (Brazil).

Sergio Andres Osorio replaced **Vitoria Restrepo** as the main contact for Camcore at Cementos Argos (Colombia).

Johan de Graaf is the new General Manager of Research & Development for Merensky (South Africa).

Charles Kempthorne is the new pine research technician at Merensky (Weza area), South Africa.

Willie Brink was named Technical Manager, MTO (South Africa).

Chris Bekker and **James Luckoff** were named the CEO and General Manager of Forestry, respectively, for Chikweti Forests (Mozambique).

Claudio Balocchi was named the Forest Group Manager for BioForest-Arauco (Chile).

Christian Montes was named Head of the Silviculture & Genetics Section at BioForest-Arauco (Chile)

Jean-Pierre Lasserre was named the new Manager of Silviculture Research & Development, CMPC-Forestal Mininco (Chile).

Edgar Londoño was named President of Smurfit Latin America.

Alberto Ramirez was named President of Smurfit Kappa Cartón de Venezuela.

Romeo Jump was hired by Camcore, NC State as the new Seed and Pollen technician.

CAMCORE BOARDS AND COMMITTEES

The 2011 Camcore Advisory Board

Ricardo Austin, Alto Paraná, Argentina

Claudio Balocchi, Arauco Bioforest, Chile

Simon van der Lingen, Border Timbers, Zimbabwe

Raúl Pezzutti, Bosques del Plata, Argentina

Sergio Andres Osorio, Cementos Argos, Colombia

James Luckoff, Chikweti Forests, Moçambique

Vernónica Emhardt/ Jean Pierre Lasserre, CMPC Forestal Mininco, Chile

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The 2011 Camcore Associate Members

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Michael Mussack & Francisco Escobedo, Grupo DeGuate, Guatemala

John R. Johnson, Mead Westvaco, USA

Barbara S. Crane/ Rusty Rhea, USDA Forest Service

The 2011 Executive Committee

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Claudio Balocchi, Arauco Bioforest, Chile

Jan van der Sijde, Komatiland Forests, South Africa

Miguel Rodríguez, Pizano Monterrey Forestal, Colombia

Mr. David, PT Sumalindo Lestari Jaya, Indonesia

Ricardo Paím, Rigesa, Celulose, Papel e Embalagens, Brazil

Rudolf Rahn, Smurfit Kappa Cartón de Colombia

Robert Purnell, Weyerhaeuser Company, USA

The 2011 Technical Committee

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Raúl Pezzutti / Raúl Schenone, Bosques del Plata, Argentina

Verónica Emhart, CMPC Forestal Mininco, Chile

Jeremy Brawner, CSIRO, Australia

Laercio Duda / Ricardo Paim, Rigesa, Celulose, Papel e Embalagens, Brazil

Arnulf Kanzler, Sappi Forests, South Africa

J. Byron Urrego, Smurfit Kappa Cartón de Colombia

Robert Purnell, Weyerhaeuser Company, USA

R. Glen Mitchell, York Timbers Pty Ltd, South Africa

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Josué Morales, INAB, Guatemala

Bernabé Caballero, INAFOR, Nicaragua

Pedro Brajcich Gallegos, INIFAP, México

Patricia Negreros Castillo, Instituto de Investigaciones Forestales, México

Osmany Salas, Ministry of Natural Resources, Belize

College of Natural Resources, North Carolina State University

Robert Brown, Dean

Dan Robison, Associate Dean for Research

Barry Goldfarb, Professor and Head, Department of Forestry and Environmental Resources

The Sylvania Wilderness on the Ottawa National Forest in Michigan's Upper Peninsula. Camcore completed a seed collection of 10 mother trees of *Tsuga canadensis* as part of the cooperative gene conservation effort with the USDA Forest Service.

Front Cover: Iván Appel next to a beautiful *Eucalyptus globulus* in the highlands of Victoria, Australia, during the 2011 Camcore Annual Meeting. This stand was naturally regenerated following a devastating fire in 1939.