camcore

Global partners for the future of our forests

NC STATE UNIVERSITY

2010 Annual Report

30th Anniversary

2010 CAMCORE ANNUAL REPORT

International Tree Breeding and Conservation

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Table of Contents

EXECUTIVE SUMMARY

1. Camcore celebrated its 30th anniversary in 2010 during the annual meeting in São Paulo, Brazil. A dinner was held to mark the occasion and included Advisory Board members from 26 organizations representing 11 countries, and special guests from the Brazilian forest industry who have enthusiastically supported the Camcore program over the years.

2. Camcore added 5 new members to the program in 2010 from Colombia, Mozambique, South Africa, the United States and Venezuela. At the end of the year, the program had 29 active and 4 associate members.

3. The Camcore membership held a strategy session in São Paulo to examine ways to meet the industry's needs over the next 10 years. Tree breeding, conservation, and species characterization continue to be important to the industry and greater emphasis will be placed on incorporating enabling technologies into the program.

4. A number of Camcore pine 2nd generation trials and hybrid tests were established by the members. Technology to verify pine hybrids using species-diagnostic SNP markers and NIR analysis was advanced. Seedlings of verified pine hybrids of *P. patula x P. tecunumanii* are being screened in the NC State phytotron (environmentally controlled chamber) to assess the heritability of cold hardiness and the correlations between growth chamber and field results.

5. The *Pinus taeda* GxE trials established in southern Latin America and two sites in South Africa are now three years of age. There is remarkable agreement among trials in that the Argentinean sources are superior in height growth to the Brazilian sources at all sites. Seed sources from warmer regions always did better than those from colder regions even when planted on colder sites.

6. Camcore initiated a bench mark study for improved *P. elliottii* that included families from Argentina, Australia (bulk only), the USA and Zimbabwe that ultimately will be established on 14 sites in South Africa and Mozambique.

7. New Camcore trials of teak were germinated in nurseries in Guatemala, Indonesia, Mozambique and Tanzania. Trials will also be established in Colombia. Camcore is collaborating with University of Copenhagen, Denmark to assess levels of genetic diversity in the species from different plantations around the world.

8. Much effort was placed in further developing the Camcore eucalypt hybrid program. Trials of the tropical *E. pellita* were established. Camcore members also received trials of cold hardy eucalypts; a family trial of *E. dorrigoensis* and a species x site trial series. These were part of a Camcore/CSIRO collaborative effort. In addition, a cold hardy bench mark trial series was distributed to members with the genetic material coming from improved orchards in South Africa. Wood studies of *E. urophylla* were initiated and pellet studies were planned.

9. Work continued on conservation parks in South Africa to hold base populations of pines and *E. urophylla*. Members in Colombia are working together to establish conservation parks for *Gmelina arborea.* Conservation activities continued for Table Mountain Pine *(P. pungens)* and Carolina and Eastern Hemlock (*Tsuga* spp) in the eastern US. Rigesa established a small *ex situ* conservation planting of Tsuga in Santa Catarina, Brazil.

10. Camcore and FABI (University of Pretoria) worked together to conduct a survey of pests and diseases in the pine forests of Guatemala. Funding for the work came from a joint NC State University/University of Pretoria grant.

11. The *Best Practices Survey* for pines, eucalypts, teak and *Gmelina* was completed. This assessment examined five areas: seedling development, cutting development, hedge production, site preparation and post-planting management.

12. At the end of 2010, the Camcore staff included 8 people at NC State and 2 people in Guatemala. The group gave 7 presentations at national or international conferences, were involved in the development/publication of 10 scientific papers, supervised five graduate students, attracted or utilized non-industrial support of US$ 129,500, taught three international short courses, and visited 25 of the 29 active members and 3 of 4 associate members in 17 countries.

RESUMEN EJECUTIVO (Español)

1. Camcore celebró su trigésimo aniversario en el 2010 durante su reunión anual en São Paulo, Brasil. Para celebrar la ocasión se tuvo una cena que incluyó la presencia de miembros de la Junta Asesora de 26 organizaciones, representando 11 países e invitados especiales de la industria forestal de Brasil quienes han servido de soporte al programa de Camcore a través de los años.

2. Camcore adhirió 5 nuevos miembros al programa en el 2010 de Colombia, Mozambique, Sur Africa, Los Estados Unidos y Venezuela. Al final del año, el programa tenía 29 miembros activos y 4 miembros asociados.

3. Los miembros de Camcore sostuvieron una sesión estratégica en São Paulo para examinar las maneras de cumplir con las necesidades de la industria en los próximos 10 años. Mejoramiento genético, conservación, y caracterización de especies continúan siendo importantes para la industria y se pondrá un mayor énfasis en la incorporación de tecnologías capacitadoras en el programa.

4. Varios ensayos de pino Camcore de segunda generación y de híbridos fueron establecidos por los miembros. Se avanzó con la tecnología para verificar los híbridos de pino mediante el uso de marcadores SNP específicos para las especies y análisis NIR (del infrarrojo cercano por sus siglas en inglés). Plántulas de híbridos verificados de *P. patula* x *P. tecunumanii* están siendo probadas en el phytotron de NCSU (cámaras de ambiente controlado) para evaluar la heredabilidad de la resistencia al frío y las correlaciones entre las cámaras de crecimiento y los resultados de campo.

5. Los ensayos de genotipo x ambiente de *Pinus taeda* establecidos en el sur de Latinoamérica y en dos sitios de Sur Africa ya cumplieron tres años de edad. Hay una tendencia entre los ensayos que muestra que las fuentes de Argentina son superiores en crecimiento en altura a las fuentes de Brasil en todos los sitios. Fuentes de semillas de las regiones más cálidas siempre se comportaron mejor que aquellas de regiones más frías aún cuando se plantaron en sitios más fríos.

6. Camcore inició un ensayo comparativo (bench mark) de *Pinus elliottii* mejorado que incluyó familias de Argentina, Australia (solamente semilla bulk), los Estados Unidos y Zimbabwe que finalmente será establecido en 14 sitios en Sur Africa y Mozambique.

7. La semilla de nuevos ensayos de Teca fue germinada en viveros en Guatemala, Indonesia, Mozambique y Tanzania. En el futuro próximo también se establecerán ensayos en Colombia. Camcore está colaborando con la Universidad de Copenhague en Dinamarca para evaluar niveles de diversidad genética en la especie de diferentes plantaciones alrededor del mundo.

8. Se dedicó mucho esfuerzo al desarrollo adicional del programa de híbridos de eucalipto de Camcore. Se establecieron ensayos del eucalipto tropical *E. pellita*. Los miembros de Camcore también recibieron semilla para ensayos de eucaliptos con resistencia al frío; un ensayo de familias de *E. dorrigoensis* y una serie de ensayos de especie x sitio. Estos fueron parte de un esfuerzo de colaboración entre Camcore y CSIRO. Adicionalmente, se distribuyó una serie de ensayos comparativos de resistencia al frío a los miembros con material mejorado procedente de huertos en Sur Africa. Se iniciaron estudios de la madera de *E. urophylla* y se planearon estudios de pellets.

9. Los parques de conservación continúan desarrollándose en Sur Africa para mantener poblaciones base de pinos y *Eucalyptus urophylla*. Los miembros en Colombia están trabajando juntos para establecer parques de conservación de *Gmelina arborea*. Se continuó con las actividades de conservación del *Pinus pungens* y de los abetos Carolina y del Este (*Tsuga spp*) en el este de los Estados Unidos. Rigesa estableció una plantación pequeña de conservación *ex situ* de Tsuga en Santa Catarina, Brasil.

10. Camcore y FABI (Universidad de Pretoria) trabajaron juntos en un levantamiento de plagas y enfermedades en los bosques de pino de Guatemala. Los fondos para el trabajo vinieron de aportes conjuntos procedentes de la Universidad Estatal de Carolina del Norte y la Universidad de Pretoria.

11. La encuesta de las Mejores Prácticas para pinos, eucaliptos, Teca y Gemlina se completó y los resultados fueron compilados. Esta evaluación examinó cinco áreas: desarrollo de plántulas, desarrollo de estacas, producción de setos, preparación de sitio y manejo después de plantar.

12. Al final del 2010, el personal de Camcore quedó conformado por ocho empleados en la Universidad Estatal de Carolina del Norte, y dos empleados en Guatemala. El grupo dió 7 presentaciones en conferencias nacionales e internacionales, estuvo involucrado en el desarrollo/publicación de 10 artículos científicos, supervisó cinco estudiantes graduados, atrajo o utilizó soporte financiero de origen no industrial por US $129,500 dólares, enseñó dos cursos cortos internacionales (manejo de bases de datos & mejoramiento genético) y visitó 25 de los 29 miembros activos y 3 de los 4 miembros asociados en 17 países.

RESUMO EXECUTIVO (Português)

1. Camcore celebrou seu 30º aniversário em 2010 durante a reunião anual em São Paulo, Brasil. Um jantar foi servido para marcar a ocasião onde estavam presentes os membros Conselheiros de 26 organizações representando 11 países e também convidados especiais do setor florestal brasileiro que, por muito anos, veem entusiasticamente suportado o programa Camcore.

2. Em 2010 Camcore adicionou 5 novos membros ao programa, sendo eles da Colômbia, Moçambique, África do Sul, Estados Unidos e Venezuela. Ao final do ano o programa tinha 29 ativos e 4 membros associados.

3. Os membros da Camcore realizaram uma sessão estratégica em São Paulo a fim de examinar maneiras de suprir as necessidades da indústria nos próximos 10 anos. Cruzamento entre árvores, conservação e caracterização de espécies continua sendo importante para a indústria e uma maior ênfase será dada à incorporação de tecnologias ao programa.

4. Uma certa quantidade de ensaios e testes híbridos da segunda geração de pinheiros da Camcore foi estabelecida pelos seus membros. Tecnologia a fim de verificar as espécies de pinheiros híbridos, especificamente marcadores SNP e análise NIR avançaram. As mudas (ou sementes) de híbridos de pinheiros *P. patula x P. tecunumanii* estão sendo selecionadas no fitotron da NC State (câmara de ambiente controlado) para avaliar a herdabilidade de resistência ao frio e as correlações entre a câmara de crescimento e resultados obtidos no campo.

5. Os ensaios com *Pinus taeda* GxE estabelecidos no sul da América Latina e dois locais na África do Sul estão com três anos de idade. Em todos os lugares em teste, existe um consenso entre os estudos indicando que as espécimes provenientes da Argentinas são superiores em crescimento em altura quando comparadas às provenientes do Brasil. Sementes provenientes de regiões mais quentes sempre foram melhores do que as de regiões mais frias, mesmo quando plantadas em locais mais frios

6. Camcore iniciou um estudo de mercado para *P. elliottii* melhorado, que incluiu as famílias da Argentina, Austrália (apenas volume), EUA e Zimbábue. Futuramente, estes serão estabelecidos em 14 locais na África do Sul e Moçambique.

7. Novos ensaios da Camcore com Teca foram germinados em viveiros na Guatemala, Indonésia, Moçambique e Tanzânia. Ensaios também serão estabelecidos na Colômbia. Camcore está colaborando com a Universidade de Copenhague, na Dinamarca para avaliar os níveis de diversidade genética das espécies provenientes de diferentes plantações ao redor do mundo.

8. Muito esforço foi colocado no desenvolvimento do programa de eucalipto híbrido da Camcore. Ensaios da espécie *E. pellita* tropical foram estabelecidos. Membros da Camcore também receberam os ensaios de eucaliptos resistentes ao frio; um ensaio da família *E. dorrigoensis* e também a série com espécies x. Estes faziam parte de um esforço colaborativo entre Camcore e CSIRO. Além disso, a série do estudo de mercado resistente a frio foi distribuída aos sócios com o material genético proveniente de pomares melhorados da África do Sul. Estudos da madeira de *E. urophylla* foram iniciados e estudos com peletes foram planejados.

9. O trabalho continuou em parques de conservação na África do Sul para manter populações base de pinheiros e *E. urophylla.* Membros na Colômbia estão trabalhando juntos para estabelecer parques de conservação para Gmelina arborea. Atividades de conservação continuaram para Table Mountain Pine *(P. pungens)* e Hemlock da Carolina e Oriental *(Tsuga* spp) no leste dos EUA. Rigesa estabeleceu uma pequena plantação de conservação ex situ de *Tsuga* em Santa Catarina, Brasil.

10. Camcore e Fabi (Universidade de Pretória) trabalharam juntas para realizar um levantamento de pragas e doenças nas florestas de pinheiros da Guatemala. O financiamento para o trabalho veio de uma concessão articulada entre NC State University e a Universidade de Pretória.

11. A pesquisa de boas práticas (Best Practices Survey) para pinheiros, eucaliptos, Teca e Gmelina foi concluída. Esta avaliação analisou cinco áreas: o desenvolvimento de mudas, desenvolvimento de corte, a produção de cepa, preparação do lugar e estabelecimento pós-plantio.

12. No final de 2010, a equipe Camcore foi composta de 8 pessoas da NC State e 2 pessoas da Guatemala. O grupo fez 7 apresentações em conferências nacionais ou internacionais, esteve envolvido no desenvolvimento / publicação de 10 artigos científicos, supervisionou cinco estudantes de pós-graduação, atraiu ou utilizou-se de apoio não-industrial no valor de $ 129.500, ensinou dois cursos internacionais de curta duração, e visitou 25 dos 29 membros ativos e 3 de 4 membros associados em 17 países.

RINGKASAN EKSEKUTIF (Bahasa Indonesia)

1. Camcore merayakan hari jadinya yang ke-30 di tahun 2010 pada saat pertemuan tahunannya di São Paulo, Brazil. Jamuan makan malam telah diselenggarakan untuk menandai peristiwa itu dan juga dihadiri oleh anggota Advisory Board dari 26 organisasi yang mewakili 11 negara, dan tamu-tamu istimewa dari industri kehutanan Brazil yang telah menyokong program Camcore dengan bersemangat selama bertahun-tahun.

2. Camcore menambah 5 anggota baru ke dalam programnya di tahun 2010, yaitu dari negara Kolombia, Mozambik, Afrika Selatan, Amerika Serikat (AS) dan Venezuela. Pada akhir tahun tersebut, program telah memiliki 29 anggota aktif dan 4 anggota tidak penuh.

3. Bagian keanggotaan Camcore mengadakan sesi strategi di São Paulo untuk memeriksa cara-cara untuk memenuhi kebutuhan industri dalam jangka waktu 10 tahun ke depan. Pemuliaan pohon, konservasi, dan pencirian spesies terus menjadi penting bagi industry dan penekanan yang lebih besar akan diletakkan dalam menggabungkan teknologi yang memampukan ke dalam program.

4. Sejumlah pinus percobaan generasi ke-2 dan uji hibrida dari Camcore telah dimantapkan oleh para anggota. Teknologi untuk membuktikan spesies pinus hibrida khusus SNP marker dan analisa NIR telah matang. Bibit yang terbukti dari pinus hibrida *P. patula x P. tecunumanii* sedang dipilih di NC State phytotron (ruang dengan lingkungan terkendali) untuk menilai penurunan sifat ketahan-dinginan dan hubungan timbal balik antara hasil di ruang tumbuh (percobaan) dan hasil di lapangan.

5. Percobaan *Pinus taeda* GxE yang ditanam di bagian Selatan Amerika Latin and dua lahan di Afrika Selatan sekarang telah berumur 3 tahun. Terdapat persetujuan yang luar biasa di antara percobaan yaitu bahwa sumber dari Argentina lebih unggul dalam hal pertumbuhan ke atas dibanding sumber Brasil pada semua lahan. Sumber-sumber benih yang berasal dari daerah hangat selalu lebih baik dari daerah dingin, bahkan jika benih itu ditanam di lahan daerah dingin.

6. Camcore telah memulai studi bench mark pada *P. elliottii* yang lebih baik yang termasuk famili dari Argentina, Australia (bulk saja), Amerika Serikat, dan Zimbabwe yang pada akhirnya akan ditanam di 14 lahan di Afrika Selatan dan Mozambik.

7. Percobaan baru Camcore untuk Jati telah mulai berkecambah di persemaian Guatemala, Indonesia, Mozambik, dan Tanzania. Percobaan juga akan dilakukan di Kolombia. Camcore sedang bekerjasama dengan Universitas Copenhagen, Denmark, untuk menilai tingkat keanekaragaman hayati dalam spesies dari berbagai perkebunan di dunia.

8. Banyak upaya diberikan untuk mengembangkan lebih jauh program hibrida Kayu Putih milik Camcore. Percobaan dari spesies tropis E. pellita telah dimantapkan. Anggota-anggota Camcore juga menerima percobaan kayu putih tahan dingin; satu famili percobaan dari *E. dorrigoensis* dan sebuah seri percobaan spesies x lahan. Itu adalah bagian dari suatu usaha kerjasama Camcore/CSIRO. Selain itu, suatu seri percobaan bench mark ketahan-dinginan telah dibagikan kepada anggota-anggota dengan bahan genetik berasal dari kebun yang telah diperbaiki di Afrika Selatan. Studi kayu *E. urophylla* dari telah dimulai dan studi pellet (butiran kayu) telah direncanakan.

9. Pekerjaan telah dilanjutkan pada hutan konservasi di Afrika Selatan untuk mempertahankan populasi dasar pinus dan *E. urophylla.* Anggota-anggota di Colombia sedang bekerja bersama untuk memantapkan hutan konservasi untuk Gmelina arborea. Kegiatan konservasi dilanjutkan untuk Pinus Gunung Meja *(P. pungens)* dan Hemlock Carolina dan Hemlock Eastern *(Tsuga* spp*)* di bagian Timur AS. Perusahaan Rigesa melaksanakan sejumlah kecil penanaman konservasi ex situ untuk Tsuga di Santa Catarina, Brasil.

10. Camcore and FABI (Universitas Pretoria) bekerja bersama untuk melangsungkan survai terhadap hama dan penyakit di hutan pinus Guatemala. Pembiayaan pekerjaan tersebut berasal dari hibah Universitas NC State/Universitas Pretoria.

11. Best Practices Survey untuk pinus, kayu putih, jati, dan jati putih telah diselesaikan. Penilaian ini memeriksa lima bidang: pengembangan pembibitan, pengembangan pemotongan, pembuatan kebun pangkas, persiapan lahan, dan pemantapan setelah penanaman.

12. Pada akhir tahun 2010, pegawai Camcore meliputi 8 orang di NC State dan 2 orang di Guatemala. Kelompok tersebut telah memberikan 7 buah presentasi di konferensi tingkat nasional dan internasional, terlibat di pengembangan/penerbitan dari 10 makalah ilmiah, membimbing lima mahasiswa paska sarjana, menarik atau mendayagunakan dukungan dari sektor non-industri sejumlah US$129,500, mengajar 2 kursus singkat internasional, dan mengunjungi 25 dari 29 anggota aktif dan 3 dari 4 anggota tidak penuh di 17 negara.

Message From the Director

It was a very good year. We celebrated our 30th anniversary, attracted 5 new members from as many different countries, and held a very successful strategy session at our annual meeting in São Paulo, Brazil. Let us examine these three different achievements.

Thirty-years is a long time to be around, especially for a program that is funded primarily (95%) by private contributions. The continuity of the Camcore program and the staff that manage it represents a great asset in a world that is changing so rapidly. Being anchored at a prestigious institution like NC State University also is very helpful. Turning the pages of the past that made Camcore what it is today are many dedicated people too numerous to list or mention. The standing ovation that the Camcore staff received at the 30th anniversary celebration in São Paulo in September was really a round of applause for everyone who has worked so hard to make the program successful over the years despite challenging odds

In 1980, we started with 4 active members, Weyerhaeuser, International Paper Company, Smurfit Kappa Cartón de Colombia, and Aracruz Florestal, and one associate member, the Forestry Seed Bank in Guatemala. Two of the four original charter members, Weyerhaeuser and Smurfit Colombia, are still with the program as is the Guatemalan Seed Bank. Today we have 29 active, 4 associate and 7 honorary members that represent 21 countries. The portfolio for the existing 29 active members is interesting: 64% of the members plant pines and eucalypts, 21% of the members plant only pines, 7% plant only eucalypts, 7% plant only Gmelina and 18% have some plantings of teak. As a group, Camcore members manage 1.95 million hectares of pines and 630,000 hectares of eucalypt plantations. Collectively, Camcore members annually establish 82,030 ha of pines and 65,600 ha of eucalypts. Our membership represents an important part of the industry that grows exotic tree species.

Every 10 years, the Camcore Advisory Board calls for a special strategy session to re-evaluate our technical goals and direction. At this year's strategy session, the discussions among members from different countries were cordial but frank, and dealt with both opportunities and challenges. We agreed that conservation, tree breeding and species characterization would remain important tenets of the program. We decided Camcore should be more involved in enabling technologies to make our tree breeding work more efficient. We questioned whether our Vision Statement needed to be amended slightly to better emphasize that Camcore is both a tree breeding and conservation organization dedicated to assist forest industry. Most importantly, we all agreed to continue to work together for the benefit of the entire group. After 30 years, the conference room for our annual meeting is still filled to capacity with CEOs, Vice-presidents and General Managers in what is arguably one of the most "open environments" for discussion and exchange of ideas that exists in any international forestry program.

Many years ago, an Advisory Board representative from Colombia told me, "Bill, keep Camcore going as long as you can". Thirty years is an important milestone for Camcore, but 60 years sounds better. We have a lot of work to do, but I am confident with the support of NC State University and the private sector, we will continue to make a positive impact on plantation forestry in the areas where we work around the world.

Thank you again for your support.

Bill Dvorak, Director

2010 Camcore Membership

Active & Associate Members

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

Australia
- CSIRO (Associate)

Brazil
- Klabin, SA
- Masisa Brasil Empreendimentos Florestais
- Rigesa, Celulose, Papel e Embalagens Ltda

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)

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, SA
- 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
- Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP)

Nicaragua
- Instituto Nacional Forestal (INAFOR)

The 2010 Annual Meeting in Brazil

The Camcore annual meeting was held in São Paulo, Brazil in October 2010. It attracted participants representing 23 active and 3 associate members from 11 countries. The meetings were divided into two parts; two days of technical sessions and two days of strategy sessions. Representatives from 6 of the most progressive forest industries in Brazil were also invited to the technical session to update them on Camcore activities. The technical session summarized the progress made by Camcore in its various working groups over the last 10 years. During the technical session, invited guest, Dr. Dario Grattapaglia from CENARGEN, EMBRAPA was asked to speak to the group about genomic selection.

The strategy sessions are a special event within Camcore that are held only once every 10 years to discuss the future direction of the program. This year's session, was led by Dr. Kevin Rice, Director for Training & Organizational Development at NC State. Prior to the meeting, Kevin and Bill Dvorak had worked on an electronic survey that was sent to the entire membership to solicit their feedback on matters relating to strengths, opportunities and threats to the Camcore program. The survey formed the basis for the discussion at the annual meeting. At the beginning of the strategy session, Mr. Daniel Contesse, Senior Vice-president of CMPC Forestal, Chile gave a presentation on his views about the future direction of the Camcore program. Bill Dvorak then summarized the results of the survey. During the roundtable sessions that followed, the group decided that the technical goals of the program should continue to be conservation, tree breeding and species characterization but also include enabling technologies. Dr. Andrew Morris, Camcore Chairman and General Manager of Research at Sappi, congratulated Kevin for a productive strategy session where everyone was encouraged to express their views in either English or Spanish.

Excellent attendance marked the 2010 technical sessions..

Juan López, José Romero, and José Quiaragua at the 30th anniversary celebration dinner.

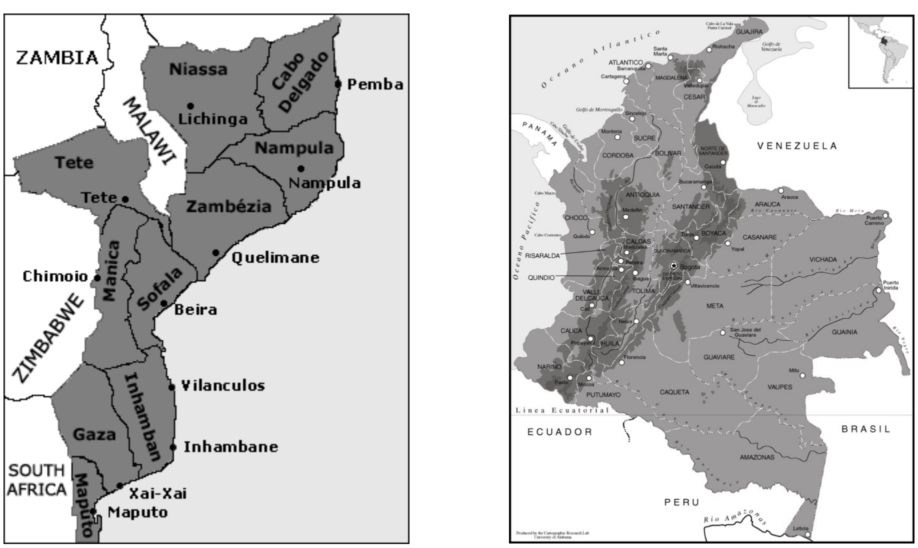
On the Thursday night of the weeklong event, Camcore celebrated its 30th anniversary with a dinner at a local restaurant. Special invited guests included: Mr. José Totti, Forest Director, Klabin, Mr. Etsuro Murakami, Forestry Director of MeadWestvaco-Rigesa and Mr. Manoel de Freitas, former Vice-president of Champion International and now a successful forestry consultant. Unfortunately, Dr. Djalma Chaves, Silviculturist, Klabin was unable to attend. Each Camcore member was given a commemorative plaque by the staff that listed the organization's name and the number of years of membership in the program. Special mention was made of Smurfit Cartón de Colombia and Weyerhaeuser as charter members of the program with 30 years of participation. The dinner ended with Andrew Morris thanking the Camcore staff for a job well done.

New Frontiers in Plantation Forestry: North-central Mozambique and Eastern Colombia

At the beginning of this decade, forestry organizations began to seriously consider north-central Mozambique for plantation forestry. The governmnent of Mozambique was eager to accept forestry projects as a means of generating jobs and revenue after a long and devastating civil war. There were large areas of land available with adequate annual precipitation for growing trees (1200-1800 mm), discovery of new mineral deposits such as coal were bringing in much needed infrastructural development into the country, and the human population levels were relatively low in the potential forestry areas. As a result, several large forestry companies conducted feasibility studies for projects in the provinces of Nampula, Niassa, Zambézia, Manica and Sofala (see map). As of today, Camcore members Chikweti Forests and Florestas de Niassa have large land holdings around Lichinga in Niassa, and the Chikweti Group also has projects around Gurué and Alto Molucue in Zambézia. Camcore member, Komatiland Forests (South Africa), purchased the IFLOMA (Manica Forestry Industries) near Chimoio six years ago and is considering further forestry expansion closer to the port city of Beira. Other multinational forestry companies are also developing projects in the provinces of Niassa and Zambézia.

Colombia has a long history of pine forestry in the Andes Mountains in the western part of the country as well as teak and *Gmelina* forestry along its northern coast. Camcore members Smurfit Kappa Cartón de Colombia, Pizano/Monterrey Forestal and Refocosta S. A. all have had long successful projects in these areas. Recently, foreign investors and large multinational forest organizations have begun looking at the great potential for plantation development in the flat eastern regions of the country called the llanos. There is as much as 3 million ha of land south of the Meta River in the Departments of Meta and Vichada that is suitable for plantation forestry (see map). The rainfall is good with annual amounts from 2800 mm to 1400 mm as one travels east from the foothills of the Andes towards Venezuela. The soils are deep Ultisols and Oxisols, mechanizeable but infertile. The political situation in the country is much more stable than it was 10 years ago making long term investments less risky, and large deposits of oil have been identified in the area that brings much needed capital and infrastructure, like roads and electricity, into the region.

The factor that will determine if northern and central Mozambique and eastern Colombia become forestry plantation centers in the world is not our ability "to grow trees",



Mozambique (left) and Colombia (right) offer new regions for plantation forestry.

but our abilty “to grow trees economically”.

We know from the past experiences of the Portuguese in Niassa and Manica provinces in Mozambique that pines can be grown successfully in the region at the higher altitidues (900-1400 m). With proper silviculture, eucalypts appear to have a good future at the lower elevations in the central part of the country. Still, the challenges for plantation forestry are many. First, it is difficult to find large contiguous areas of land for plantations that do not harbor one or more villages. Great people skills are needed in dealing with local villagers regarding employment and training, as well as meeting the challenges of malaria and increasing rates of HIV/AIDS. Fires set by villagers during the dry season to clear land for agriculture and regenerate grasses for livestock pose a real and constant threat to the plantation investments. Second, markets for wood are far away from the plantation area unless land can be found near the Beira or Nacala corridors with open access to sea transport. Will the infrastructure develop sufficiently to allow products to get to export markets at a competitive cost? New roads and bridges are being built in Mozambique, but several years ago it could take a truck six weeks to travel from Maputo in the southern part of the country to Lichinga in the north. Third, will forestry organizations use the right species/site match, or will they use seeds of species that are not really adapted to the region because they are more available on the open market? The highlands of Niassa are a near perfect altitudinal and latitudinal match for tropical pines *P. tecunumanii* and *P. maximinoi,* although the 8-month dry seasons in Mozambique are longer and more severe than those in Central America. The greatest challenge to successful plantation forestry (along with fire danger) is how to control excessively rapid weed growth. Herbicide usage is the only option in the region to keep projects sustainable. Low labor costs in Mozambique set the stage for large industrial development. The local people are smart and eager to learn, but there must be a continued country-wide and company-wide effort to train young professionals. Many of the forestry companies are working diligently with local universities to educate future foresters, but it will take time.

Like Mozambique, enough pilot plantings have occurred in the eastern llanos of Colombia to confirm that Caribbean pine can be successfully grown there. The Refocosta project at Villaneuva has also shown that eucalypts have great potential. With the right species, clonal forestry, fertilizer, and weed control, MAIs near 40 m^3/ha/yr are probably obtainable in the higher rainfall areas close to the foothills of the Andes (productivity will decrease as one travels east because rainfall drops off). *Acacia mangium* also has potential in areas of high precipitation. Like Mozambique, there is a question about how fast infrastructure will develop in the llanos. It can be a 12-15 hour drive from points in the Colombian llanos to Bogota, and the 2300 m climb up the Andes on winding roads to the capital city can be arduous and probably impractical for a large number of heavily laden trucks. A more feasible route for export of forestry products produced in the llanos might be transport down the Meta and Orinico Rivers to the Atlantic Ocean. However, river transport crosses international borders with Venezuela, and future political relations between the two countries will probably determine whether a water route for export will be feasible. With expanding oil exploration in the llanos, the infrastrucure problem may be resolved in the next few years. Colombia is well positioned to develop productive forest industries in the llanos because the country has a strong business culture with a well educated populace, including well-trained foresters. Political instability and market distance are really the only factors that could limit plantation development.

Plantation development has already begun in north-central Mozambique. It is anticipated that large plantation areas will be secured by local and international companies in eastern Colombia in the next 18 months if the economic and political climate remains favorable. Camcore, working with its members, is very much involved in plantation forestry in both countries. Field trials have been established to demonstrate what species and populations will best serve the forestry community. We are currently addressing some of the social aspects of forestry in Mozambique. Branden Ramage, Camcore graduate student, is assessing how plantation forestry benefits small rural communities (see "Graduate Programs" in this report). This research is partially sponsored by the Chikweti Group. We are confident that with hard work and creative thinking, we will meet the challenges to plantation development in these new forestry regions.

Developments in Camcore

Four new active members joined Camcore in 2010: **Cementos Argos** (Colombia), **Florestas de Niassa** (Mozambique), **PROFORCA** (Venezuela) and **York Timbers** (South Africa). **MeadWestvaco** (USA) joined as an associate member. We welcome our new partners! At the end of 2010, the Camcore program had 29 active members, 4 associate members, and 7 honorary members that represent 21 countries.

The Camcore staff made technical visits to all but two of its active members in 2010. Below, we summarize some of our activities.

Argentina

Gary Hodge visited **Alto Paraná (APSA)** in August. 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 in the first series of pine hybrid trials. In 2011, APSA will make selections in their first-generation progeny tests of *P. caribaea, P. tecunumanii,* and *P. maximinoi.* APSA will also be taking wood samples for the Camcore *E. urophylla* wood quality project.

Also in August, Gary Hodge and Jesus Espinoza visited **Bosques del Plata (BDP).** BDP hosted the Camcore Southern Latin America Regional Meeting. Six member companies sent representatives to the meeting, and there were 16 participants total. As at Alto Paraná, the hybrids of *P. caribaea x P. tecunumanii* and *P. caribaea x P. oocarpa* looked very good. BDP is serving as the Regional Coordinator for the pine hybrid project, with the second series of hybrid trials is scheduled to go out in late 2010. This series contains *P. greggii* S x *P. tecunumanii,* which has the potential to do very well in Argentina since the *P. greggii* S contributes some frost hardiness to the hybrid.

Juan Schapovaloff, Germán Raute, and Carlos Gioia of Alto Paraná with an outstanding tree in the Camcore *E. urophylla* provenance / progeny trial.

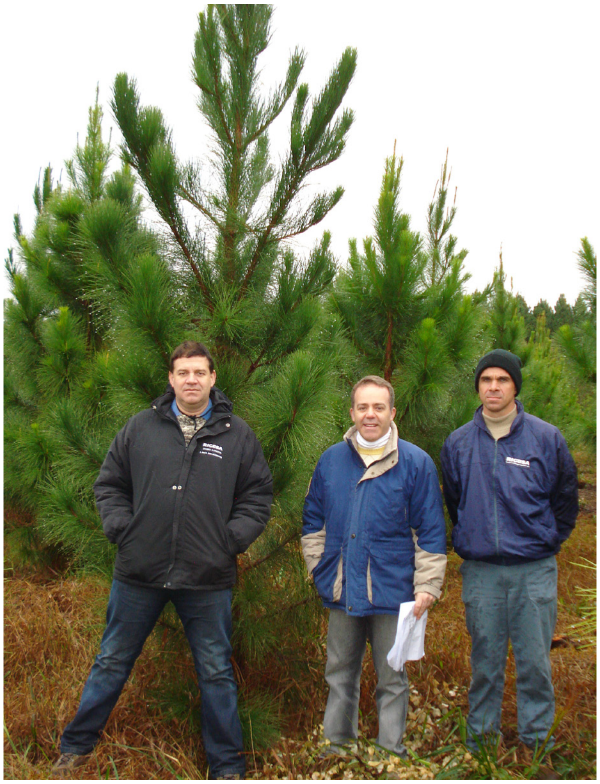
Jeremy Brawner (CSIRO) looks at a clonal trial of *P. elliottii x P. caribaea* var.. *hondurensis* in Queensland

Australia

Bill Dvorak visited **CSIRO** in Queensland to discuss the possibility of having the 2011 Camcore annual meeting in Australia. As part of the planning process, Bill visited several progeny trials and natural populations of eucalypts as well as some of the old pine clonal studies established by local forestry organizations in the area. Bill also stopped at the University of the Sunshine Coast to see some of the tree breeding research being conducted by local scientists.

Brazil

Bill Dvorak and Juan López visited **Klabin** in July, and Jesús Espinoza followed up with a short visit in August. In the field, they visited the Camcore *P. taeda* G x E trials, a pine hybrid trial, a commercial planting of *P. maximinoi* and several of the old Camcore plantings of *P. pringlei.* The talk was about ways to reduce the length of the breeding cycle and also about methods to conserve some of the important Camcore base populations that exist on Klabin land that are more than 20 years old. Jesús' visit dealt with working with Klabin researchers on the nutrient base line project for tropical pines.



Laercio Duda, Ricardo Paim, and Waldemar Veiga of Rigesa visit a 3-year-old Camcore *P. taeda* GxE trial in Paraná, Brazil.

Bill and Juan also visited **Rigesa** in July. Field visits were made to the Camcore *P. taeda* G x E trials and two pine hybrid trials. The Rigesa *P. greggii* clonal bank is developing well. We spoke about opportunities with some of the cold hardy eucalypt species that Camcore is testing and also visited the small nursery with hemlock *(Tsuga)* seedlings. Rigesa coordinated the propagation of rooted cuttings of pine hybrids with a privately owned nursery for distribution to the other members in Brazil and Uruguay. Rigesa did a great job as the regional coordinator and hybrid trials were planted by Rigesa, Klabin and Weyerhaeuser.

Chile

Gary Hodge and Robert Jetton visited **Bioforest – Forestal Arauco** in June. With Arauco, discussion topics included optimal breeding strategies for eucalypt hybrids and importation of second-generation seed of Camcore species from Brazil. Chile continues to have some of the most rigorous phytosanitary requirements in the world, and the imported seed will need to be grown in special quarantine greenhouse for one year.

Arauco continues to do an excellent job maintaining the Carolina hemlock *(Tsuga caroliniana)* conservation bank established at Cuyimpalihue in 2008. The construction of a wire fence around the trial and the use of animal repellent has successfully limited rabbit browsing and related seedling mortality in the field plot. We also discussed Arauco rooting stem cuttings from the planted hemlocks so that the conservation bank can be replicated on a second site.

Gary went on to visit with **CMPC Forestal Mininco.** Discussion topics there included somatic embryogenesis of pines (both *P. radiata* and Camcore pine species), appropriate economic weights for growth, density and pulp yield in the CMPC eucalypt breeding programs, and pine and eucalypt hybrid breeding. CMPC has been working for a number of years now with hybrids of cold-tolerant *E. nitens* and *E. globulus.* The Camcore Temperate Eucalypt species trials will offer the possibility of broadening the species portfolio for the company. CMPC will also import pine hybrid seed from South Africa, which will be kept in their quarantine greenhouse for one year. The seedlings will be managed as hedges, and after one year, cuttings produced for hybrid tests for both CMPC and Arauco.

Colombia

Jesús Espinoza and Bill Dvorak visited **Refocosta** in November 2010 to review and consolidate the breeding strategies for the pines, eucalypts and teak species. Refocosta has intensified its effort to establish more trials to generate useful information for each of those species. In 2010, the company's teak clonal seed orchard began to produce seeds; in the near future, Refocosta will be able to supply seed both for its own needs, and also for the commercial market. In the near future, the company is also planning to establish a *Pinus caribaea* seed orchard between 900 and 1300 m elevation.

Jesús and Bill also visited **Monterrey Forestal (Pizano)** to review the breeding strategies for both *Gmelina arborea* and *Pachira quinata,* and to make suggestions on how to develop a eucalypt resource in the company. Today, the company has one of the most advanced breeding programs of *G. arborea* and *P. quinata* in the world. Monterrey Forestal has two second-generation *Gmelina* seed orchards and two thrid-generation *Pachira* seed orchards. Camcore selections are part of the material used in the seed orchards for both species.

José Luis Romero, Carolina Guevara and Sandra Leiva at the Refocosta (Colombia) teak clonal seed orchard.

East Africa

Bill Dvorak visited **East Africa** in February. The trip was designed to see the new Camcore progeny trials of *E. urophylla* established in the field by TAFORI in Tanzania as well as to visit the nurseries where the Camcore teak seedlings were being grown. Accompanying Bill on the trip was Ben Kanyi, the coordinator of the Camcore East African group and Mbae Muchiri from KEFRI (Kenya) as well as the TAFORI research team. The *E. urophylla* trial we saw near Morogoro was very well established and will provide the country a useful source of genetic material. TAFORI has sent in all the establishment reports and first-year data for the trials. The germination of the Camcore teak seedlings experienced some problems in the pricking out phase at Mitibwa nursery, but good practices thereafter have recovered enough seedlings to establish useful trials.

Guatemala

Camcore is giving technical support to **Grupo DeGuate** for the establishment of a clonal seed orchard of *P. maximinoi* and *P. oocarpa* in Guatemala. During Juan's technical visit in May, he noted that Grupo DeGuate had done a great job making selections of good phenotypes of *P. oocarpa* in the stands of El Incienso farm. They have been practicing and training personnel to prepare for grafting the scions of selected trees. The second-generation studies planted by Grupo DeGuate with INAB have been well maintained.

Indonesia

Bill Dvorak visited **PT Sumalindo Lestari Jaya** in January. Because of extremely heavy rains, we were not able to visit the *Gmelina* plantations at Batu Putih. Still it was a productive trip because it gave us the opportunity to go over the *Gmelina arborea* breeding and clonal strategy. One of the key questions with both Gmelina and teak is how does one conduct early thinning at 3 to 4 years of age in genetic trials so it does not affect family and individual tree rankings? We also discussed the initiation of the Camcore teak trials.

Mexico

In the month of November, Gary Hodge and Juan López visited **Fomex**. Camcore continues to give assistance to the company in the selection of species and land for the expansion of its forestry project in the states of México and Michoacán. *Gmelina arborea, Eucalyptus pellita* and *Corymbia torrelliana* show great potential in México, and *E. nitens, E. globulus* and *E. dunnii* are very promising in Michoacán. Genetic trials of *E. pellita* from Indonesia were sent to the company by Camcore this year for establishment in the areas of Tabasco and Veracruz, where the species has great potential. Camcore is helping Fomex to update and implement its tree breeding program with *E. urophylla* in the Southeast and *E. nitens* in Michoacán. Fomex is participating in temperate and tropical species projects, as well as taking a large number of samples for the *E. urophylla* wood quality project.

Mozambique

Bill Dvorak and Jesus Espinoza visited the **Chikweti Group** and **Florestas de Niassa.** Chikweti has developed an active research program in northern and central Mozambique for pines, eucalypts and teak. At Chikweti Forests, large plantation areas of *P. tecunumanii* and *P. maximinoi* are being developed on the clay soils in the area. Several Camcore pine trials and one hybrid trial have been established. Future seed stands of *P. caribaea, P. maximinoi, P. oocarpa* and *P. tecunumanii* have been demarcated and will serve as a temporary source of seeds until more improved material can be developed. The company has worked very hard to establish a number of genetic and silvicultural trials to move the operational program along quickly. We also visited the eucalypt (N'tacua) and teak (Tectona) programs in the Chikweti group. At N'tacua, we discussed the need to establish more eucalypt trials of different species and went over some of the protocols for vegetative propagation of eucalypts with the research staff. N'tacua will receive the Camcore *E. pellita* trials. At Tectona, we visited a number of teak sites and discussed the limitations of the species with respect to the soils in the area. Tectona has received the Camcore teak trials and these were about to be planted after our visit.

Florestas de Niassa is just beginning its program. We talked about choice of tree species and populations for Florestas de Niassa. In their first year as a Camcore member, they have received seeds of *P. maximinoi* and *P. tecunumanii* from Camcore as well as the *P. elliottii* benchmark study (see section on *P. elliottii*). The company is working to develop its research team and we expect to see much progress in the next 12 months.

South Africa

Gary Hodge and Juan López visited **Sappi** in February. We spent time discussing Sappi's internal breeding program for *E. dunnii*, as well as the operational control pollination program for the production of *P. patula x P. tecunumanii* hybrids. Sappi has also shifted its nursery production of eucalypt hedges from macro-hedges to mini-hedges in sand beds, and will do the same with their pine cutting program. Field visits were made to the *P. greggii* N clone bank, and a *P. jaliscana* trial.

Gary and Juan also visited **Mondi** during their February visit. Mondi has scaled up their pine hybrid production, with commercial production of *P. patula x P. tecunumanii* and *P. patula x P. greggii* S, and pilot level production of 9 other hybrids planned for 2011. Mondi has also completed a significant expansion of greenhouse facilities for both pines and temperate eucalypts, and will be serving as the Regional Coordinator for southern Africa for the third pine hybrid series. The Pine Hybrid Wood Quality research project (part of Juan López's PhD research) will utilize *P. taeda x P. tecunumanii* and *P. greggii x P. tecunumanii* samples from Mondi, as well as *P. patula x P. tecunumanii* samples from Sappi.

Jesús Espinoza (Camcore, left), John Mortimer (middle) and Irvine Kanyemba (Florestas de Niassa, right) talk about using the correct seed sources of pines and eucalypts

Bill Dvorak visited **MTO** in March and **Komatiland Forests (KLF)** and **York Timbers** in June. In the last several years, **MTO** has established a large number of Camcore trials while continuing their local work on *P. radiata* and *P. elliottii* hybrids. Second-generation trials of *P. tecunumanii* and *P. maximinoi* are in the ground as are several pine hybrid trials and assorted first-generation material. *Pinus taeda* has been planted in the Cape region of South Africa for decades, but recently Camcore helped MTO secure second-generation *P. taeda* from Marion County, Florida, which had never been tested there before. Its initial growth after several years is very promising, and of course, it is resistant to the Pitch Canker fungus. The MTO research team did a great job handling a very heavy trial establishment workload.

The visit to **KLF** emphasized the development of the pine hybrid program and Conservation Park. The early growth of the *P. patula x P. tecunumanii* hybrid has been phenomenal in the Sabie area and KLF has large genetic bases of both species for further breeding. KLF has invested much effort in completing the Camcore Conservation Park; much of the genetic material is being moved into the Park by grafting. There were good discussions in the office about ways to reduce the breeding cycles and the need to utilize the fast growth of some of the Mexican pines and hybrids to reduce rotation age for solid wood products.

The visit to new member **York Timbers** was to better understand what genetic material was available for development and breeding. York has a wealth of old Camcore trials from the days Mondi owned the property as well as a large amount of additional material developed locally. We owe much thanks to the past research managers at York who maintained these valuable resources in good shape. Furthermore, York is making a large

Andre van der Hoef (MTO) walks through a young planting of 2nd generation *P. taeda* from Marion County, Florida, USA planted in the Cape region of South Africa.

number of its own pine hybrid crosses to test in the field. York has received Camcore *P. tecunumanii* and *P. maximinoi* material, the Camcore pine hybrids trial, the *P. elliottii* benchmark study and will participate in some of our eucalypt testing.

In August, Bill Dvorak and Gary Hodge visited **Merensky Holdings**. Merensky has made good progress in recent years in the establishment of progeny tests, hybrid trials, and species-provenance tests. Field trips were made to Weza and Langeni. The conservation park for *E. urophylla* is developing well at Weza. The second-generation *P. maximinoi* and *P. tecunumanii* trials are growing well and are ready for their third year assessment. We also saw a number of natural *P. tecunumanii* x *P. patula* hybrids in the second-generation trials, and have identified this as an issue for further study and consideration. As elsewhere in South Africa, *P. patula x P. tecunumanii* hybrids are developing nicely at a young age, and we discussed other possible pine hybrid combinations that have potential for the company.

Gary and Bill also visited **PG Bison** in August. The most important accomplishment there was the conversion of a number of old Camcore, Mondi and SAFRI progeny tests of *P. patula* into Seedling Seed Orchards. These stands were in danger of being lost completely due to overstocking and severe *Sirex* problems. With the thinning completed, the company has taken a huge step toward the production of their own genetically improved *P. patula* seed. Similar work on thinning the *P. greggii* trials will be done in 2011. We had good discussions about future breeding and testing strategies, seedling and cutting production options for these species, and the potential value of alternate species such as *Pinus leiophylla* (with its good growth, fire resistance, and ability to hybridize with *P. patula*). PGB is also expanding its plantations of *E. nitens*, and Camcore is providing the company with additional species and provenances of cold hardy eucalypts for testing.

United States

MeadWestvaco joined Camcore as an associate member and their representatives were present at our annual meeting in São Paulo in mid-September. The company is interested in learning more about the Camcore eucalypt program and developing contacts with members from around the world.

Camcore continued to cooperate with the **USDA Forest Service** on grant-funded forest resource conservation projects with Eastern hemlock *(Tsuga canadensis)*, Carolina hemlock *(Tsuga caroliniana)*, and Table Mountain pine *(Pinus pungens)* that are of domestic importance in the US. We visited several national forest sites dur-

Louis van Zyl of Merensky next to a 3-year-old *P. tecunumanii* growing at Weza, South Africa.

ing the year and worked closely with Forest Service personnel to identify and collect seeds from new populations of each species. We also participated in Forest Service-sponsored scientific meetings, and with Forest Health Protection cohosted a meeting on hemlock genetics in Raleigh in May.

Uruguay

Jesús Espinoza visited **Weyerhaeuser** in July. Several topics about nursery management, second-generation and hybrid pine trial establishment as well as the future subtropical, temperate and *E. dorrigoensis* Camcore/CSIRO eucalypt projects were discussed. The company has begun to study the integrated management of the different tropical and subtropical pine and eucalypt species, including nursery production and management. This will help to understand differences in the requirements and behavior of these species in the nursery and in the field. The new nursery facilities are helping to improve the production and quality of the seedlings. The company also has been working to better understand how to manage eucalypt plantations to reduce the problems in the mill for solid wood products.

Venezuela

In 2010, **PROFORCA** rejoined Camcore as an active member after several years of absence. PROFORCA plays a very important role in the plans of the Venezuelan government to develop an ambitious reforestation program for the country. During a visit in March, Juan López and Jesús Espinoza gave recommendations to the forestry group to help the organization with their pine tree breeding program and the implementation of a clonal program. Camcore will send pollen of different pine species to make hybrid crosses in the *P. caribaea* seed orchard.

Camcore continues to assist **Smurfit Kappa Cartón de Venezuela (SKCV)** with its tree breeding strategies for *P. caribaea, E. urophylla* and *Gmelina arborea.* Seeds for second-generation progeny trials of *P. caribaea* from Camcore selections at PROFORCA have been received by SKCV. The establishment of these new trials will increase future gains in plantations and will broaden the genetic base of the species. Unique seeds of *E. pellita* families collected by Camcore in Indonesia will be sent to SKCV at the beginning of 2011 for the establishment of provenance/progeny trials. The tests will help the company to explore the potential of the species as a pure species and as a hybrid with other eucalypts.

Jésús Espinoza and Juan Pedro Posse visit a Weyerhaeuser *P. taeda* pruning trial in northern Uruguay.

Camcore continues to help **Terranova** develop its clonal program with *P. caribaea* in the eastern part of Venezuela. Juan López and Jesús Espinoza gave recommendations during the Camcore technical visit in March to accelerate the tree improvement program and to move the genetic gains obtained from research to operational level. As part of this process, Camcore coordinated a visit of Terranova's technical staff to Smurfit Kappa Cartón de Colombia this year, for practical training in vegetative propagation of pines. Camcore continues to work hard with Terranova to move its tree breeding program forward.

Zimbabwe

Bill Dvorak visited with **Border Timbers** in April. The company has a well-established plantation program with *P. patula, P. taeda,* and *P. elliottii.* The company also has eucalypt programs with *E. grandis* and *E. cloeziana.* It grows plantations for solid wood products. The subject of our discussion was to find ways to rapidly test *P. tecunumanii* and *P. maximinoi* across different sites as a possible replacement for *P. patula* at the lower elevations. Discussions were also about alternatives to planting pure *E. grandis.* Camcore has provided Border Timbers with *P. tecunumanii* and *P. maximinoi* trials and it has received a pine hybrid trial from KLF. Camcore has also sent a small amount of teak to Border Timbers to try on a research scale.

Pine Second-Generation Progeny Testing

The first generation of pine provenance / progeny tests established with seed collected from native stands has produced tremendous benefits. Species such as *Pinus maximinoi, P. tecunumanii, P. greggii, P. patula*, and *P. caribaea* all have utility as commercial species somewhere in the world, even as unimproved material. Camcore members have identified outstanding families and made well over 2000 selections from these species, and have been working hard to conserve those selections in orchards and clone banks, and collect seed for the next cycle of testing. Over the past several years, we have made a substantial effort to move many of our pine species into the second generation of testing. There are currently a total of 71 second-generation trials of pines, with the bulk of them of *P. tecunumanii* and *P. maximinoi* (Table 5), and most of the tests have been established in southern Africa and Colombia. In 2010, second-generation seed of *P. maximinoi*, *P. patula, P. greggii*, and *P. tecunumanii* were distributed to seven members in southern Latin America (Argentina, Brazil, and Uruguay). Some of these seedlots were sown and were growing in the nursery at the end of 2010. Tests were scheduled for planting either just at the end of 2010 or the beginning of 2011.

We continue to see impressive growth in the second-generation tests of *P. tecunumanii* and *P. maximinoi* that were planted in South Africa in 2008, and anticipate that we will see substantial genetic gains when these tests are measured at ages and 5 and 8 years.

Table 5. Second-generation progeny tests of pine species planted by Camcore members as of 2010.

Species	Tests Planted
P. tecunumanii	27
P. maximinoi	21
P. patula	12
P. chiapensis	6
P. caribaea	2
Miscellaneous pines	3
Grand Total	**71**

Lebo Mohahlele of Komatiland Forests in front of a 2-year-old tree in a 2nd genereation *P. tecunumanii* trial in Mpumalanga, South Africa.

Eucalyptus urophylla Wood Quality Study

In 2009, the Camcore Advisory Board approved a research project on the wood properties of *E. urophylla* wood quality. Camcore has sampled 1116 families from 62 provenances from all 7 islands in Indonesia where the species is found. The purpose of the project is to evaluate wood properties at the provenance level. Wood samples will be taken from 2140 trees in five countries (Argentina, Colombia, Mexico, Venezuela and South Africa). A total of 56 provenances will be sampled, with 37 of the provenances sampled in two or more regions. Currently, we plan to measure density and cellulose content, although other wood properties could be measured in the future. Camcore members Alto Paraná, Fomex, Merensky, Mondi, Smurfit Kappa Cartón de Colombia, and Smurfit Kappa Cartón de Venezuela will be involved in the wood sampling, which began in 2010.

Teak and *Gmelina* Update

The Camcore teak program has been well received by its members and is of interest to other organizations. By mid 2010, Cementos Argos from Colombia joined as an active member of Camcore with the purpose of advancing its tree breeding program with teak and participating in the seed exchange with other members of Camcore. Cementos Argos has already sent teak seeds of 20 selected trees to the Camcore office in Raleigh, material that will be distributed to the other members planting this species.

Genetic trials were designed and distributed with all the seeds received by Camcore from its members in 2009. Seeds were shipped to all the members taking part in the teak program for the establishment of two source/progeny trials on different sites. Close to 100 families comprise the total amount for the two trials that share 33% of the families. Table 6 illustrates the status of trial establishment: as of December 2010, 5 trials at 2 different companies have been planted in the field: Chikweti and Grupo DeGuate. In 2011, seven more trials will be established by East Africa, Sumalindo, Refocosta and Cementos Argos.

During the 2010 annual meeting in Brazil, a research study on teak was approved by the Camcore group. The study is related to the economics of reducing teak tree improvement program cycles through induction of flowering in young plantations, using different doses and methods of application of Paclobutrazol. This is the first of a series of Camcore research studies on teak, aiming to increase flowering and fruit production efficiency in order to shorten the tree improvement programs, saving time and money for the companies. In 2012, once results of this trial are known, a subsequent study on efficiencies of controlled pollination techniques will be conducted.

Camcore continues to stay in constant communication with its members to bring new ideas and activities into the program. After the annual meeting in October, Camcore sent a comprehensive list of teak references of research studies on genetic improvement, vegetative propagation and silviculture, including recent articles. In December 2010, Camcore sent a survey to its members planting teak and *Gmelina arborea*, asking questions regarding developments in their tree improvement programs.

Table 6. Status of teak source/progeny trials establishment by Camcore members 2010.

Country	Member	Trials in storage	Trials in nursery	Trials in field
Mozambique	Chikweti			2
Guatemala	Grupo DeGuate			3
Tanzania	East Africa		1	
Indonesia	Sumalindo		2	
Colombia*	Refocosta	2		
Colombia*	Cementos Argos	2		

* Import permit for the seeds took several months for approval.

The purpose of the survey is to learn more about the needs of the companies and the ways that Camcore can better help them. In 2011, Camcore will start the publication of a teak and Gmelina newsletter with the objective of keeping its members updated on research and technology activities developed with the species within and outside of Camcore.

Camcore is also trying to overcome the hurdles on restrictions to import genetic material of teak from several Asian countries like India and Thailand. Multiple contacts have been established searching for seed sources that will allow bringing in more genetic diversity and variability of the species to the program.

From our Camcore office in Raleigh we have been coordinating seed collections of *Gmelina arborea* from selected trees in the field trials on members' land and other activities among the members. In 2010 we received seeds from Pizano and Smurfit Kappa Cartón de Venezuela that will be used for the establishment of second-generation trials. Two trials with seeds from both companies will be shipped to Sumalindo and two trials with seeds from SKCV will be shipped to Pizano in 2011. Genetic material of China origin will be shipped from SKCV to Pizano in Colombia for the establishment of clonal trials. Rooted cuttings of *Gmelina arborea* were sent from Smurfit Kappa Cartón de Colombia to Pizano and Refocosta for the establishment of a conservation bank and clonal trials.

We expect that other companies with commercial plantations of teak and/or *Gmelina* will become members of Camcore in 2011 to receive all the benefits of Camcore synergies, knowledge and experience. New members come to the program with additional seed sources.

Teak Genetic Diversity Study

In 2009 Camcore was invited to participate in a genetic diversity study of teak by the University of Copenhagen in Denmark. The objective is to study the genetic diversity of teak, looking for relationships between native populations in Southeast Asian countries and land races in Africa and Central America. Twenty-five populations from the natural distribution area in India, Thailand, Laos and Indonesia will be compared to landraces from Tanzania, Ghana, Ivory Coast, Costa Rica, Nicaragua, Panama, Colombia, Guatemala, Indonesia, Mozambique and Venezuela. The following Camcore members provided seed samples for the study: Refocosta, Grupo DeGuate, Sumalindo, Chikweti and Smurfit Kappa Cartón de Venezuela. Results of the study will be obtained in 2011, which will bring valuable information on the variability present within the Camcore genetic trials.

Eucalyptus Benchmark Trials

About 75% of Camcore members plant eucalypts, and thus have their own proprietary breeding and selection programs for their commercial species. As part of Camcore's effort to broaden its work with eucalypts and to develop cooperative projects that would benefit our members, in 2010 we initiated a test series called "South Africa Eucalypt Benchmark Trials" for the subtropical and temperate species. The objective of this study is to compare improved Sappi and Merensky material to local controls for growth and cold hardiness. For the temperate species series, the species included will be *E. nitens, E. dunnii, E. macarthurii, E. smithii, E. benthamii,* and *E. saligna.* Bulk seedlots of improved seed of the first five species were purchased by Camcore from Sappi, and the *E. saligna* seed was contributed by Merensky. The trial series will be established in 2011 in 28 locations in 7 different countries (Argentina, Brazil, Chile, Colombia, Mexico, Uruguay, and South Africa). Given the large number of sites for the trial series, a second objective of this study is to assess the level of plasticity or adaptability of those species to different environments (G x E). Plans are developing for a second Eucalypt Benchmark Study for the tropical eucalypt species between 2011and 2012.

Special Member Projects: BLUP & NIR Analyses

Camcore staff continue to conduct special data analyses for members as time permits. In 2010, we completed five such projects:

1. For MTO, we completed a BLUP analysis for their *P. radiata* program. Nine full-sib tests were analyzed and family and individual tree rankings were generated.
2. For Pizano, we updated a clonal BLUP analysis for their *Gmelina* program, and made recommendations about clones to use in their commercial plantations.
3. For Klabin, we generated lignin and cellulose measurements on over 2000 wood samples from their *P. taeda* breeding program. Lignin and cellulose were predicted using the Camcore Global Pine NIR model.
4. For Refocosta, we completed a special BLUP analysis for their *P. caribaea* program. The project used data from operational family block plots, and the rankings should be useful to guide future decisions about future plantations and breeding.
5. For Sappi, we completed a BLUP analysis for their *E. grandis x E. urophylla* hybrid programs. There were 21 tests for hybrid family seedling data, and 19 tests of hybrid clones. The BLUP results will be used to guide new crosses, and to identify clones to test further as operational clones.

Pinus taeda GxE Study: 3-year Results

In 2005, Camcore initiated a large long-term study to examine Genotype x Environment interaction (GxE) in *P. taeda* planted in the southern hemisphere. Objectives of the study were to understand the magnitude of GxE and the environmental factors contributing to GxE. With a better understanding of these issues, it might be possible to develop cooperative breeding and testing of *P. taeda* across different geographic regions. The following is a preliminary report on the 3-year growth results from that project.

Materials and Methods

Seven different Camcore members in Brazil, Argentina, and South Africa contributed 20 open-pollinated families from their operational breeding programs (from Brazil, Klabin Paraná, Klabin Santa Catarina, Rigesa and Arauco Brazil (formerly International Paper); from Argentina, Alto Paraná and Bosques del Plata; and from South Africa, Sappi Forests). In terms of genetic quality, the only guideline was that the families should come from a first-generation seed orchard (at a minimum). Seedlots were distributed among all seven organizations, and tests were established in 2006 and 2007. Two additional organizations, Masisa do Brazil and Montes del Plata, received some of the seedlots and established tests in 2008. Each member planted two tests, with a single-tree plot design and 20 replications. Most tests contained between 100 and 125 families, depending on seed availability and germination, and survival in all tests was quite good. There were typically between 80 to 110 families common between any given pair of tests, thus it is an excellent data set to examine GxE. Currently, measurements are available for 12 trials (Table 7). Height and diameter at breast height (DBH) were measured at age 3 years, and a volume index calculated (volume index = 0.00003 x height x DBH^2).

Results and Discussion

On average, there was relatively little GxE observed across all of the trials, despite fairly significant variation in latitude (from 24° 07’ S to 27° 59’ S), elevation (from 127 m to 1381 m), precipitation (from 1001 mm to 2172 mm), as well as differences in soil and climate. There are various ways to calculate GxE, but most convenient is the Type B genetic correlation among family or seed source performance across different sites. This parameter ranges from zero (indicating extreme GxE) to 1.0 (indicating no GxE, and perfect correspondence across environments). For the seven different seed sources, there was very strong agreement across tests – the type B correlation of

Table 7. Site information for 12 *Pinus taeda* Genotype x Environment trials in Brazil, Argentina and South Africa.

Test	Date Planted	Location	Lat	Long	Elev (m)	Precip (mm)
SAPPI	Feb-07	Clan C13b	26º 23’ S	30º 24' E	746	1001
SAPPI	May-07	Usutu C9	26º 29' S	30º 57' E	1381	1124
KLABIN SC	Dec-06	Salto SAL C1B	27° 29' S	50º 14' W	840	1394
KLABIN PR	Nov-06	Anta Brava ABR 06E	24° 07' S	50º 29' W	740	1812
RIGESA	Nov-06	Taunay R078	26° 04' S	50º 36' W	780	2172
RIGESA	Oct-06	Gugelmin R063	25° 54' S	50º 37' W	790	2172
ARAUCO	Dec-06	Barra Mansa - Bonança	24º 01' S	49º 56' W	755	1167
ARAUCO	Feb-07	São Nicolau	24º 18' S	50º 00' W	960	1167
APSA	Sep-06	La Querencia	26º 02' S	54º 37' W	195	1965
APSA	Oct-06	Monte Quemado	26º 02' S	54º 37' W	195	1965
BDP	May-06	Timbauva	27º 59' S	56º 01' W	127	1470
BDP	May-06	Jesus Cué	27º 53' S	56º 09' W	127	1462

seed source means was 0.77. Of particular interest was the fact that the two Argentinan seed sources ranked first and second out of seven seed sources at almost every site (11 of the 12 tests, Table 8). This is most likely due to the influence of genes from the fast growing "Florida loblolly" populations – these populations make up a substantial portion, from 50 to 75% of the Argentinian breeding populations, and are not represented in the Brazilian and South African breeding populations.

At the family level (ignoring seed source), the Type B genetic correlation remained high at 0.76. Even when accounting for seed source in the model, the Type B genetic correlation of families within seed source was 0.67.

Implications and Next Steps

These are preliminary results, and further, more complex analyses will be forthcoming. Some of the apparent GxE that is currently observed (even though relatively small) may be due to environmental "noise" in the data. We are planning on using row-column analyses to more precisely account for microsite variation within each test, which will effectively increase the precision of family rankings. This may lead to higher correlations of family ranks across tests, or in other words, lower estimates of GxE. In addition, we will look closely at environmental factors which contribute to the GxE we do observe. Climatic factors, as well as soil factors, will be examined.

It is important to remember that these are only 3-year results. However, GxE in forest trees typically decreases with age, so it seems reasonable to conclude that GxE in *P. taeda* in the southern hemisphere is rather low. Certainly it seems as though there is opportunity for exchange of genetic material across geographic regions, joint testing and breeding programs, and perhaps region-wide clonal testing.

Table 8. Seed source means for 12 tests of *P. taeda* at sites in Brazil, Argentina, and South Africa. Values are seed source means across 5 to 20 families for 3-year height growth in meters (center column), and volume index in m^3 (right column).

test = Rigesa 1			test = Rigesa 2		
APSA	4.7	0.0129	APSA	6.4	0.0288
BDP	4.3	0.0090	BDP	6.1	0.0239
Inpacel	4.3	0.0083	Inpacel	6.2	0.0226
Sappi	4.2	0.0081	Sappi	6.0	0.0221
Rigesa	4.1	0.0073	KlabinPR	5.9	0.0193
KlabinPR	4.2	0.0072	Rigesa	5.8	0.0187
KlabinSC	3.9	0.0056	KlabinSC	5.7	0.0172

test = AltoPar 1			test = AltoPar 2		
BDP	5.1	0.0143	APSA	5.0	0.0148
APSA	5.2	0.0139	BDP	4.2	0.0089
Inpacel	4.8	0.0106	Inpacel	4.2	0.0080
Sappi	4.6	0.0094	Sappi	4.0	0.0071
KlabinPR	4.3	0.0076	Rigesa	3.7	0.0055
Rigesa	4.2	0.0076	KlabinPR	3.6	0.0054
KlabinSC	4.0	0.0065	KlabinSC	3.4	0.0048

test = Arauco 1			test = Arauco 2		
APSA	5.9	0.0256	APSA	5.6	0.022
BDP	5.4	0.0190	BDP	5.1	0.017
Inpacel	5.5	0.0184	Sappi	5.0	0.015
Sappi	5.3	0.0170	Inpacel	5.0	0.014
KlabinPR	5.0	0.0133	Rigesa	4.6	0.011
Rigesa	4.9	0.0129	KlabinPR	4.7	0.011
KlabinSC	4.6	0.0109	KlabinSC	4.3	0.009

test = BDP 1			test = BDP 2		
APSA	4.5	0.0075	APSA	4.2	0.0063
BDP	4.2	0.0061	BDP	3.9	0.0052
Sappi	4.2	0.0060	Inpacel	3.8	0.0048
Inpacel	4.2	0.0059	Sappi	3.7	0.0044
Rigesa	3.9	0.0047	Rigesa	3.7	0.0043
KlabinPR	3.9	0.0046	KlabinPR	3.6	0.0039
KlabinSC	3.8	0.0043	KlabinSC	3.5	0.0036

test = Sappi 1		test = Sappi 2	
APSA	5.4	APSA	4.2
BDP	5.3	Sappi	4.1
Inpacel	5.3	Inpacel	4.1
Sappi	5.1	BDP	4.1
Rigesa	5.0	KlabinPR	3.9
KlabinSC	4.9	Rigesa	3.8
		KlabinSC	3.8

test = KSC 1			test = KPR 1		
APSA	6.0	0.0264	APSA	5.9	0.0212
BDP	5.7	0.0224	BDP	5.4	0.0152
Inpacel	5.8	0.0217	Sappi	5.3	0.0144
Sappi	5.7	0.0211	Inpacel	5.3	0.0127
Rigesa	5.5	0.0189	KlabinPR	4.9	0.0103
KlabinPR	5.6	0.0187	Rigesa	4.8	0.0098
KlabinSC	5.4	0.0182	KlabinSC	4.7	0.0095

Eucalyptus Species / Provenance Trials

Eucalyptus plantations are becoming increasingly important in the global forest sector. Many Camcore members have done a great deal of work with both temperate and sub-tropical and tropical eucalypt species. For example, among the Camcore membership are organizations working with the major eucalypt species that possess some cold hardiness (*Eucalyptus nitens, E. globulus, E. dunnii* and others), while other members have programs with more tropical species like *E. grandis, E. urophylla,* and *E. tereticornis* and others.

Despite all of the good work that has been done in eucalypt testing and breeding, and identifying productive species, provenances, families and clones, breeders must always be preparing for change. There is the looming possibility of climate change, which might make cold hardiness or drought resistance more important than in the past. The economic climate can also change, which could shift or modify the target traits that are important for breeding. There is a constant threat of new insect pest or pathogens for which breeders must have a source of genetic resistance. Finally, even without major changes in climate or the economy, breeders (and managers) always want more: faster growth, higher pulp yield, lower lignin, more disease resistance, more pest resistance, more drought resistance, etc.

The first step in genetic improvement is to evaluate what is already available at the species level. Since there are between 600 and 900 species of eucalypts (depending on which taxonomic classification one accepts), there are many species that are not well studied, and there is certainly much valuable genetic diversity to explore.

In 2010, Camcore began a joint project with CSIRO (Australia) to study and field test relatively "obscure" eucalypt species with a focus on trying to find species with cold hardiness and drought resistance. The project began with a group of 10 temperate and 12 sub-tropical species (Table 9), most of which have small natural ranges in Australia and have not been widely studied. A total of 13 Camcore members are particiapting in this project. Seed has been distributed to interested members, and the workplan calls for each member to establish two to three small species-site trials on environmentally challenging or marginal quality sites. The field trials will be established in 2011, and will be complemented by greenhouse studies on cold and drought tolerance in Australia.

We anticpate that Camcore will be involved in species / provenance testing of eucalypts for many years to come. We plan to do additional species-level tests with other species in the future, and once we identify promising new species, more in-depth provenance and family testing will follow.

Table 9. List of obscure sub-tropical and temperate eucalypt species that Camcore and CSIRO are distributing to be tested to assess growth, cold and drought resistance, disease resistance, wood quality and bioenergy potential.

Temperate	
1	*Corymbia maculata*
2	*E. badjensis*
3	*E. benthamii*
4	*E. cladocalyx*
5	*E. dunnii*
6	*E. globulus ssp bicostata*
7	*E. microcarpa*
8	*E. occidentalis*
9	*E. sideroxylon*
10	*E. tricarpa*

Sub-Tropical	
1	*Corymbia citriodora* var. *variegata*
2	*E. argophloia*
3	*E. benthamii*
4	*E. crebra*
5	*E. dorrigoensis*
6	*E. drepanophylla*
7	*E. longirostrata*
8	*E. major*
9	*E. moluccana*
10	*E. raveretiana*
11	*E. siderophloia*
12	*E. thoetziana*

Diana Perez, Miguel Rodríguez, and Hernán Ureño of Pizano Monterrey (Colombia) with an outstanding *Gmelina arborea.*

A plus tree selected by the Tanzania Forestry Research Institute (TAFORI). Collected seeds were exchanged with other Camcore member organizations.

Jesús Espinoza (Camcore, left), João de Brito and Arno Brune (Chikweti) discuss nursery practices at the N'tacu project in Mozambique.

Robert Jetton (Camcore) collecting *P. pungens* cones at Hanging Rock State Park in North Carolina (USA) as a part of a collaborative gene conservation project with the USDA Forest Service.

John Vidal, Patricio Alzugaray, and Verónica Emhart (CMPC Forestal) with *P. radiata* hedges at the Carlos Douglas nursery in Los Angeles, Chile.

Bonitta Meyer (KLF) with a *P. patula x P. te-cunumanii* hybrid near Sabie, South Africa.

Discussions about *P. caribaea* propagation at the PROFORCA nursery in Chagaramas, Monagas, Venezuela. From left, Jesús Espinoza (Camcore), WIlliams Vera, Jairo Morales, Ricaurte Leonett (all from PROFORCA), and Juan López (Camcore).

Ramón Aguilar (FOMEX) standing in a 4-month-old Camcore *E. pellita* provenance / progeny trial in Tabasco, Mexico.

Bill Dvorak (Camcore) and Irvine Kanyembe (Florestas de Niassa, Mozamique) discuss eucalypt siviculture and weed control.

Julian Moreno Chan (PG Bison, South Africa) and Gary Hodge (Camcore) visit a group of Camcore *P. patula* provenance / progeny tests converted into seedling seed orchards.

Pine Somatic Embryogenesis: Update

Background

For a number of years now, forestry companies have been developing somatic embryogenesis (SE) protocols for important commercial species such as *Pinus taeda, P. radiata, Pseudotsuga menziesii* (Douglas fir), and *Picea alba* (white spruce). In 2009, Camcore took the first steps toward developing SE protocols for some of our most important tropical and sub-tropical pine species. We initiated a project with Dr. Yill Sung Park of Natural Resources Canada to test some SE initiation protocols on immature seed of *P. maximinoi* and *P. tecunumanii* from Brazil and Colomba. The results of this research were very encouraging, with between 3 to 8% initiation using the best growth media.

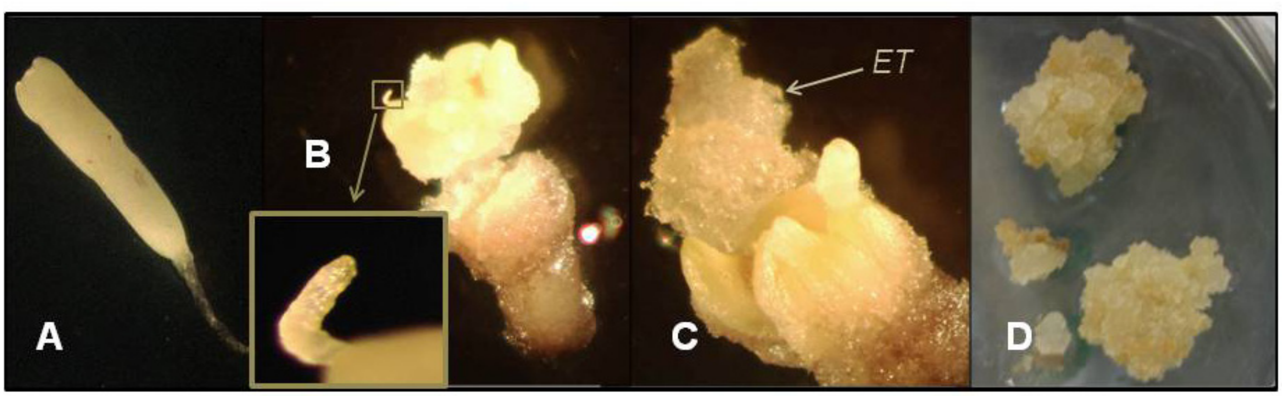
In 2010, we followed up on this research with a project done in collaboration with Dr. Jerry Pullman of the Institute of Paper Science and Technology in Atlanta, Georgia. Building on what we learned from Dr. Park's work, Dr. Pullman attempted to extend the protocol to mature, stored seed of *P. maximinoi* from the Camcore seed inventory.

Methods and Preliminary Results

Open-pollinated seeds were collected from *P. maximinoi* seed orchards / seed stands in Brazil , Colombia, and South Africa. The seed were sent to Camcore offices in Raleigh, NC, and were kept in cold storage until they were sent to Atlanta, GA, for this study. Approximately 850 seeds from 16 open-pollinated families were dissected and 251 (30%) contained full term embryos. The full-term embryos were placed on five versions of modified Litvay medium (MLV), each with variant strengths and presence of ingredients known to increase initiation rates of somatic embryogenesis in other coniferous species. Final evaluations have been made for 210 of the 251 embryos plated. Approximately 26% of the plated embryos showed presence of embryogenic tissue after 9-10 weeks on initiation medium

Outlook

In this project, somatic embryogenesis from full-term *Pinus maximinoi* seed was successfully initiated for the first time. Generally, SE researchers have had the most success beginning with immature embryos extracted from immature cones. With most species, there is a narrow window of time (from two to four weeks) when the immature cones must be harvested, and the dates will vary from year to year depending on climatic conditions. The ability to use mature seed for SE would offer tremendous logistical advantages in an operational SE clonal development project. Phytosanitary regulations grow more restrictive each year, and sending green immature pine cones across international boudaries is already difficult and likely to become more so. In contrast, it is still fairly simple to import and export mature seed.



Embryogenic tissue formation in *Pinus maximinoi* from full term seed embryos.
A) Zygotic embryo excised from seed.
B) Direct embryogenesis on a cotyledon. The new somatic embryo shown in the square is magnified below.
C) Embryogenic tissue *(ET)* emerging from the cotyledon region/ meristem region.
D) *P. maximinoi* embryogenic tissue growing on maintenance medium.

Bench Mark Trials of *Pinus elliottii*

Pinus elliottii (Slash pine) is a very important plantation species in southern Africa, especially in South Africa and Zimbabwe. It is often targeted for harsh, dry sites, while *P. patula* is established on better soils where more frequent precipitation is common. In the southern and eastern Cape region of South Africa, *P. elliottii* and the hybrid *P. elliottii x P. caribaea* is often planted instead of *P. radiata* because of its acceptable growth and resistance to the Pitch canker fungus.

Critics of *P. elliottii* often (rightly) claim that other pine species can be found that outgrow *P. elliottii.* However, local foresters in southern Africa like to establish *P. elliottii* because it is easy to manage in the nursery, and after field planting can survive low intensity fires, grazing damage and weed competition better than most other pine species. It's naturally straight stem form is well suited for solid wood production.

Pinus elliottii was first introduced into South Africa in 1916. Between 1918 and 1939, not less than 2.8 tons of seed were imported from the United States, the precise origin is unknown. Most of the seed was probably collected in the southeastern parts of Georgia in Jenkins County. Other seed groups came from Alabama, Florida, Louisiana and Mississippi (Poynton, 1977). The first introduction of *P. elliottii* into Zimbabwe came from South African material in 1933 (Barrett & Mullin 1968).

Pine breeding started in South Africa in 1958 with the selection of plus trees in existing plantations and in Zimbabwe in the 1960s. Most breeding programs are now entering their 3rd cycle of selection and testing. In South Africa most of the genetic material in the various programs originated from the old government research efforts in the 1950s and 1960s and therefore selections are probably somewhat related across companies.

To assist Camcore members in southern Africa, we have initiated a *P. elliottii* trial series to compare the performance of the most advanced South African genetic material with second-generation seeds from Queensland, Australia, the Forest Research Centre, Zimbabwe, the southern US and first-generation material from a genetically rogued clonal seed orchard of Bosques del Plata in northern Argentina. The trial series will be established across 14 locations, 12 in South Africa and 2 in Mozambique. The control lots of local South African material come from Komatiland Forests, Mondi and Sappi. Trials will be field established in 2011. In addition to bench marking the improved South African material against improved material from other countries, we will also examine the magnitude of G x E across locations. The genetic material selected in these trials in future years will serve to broaden the existing genetic base of local programs in southern Africa.

Poynton, RJ. 1977. Tree Planting in Southern Africa Vol. 1, The Pines. Department of Forestry, Republic of South Africa. 576p.

Barrett, RL and LJ Mullin. 1968. The Rhodesia Bulletin of Forestry Research. No. 1. A Review of Introductions of Forest Trees in Rhodesia. Rhodesia Forestry Commission. 227 p.

Eucalyptus dorriogoensis Provenance / Progeny Trials

Eucalyptus dorrigoensis is a species that has good growth and wood properties. It is closely related to *E. benthamii* which has shown good performance in southern Latin America (and the southern US) for both growth and frost resistance. Camcore collaborated with CSIRO Australia to obtain 40 open-pollinated families from four provenances for testing. *Eucalyptus benthamii* has a very small native range, so the opportunity to hybridize these two species gives Camcore members the opportunity to expand their genetic base of the *E. benthamii/dorrigeonsis* complex. Organizations in Brazil (Klabin and Rigesa), Chile (Arauco, CMPC), Mexico (FOMEX), South Africa (Mondi and PG Bison), and Uruguay (Montes del Plata and Weyerhaeuser) have received seed and will be establishing trials in 2011.

2010 Seed Collections in Mexico and Central America

Seed collections in Mexico and Central America continue to be an annual activity at Camcore. In 2010, seeds of four species of pines were collected from seven natural populations in Guatemala, Honduras and Nicaragua (Table 1).

We also received seeds from four different populations of *P. greggii* var. *australis* collected in the natural forest in the states of Querétaro and Hidalgo in Mexico. The seeds were collected by the University of Chapingo in 2008 and 2009 and sent to Camcore in Raleigh in 2010. This material will be used for the establishment of genetic trials and conservation parks by Camcore members. *Pinus greggii* has potential for commercial plantations as a pure species and as a hybrid in countries like South Africa, Brazil and Argentina, where the trees grow well in areas with low temperatures. The provenances El Madroño and Laguna Atezca have performed very well in northern Argentina, while Laguna Atezca shows volume gains in the highlands of Santa Catarina in Brazil. El Madroño also grows well in South Africa.

Camcore's agreements with the governments of the countries where we collect seed aim for mutual benefit, and focus on *ex situ* conservation of the species and populations. Selected trees in genetic trials growing in other countries provide seeds that can be reintroduced to the countries of origin. Camcore currently has seven second-generation / reintroduction trials established through government organizations and universities: three in Mexico with *P. patula* and *P. greggii* var. *greggii,* and four in Guatemala with *P. maximinoi* and *P. tecunumanii*.

Josué David Cotzojay Chamalé, Camcore tree climber in Guatemala, collecting seeds of *P. tecunumanii* low elevation in Yucul, Matagalpa, Nicaragua

Table 1. Summary of seed collections completed in Central America and Mexico in 2010.

Country	Species	Provenance	Status	Latitude	Longitude	Trees
Guatemala	*P. tecunumanii*	Sacul	Critically Endangered	16° 30’ N	89° 16’ W	23
Guatemala	*P. tecunumanii*	San Jerónimo	Vulnerable	15° 03’ N	90° 18’ W	14
Guatemala	*P. oocarpa*	Selva Pinares	Vulnerable	14° 22’ N	90° 04’ W	20
Honduras	*P. caribaea*	La Brea	Vulnerable	15° 45’ N	86° 00’ W	19
Honduras	*P. maximinoi*	Dulce Nombre de Copán	Endangered	14° 50’ N	88° 51’ W	10
Nicaragua	*P. tecunumanii*	Yucul	Low Risk	12° 55’ N	85° 44’ W	20
Nicaragua	*P. tecunumanii*	San Rafael del Norte	Vulnerable	13° 13’ N	86° 07’ W	15
Mexico	*P. greggii*	Valle Verde	Low Risk	21° 30’ N	99° 10’ W	18
Mexico	*P. greggii*	El Madroño	Low Risk	21° 16’ N	99° 10’ W	17
Mexico	*P. greggii*	Laguna Atezca	Vulnerable	20° 48’ N	98° 46’ W	15
Mexico	*P. greggii*	Laguna Seca	Vulnerable	21° 02’ N	99° 10’ W	18

Gene Conservation of *Pinus pungens* in the Southern Appalachian Mountains

In 2009, Camcore began working with the USDA Forest Service to conserve the genetic resources of *Pinus pungens* (Table Mountain pine) in the Southern Appalachian Mountains, a three-year project funded by a $48,563 grant from Barbara Crane, USDA Forest Service Regional Geneticist in the southeastern United States. The objectives of the project are to make genetically representative seed collections from across the Southern Appalachian region, place seeds into cold storage for long-term preservation, and outplant seedlings into conservation banks at seed orchard locations managed by the US Forest Service. Camcore's work on this conservation effort strengthens our relationship with the US Forest Service and our reputation in forest resource conservation within the United States.

Pinus pungens is a member of the pine subsection *Australes* and its closest genetic relatives are *P. rigida, P. taeda,* and *P. serotina.* The natural distribution of *P. pungens* spans the Appalachian Mountains from central Pennsylvania south to northern Georgia where most populations occur at elevations between 300 and 1200 meters, although a few trees are known to occur as low as 46 meters and as high as 1400 meters. At the higher elevations it often occurs in nearly pure stands while at lower elevations (below 700 meters) it grows in mixed stands with *P. rigida* and *P. virginiana. Pinus pungens* is sometimes used commercially for pulpwood, low-grade sawtimber, and firewood when harvested from natural stands, but no references to selection and breeding for plantation silviculture are found in the literature. Its most valuable assets are the ecosystem services natural stands provide in the form of food for wildlife and soil stabilization to limit erosion and runoff.

The primary threats to the current distribution of *P. pungens* that necessitate genetic resource conservation are wildfire suppression policies in the United States that restrict successful regeneration in many stands. The species is fire adapted, requiring fire and other major disturbance events to prepare the seed bed and release seeds from the serotinous cones. In the absence of more frequent wildfire, over the last several decades this once widespread species is now limited to no more than 12,000

Table 2. Summary of *P. pungens* seed collections completed in the southeastern United States in 2010.

Prov. No.	Provenance	County, State	Latitude	Longitude	Altitude (m)	Trees
1	*Briery Branch*	Rockingham, VA	38.48 N	79.22 W	1133	10
2	*Hanging Rock*	Stokes, VA	36.39 N	80.26 W	648	8
3	*Walnut Fork*	Rabun, GA	34.92 N	83.28 W	702	10
4	*Poor Mountain*	Oconee, SC	34.76 N	83.14 W	479	6
5	*Pine Mountain SC*	Oconee, SC	34.69 N	83.29 W	507	7
6	*Looking Glass Rock*	Transylvania, NC	35.30 N	82.79 W	1186	8
7	*Bent Creek*	Buncombe, NC	35.46 N	82.64 W	876	2
8	*Table Rock NC*	Burke, NC	35.89 N	81.88 W	1181	10
9	*North Mountain*	Rockbridge, VA	37.82 N	79.63 W	927	10
10	*Ravens Roost BRP*	Augusta, VA	37.93 N	79.95 W	974	2
11	*Bald Mountain BRP*	Nelson, VA	37.89 N	79.05 W	867	10
12	*Buena Vista BRP*	Rockbridge, VA	37.78 N	79.27 W	748	10
13	*Iron Mine Hollow BRP*	Botetourt, VA	37.43 N	79.73 W	716	3
14	*Nolton Ridge*	Graham, NC	35.28 N	83.69 W	1097	6
15	*Camp Merrill*	Lumpkin, GA	34.62 N	84.11 W	606	4

hectares, occurring in small isolated populations distributed across its historical distribution. A secondary and more periodic threat to *P. pungens* is the bark beetle *Dendroctonus frontalis*, the most serious insect pest of southern pines in the southeastern United States.

Since beginning work on this project in June 2009 Camcore has made substantial progress with respect to population identification, exploration, and seed collection. Working with federal and state cooperators across the Southern Appalachian region we have identified 30 *P. pungens* populations (Figure 1) and completed seed collections from 15 of these, representing a total of 106 mother tree selections (Table 2, Figure 1). During the final year and a half of the project we plan to complete seed collections in all 30 populations identified and begin research on *P. pungens* population genetics, seed technology, and nursery production.

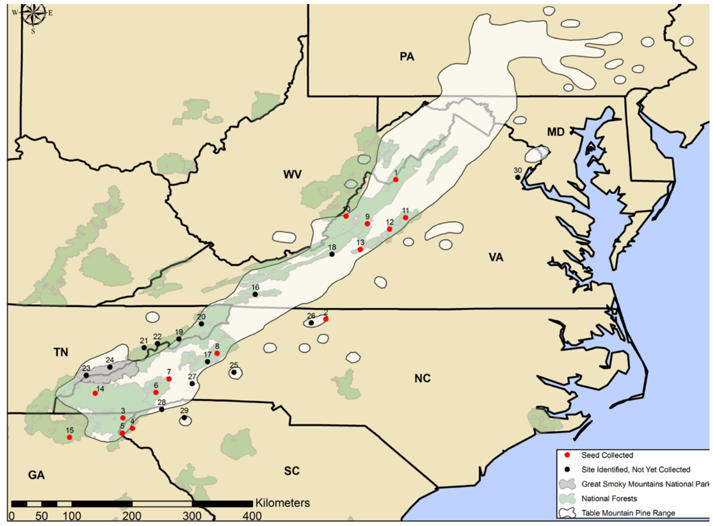


Figure 1. Map depicting the natural distribution of *P. pungens* in the eastern United States and populations that Camcore has identified (numbers on map correspond to Prov. No. in Table 2).

Conservation parks of *Gmelina arborea* in Colombia

As part of the Camcore conservation strategy, a conservation park of *Gmelina arborea* will be established by Pizano and Refocosta on their land in the northern part of Colombia. The Camcore Conservation Park will serve as a holding place for genetic material of *Gmelina arborea* populations that have been collected by Camcore and its members in native stands in India, Myanmar and Thailand over the last two decades. Because there is no current stock of *Gmelina arborea* seeds at Camcore, it was decided that the material for the conservation parks should come from rooted cuttings. Smurfit Kappa Cartón de Colombia (SKCC) collected sprouts from all of its Camcore provenance/progeny trials and conservation banks, and rooted them in the nursery and sent the trees to Pizano. Pizano placed this material in sand beds in the nursery to multiply it through rooted cuttings. Pizano will include some of the provenances and families from India not provided by SKCC. Initially, trees from 10 provenances and 104 families will be planted in the conservation parks in 2011. This genetic material will benefit both Pizano and Refocosta. Both companies will be able to establish clonal trials and make selections of the best clones to deploy in plantations. Many thanks to SKCC and Pizano for all the hard work they did on this project in 2010.

Pizano will multiply Gmelina sprouts using rooted cuttings for the establishment of conservaton parks to preserve important genetic diversity of the species.

Gene Conservation of Hemlock Species

The past year was another successful one for Camcore's cooperative effort with the USDA Forest Service to conserve the genetic resources of Eastern *(Tsuga canadensis)* and Carolina *(Tsuga caroliniana)* hemlocks in the eastern United States. As mentioned in last year's annual report, in late 2009 Camcore received an additional $314,321 grant from the USDA Forest Service to continue with seed collections from Eastern and Carolina hemlock populations in the southern US, expand seed collections efforts into the northeastern and Midwestern regions of the country, and move forward with *ex situ* conservation bank establishment.

Although extensive seed cone explorations by Camcore and our federal and state cooperators during the summer revealed a rather poor cone year for hemlocks throughout the eastern US, we were able to make some progress on seed collections in 2010, including our first extensive collection of Eastern hemlock seed in the northern US from populations in Wisconsin (Table 3.) This brings our total collections since the project began in 2003 to 237 families in 35 southern populations of Eastern hemlock, 32 families in 4 northern populations of Eastern hemlock, and 134 families in 19 populations of Carolina hemlock.

Carolina hemlock conservation banks in Chile and the US have been established and continue to grow nicely, and Bioforest-Arauco is currently rooting stem cuttings from its conservation bank at Cuyimpalihue so that this planting can be replicated on a second site. Additionally, in November 2010, Rigesa planted small conservation banks for both Eastern and Carolina hemlock in Brazil.

In 2010, we published one peer reviewed and three technical articles and gave five oral and poster presentations at scientific meetings about our conservation work with hemlock. These presentations included invited talks by Andy Whittier at the Virginia Association of Forest Health Professionals in February and Robert Jetton at the Fifth Symposium on Hemlock Woolly Adelgid in the Eastern United States in August. Camcore also hosted the first meeting of the Working Group on Genetics and Host Resistance in Hemlock in Raleigh in May (see *Camcore News Items*) where presentations were given by Camcore staff members Bill Dvorak, Gary Hodge, and Robert Jetton and Camcore member representatives Rusty Rhea (USDA Forest Service) and Jaime Zapata (Bioforest-Arauco). Also highlighted in this Annual Report are research results about Eastern hemlock genetic diversity and hemlock seed technology.

USDA Forest Service tree climber Allan Braun climbs an Eastern hemlock for seed collection at the Round Lake Provenance in Wisconsin.

Table 3. Summary of Eastern and Carolina hemlock seed collections complete in the eastern United States in 2010.

Species	Provenance	County, State	Latitude	Longitude	Altitude (m)	Trees
Eastern Hemlock	*Anna Ruby Falls*	White, GA	34.76 N	83.71 W	708	2
Eastern Hemlock	*Poole's Creek*	Rutherford, NC	35.41 N	82.23 W	403	8
Eastern Hemlock	*Echo Lake*	Vilas, WI	45.91 N	89.04 W	525	10
Eastern Hemlock	*Muskellunge Creek*	Ashland, WI	46.14 N	90.70 W	483	10
Eastern Hemlock	*Round Lake*	Price, WI	45.84 N	90.07 W	501	10
Carolina Hemlock	*Looking Glass Rock*	Transylvania, NC	35.30 N	82.79 W	1179	8

Genetic Diversity of Eastern Hemlock

In 2010, Camcore and the USDA Forest Service completed a population genetic diversity study of Eastern hemlock *(Tsuga canadensis)* that we first reported on in the 2009 Annual Report. Foliage samples were collected from 60 hemlock populations across the eastern regions of the U.S. and Canada (Figure 2), and DNA from those samples was screened across 13 polymorphic microsatellite (SSR) loci. Presented here are some preliminary results; a more detailed analysis will be submitted for publication in a peer-reviewed journal in the near future.

Eastern hemlock has a moderate level of genetic variation, significant levels of inbreeding, and moderate genetic differentiation among populations (approximately 6.5 percent of variation occurs among rather than within populations). Populations with the highest levels of genetic variation tend to occur within two areas, in the Southern Appalachian region within and near North Carolina and in a region encompassing New York and the New England states (Figure 2). The exception was the number of population-level unique alleles, which were highest in populations along the western periphery of the eastern hemlock range, in Indiana, Ohio and Michigan.

Isolated populations often experience small-population effects, including inbreeding and genetic drift, that lead to lower overall genetic variation, while adaptive pressures could push disjunct populations toward greater genetic differentiation from interior populations. This appears to be the case in the disjunct populations of Eastern hemlock, which are less genetically diverse by most measures than interior populations (Table 4). The exception is the mean number of unique alleles, which is higher in disjunct populations. Disjuncts are also considerably more inbred than interior populations, and are more genetically differentiated on average from all other populations in the study (Table 4).

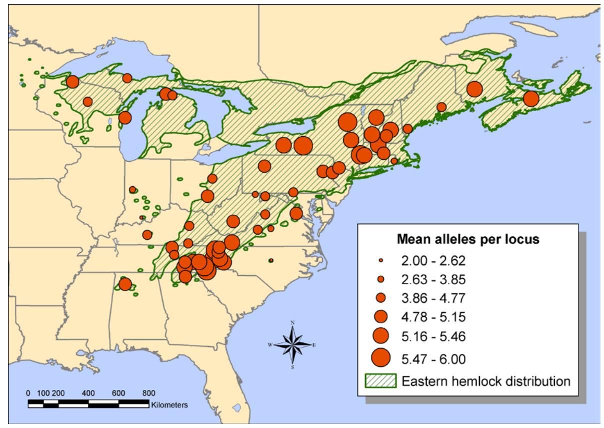


Figure 2. Mean alleles per locus for each of the 60 Eastern Hemlock populations included in the study.

A comparison of Eastern hemlock populations in the north and the south reveals that Southern populations are more highly differentiated on average (Table 4). This is expected, given the region's proximity to the glacial refuge for the species during the most recent glacial maximum of the Pleistocene. Populations in the north, however, had more unique alleles, higher heterozygosity, and lower inbreeding than in the south, suggesting that southern populations may have undergone stronger pressure from changing climate as the species' range was pushed north following the end of the Pleistocene.

Finally, the results indicate that Eastern hemlock populations at immediate risk from hemlock woolly adelgid are not more genetically diverse than those not currently at risk (Table 4). In fact, populations at lower risk appear to have more unique alleles and higher heterozygosity on average. While genetic variation will surely be lost as a result of HWA infestation, time remains to adequately conserve much of the genetic diversity of eastern hemlock that remains in these as-yet uninfested populations.

Table 4. Genetic variation measures* for different groupings of Eastern hemlock populations: interior vs disjunct, northern vs southern, and at risk from hemlock woolly adelgid (HWA) vs not at risk.

Group	n	A_R	A_P	P_P	H_O	F_{IS}	F_{ST}
Interior	*52*	*3.12*	0.31	98.2	0.54	0.07	0.05
Disjunct	*8*	*2.73*	0.75	90.4	0.43	0.10	0.16
North	*28*	*3.03*	0.57	97.3	0.54	0.04	0.06
South	*32*	*3.10*	0.19	97.1	0.52	0.10	0.07
HWA	*17*	*3.01*	0.18	95.0	0.51	0.08	0.07
no HWA	*43*	*3.09*	0.44	98.0	0.53	0.07	0.07

* Allelic richness (A_R), unique alleles (A_P), percent polymorphic loci (P_P), observed heterozygosity (H_O), inbreeding (F_{IS}), and mean pairwise differentiation with all the other populations (F_{ST}).

Progress in Pine Hybrid Testing

In 2010 Camcore members planted 18 new pine hybrid trials in the field in addition to the 28 already planted between 2007 and 2009. In this pioneering work developed by the program, 21 hybrids among species of pines are being tested in 46 trials in 6 different countries. Survival in most trials is over 90% at one year, and some trials have been measured at 3 years of age.

A number of seedlots received from members during the last 3 years were verified with SNPs at Camcore. Many of the crosses have been confirmed as true hybrids, and we have begun distributing the seed to the regional coordinators for vegetative propagation. The regional coordinators will produce enough rooted cuttings to be distributed among the members of the region for the establishment of more pine hybrid trials in 2012 and 2013. We estimate that in 2011 at least 7 more hybrid trials will be planted with material already in production.

So far, most of the verified hybrids have been from crosses made with *P. patula, P. tecunumanii, P. taeda, P. elliottii, P. greggii* and *P. caribaea.* We will continue to attempt crosses with *P. maximinoi* and *P. radiata,* species which have shown poor results in hybrid crosses up to now, but which are very important for some of the members. In 2010, we verified our first successful *P. maximinoi* hybrids (see article on SNP markers in this Annual Report). We have also initiated a collaborative project with graduate student Hannél Ham at Stellenbosch University (South Africa) to look into the reproductive biology of *P. radiata* as a means of increasing our success in hybrid production with that species (see "Graduate Programs and Training"). Lastly, we will begin crosses with a number of species which have not yet been widely used in our hybrid program: *P. jaliscana, P. herrerae, P. leiophylla* and *P. pringlei.* These species offer a number of potential advantages in hybrid crosses, either in fire resistance, *Fusarium* resistance, or cold tolerance.

Many thanks to the members for their enthusiasm and hard work in pollen collection, controlled pollination, propagation, and establishment of the field trials. The work in pine hybrids is already yielding some benefits, and we believe that the in the long term this project will produce many new options for plantation forestry.

Bill Dvorak (Camcore) with a *Pinus elliottii x P. patula* hybrid on Merensky land at Weza, South Africa.

Eucalyptus Hybrid Breeding

At the 2010 Annual Meeting, we discussed plans to develop a Eucalyptus Hybrid Breeding Project, modeled on the success we have had with the Pine Hybrid Project. Briefly, the workplan will call for each member to make a number of full-sib families of a particular hybrid. This seed would be shared with other members, who each made a different hybrid cross. The end goal is that each participant would receive a10 to 20 full-sib families from four to six different hybrid crosses. A total of 19 companies indicated their intent to particiapte in the program. These members have genetic resources in a number of sub-tropical and tropical species such as *E. grandis, E. urophylla, E. pellita, E. tereticornis, E. camaldulensis, E. saligna, E. longirostrata* and others, and temperate species such as *E. nitens, E. globulus, E. dunnii, E. macarthurii, E. badjensis, E. dorrigoensis, E. smithii,* and others. With this wealth of species, there is opportunity for the group to create many hybrids of interest. Some work on pollen collection has already begun, and in 2011, we plan to finalize many of the details and begin work on crossing.

Optimization of a SNP Marker System for the Verification of Pine Hybrids

Background

Camcore has been breeding and testing pine hybrids since 2001. To verify that seed produced from controlled crossing are actually hybrids, we have used isozymes and random amplified polymorphic DNA (RAPD) markers with some success. However, these types of markers present certain restrictions on the reproducibility and amount of information provided, and these limitations led to the desire for a powerful, high-resolution marker system that could be used to verify pine hybrids for any kind of cross, even when lacking knowledge of the specific parental genotypes. Single nucleotide polymorphisms (SNPs) represent an abundant form of genome variation (Brookes 1999), and offer the potential for such a verification system.

In 2007, Camcore initiated a joint project with FORBIRC, the forest biotechnology research group at NCSU, to develop single nucleotide polymorphic markers (SNPs) for the purpose of verifying pine hybrids. That project was succesful in identifying species-diagnostic SNP markers that could be used to verify putative hybrids among any possible cross of 16 different pine species and varieties (see 2009 Camcore Annual Report). In 2010, Camcore graduate student José Jimenez Madrigal began a project to optimize the use the newly identified SNP markers for operational verification of a large set of 35 different putative pine hybrids.

Methods and Results

Consensus DNA sequences developed in the Camcore-FORBIC project were used to select potential species diagnostic SNP markers (for more details please refer to Khan 2010). Two approaches to use these markers for hybrid verification are currently being tested.

The first approach involves SNP genotyping using the Sequenom MassARRAY iPLEX platform. This platform relies on the use of several site-specific PCR reactions and the addition of a mass-modified base which is later detected by mass spectrometry analysis. The mass tag added is tailored to the specific SNP desired, yielding an accurate genotype (Gabriel et. al.2009). For this assay we selected 12 SNPs, each one diagnostic for a particular species. The assay was run in a multiplex reaction, meaning that all 12 markers were tested against every hybrid individual resulting in a genotype profile specific for each hybrid cross. With this approach, only 8 out of 32 different hybrid crosses (with several seedlots per cross and several individuals per family representing each putative hybrid) were confirmed as hybrids (more than 50% individuals being true hybrids). These verified hybrids include: *P. elliotti x P. taeda, P. greggi* var. *australis x P. oocarpa* and *P. taeda x P. maximinoi,* among others. The remaining 24 showed less than 50% hybrid individuals or failed to provide conclusive information, despite the 99.7% genotyping accuracy claimed by the manufacturer.

In light of the previous results, we opted for a second approach. This new approach mimics the Sequenom platform in the use of PCR reaction and SNP-specific primer design, however, in this instance the assay is not conducted in a multiplex reaction. The process is more labor intensive than the first approach, but on the plus side, the chemical reagents are less expensive, the equipment needed for the process is common in most molecular genetic laboratories, and the results can be easily analyzed without the need for expensive and proprietary software, as in the case of the Sequenom output data. The markers were designed using WASP, a web based allele specific PCR assay designing tool for detecting SNPs and mutations (Wangkumhang et. al. 2007). This tool can be freely accessed online. For this approach, SNPs different than the ones used before were selected. A total of 14 markers have been developed so far, some of them incorporating more than one SNP to increase specificity. With this approach, 19 out of the 32 different hybrid crosses have been tested so far, with 10 showing more than 50% individuals as true hybrids. The verified hybrids include: *P. greggi* var. *australis x P. maximinoi*, and *P. patula x P. tecunumanii* (both high and low elevation varieties and from different Camcore partners), among others.

Outlook

There are still some hybrid crosses to be tested, but a number of new and exciting hybrid crosses have been verified. The seeds from these hybrids have been included in the third shipment of Camcore hybrids distributed for field testing.

There remains some work to be done on analyzing and comparing the results of the two SNP approaches, but so far the WASP system seems to have the greatest potential for quick implementation at a cost effective rate.

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Verified Hybrids of *P. maximinoi*

Pinus maximinoi is a species that offers extremely fast growth and very good wood quality. However, it is not frost resistant, so hybrids of *P. maximinioi* with species like *P. taeda* or *P. greggii* would be attractive for regions where frost is a concern. Using the SNP marker system, we have confirmed the first *P. maximinoi* hybrids produced in the Camcore hybrid project:

- *P. taeda x P. maximinoi*
- *P. greggii* var. *australis x P. maximinoi*
- *P. pseudostrobus x P. maximinoi*

Pine Hybrid Verification Using NIR

For a number of years, Camcore has been working to find a method to cost-effectively confirm that hybrids have been successfully produced. Molecular markers such as RFLP, RAPD, AFLP, and SSR that are often used to distinguish pine species can have disadvantages such as the need for highly skilled labor, expensive set up costs, a requirement for hazardous chemicals, time consuming protocols, and occasional inaccuracies (e.g., with RAPDs, hybrids show atypical banding patterns). Our work with SNP markers is highlighted in this annual report, and this approach appears to be repeatable, useful, and relatively cost-effective. However, it still will require trained personnel to extract DNA, and a simpler and faster method of hybrid verification would be beneficial to an operational breeding program.

In the 2009 Annual Report, we reported on the results of a study to develop a pine hybrid verification methodology using near-infrared (NIR) spectroscopy. NIR is normally used to determine chemical composition of a sample based on the reflectance and absorption of different wavelenghts of near-infrared light. The 2009 study was conducted on seedlings from 16 different pine species. Models were developed to discrimiante among all possible pairs of the species, with the calibration models based on 15 seedlings of each pure species, and then verified on 10 independent seedlings of each species. The results were very encouraging: on average across all possible pairwise combinations, the NIR models correctly classified 95% of the seedlings in the independent data sets. This suggests that perhaps NIR models could be developed which would distinguish hybrids from both of their parental species.

Based on these results, in 2010 Camcore conducted a small second-phase study to further investigate if NIR could be used to classify or verify pine hybrids using foliage samples. This study involved the fabrication of foliage samples from "pseudo-hybrids" by mixing foliage from two pure species.

Material and methods

This study used the same plant material as was reported in the 2009 study. There were three case studies involving "pseudo-hybrids" of interest: *P. patula x P. tecunumanii, P. taeda x P. greg-*

gii, and *P. elliottii x P. caribaea.* In each case, 15 dried and ground foliage samples from the two pure species were scanned with NIR. Then 30 "hybrid" samples were fabricated by mixing ½ of a sample from one pure species with ½ of a sample the other pure species. These "hybrid" samples were then scanned and used to create an NIR calibration model. An independent verification data set was created in a similar manner using 10 foliage samples from each pure species, and 20 fabricated "hybrid" samples. All foliage samples were dried at 70°C until constant weight was achieved, and scanned with a FOSS 6500 spectrometer with wavelengths every 2 nm from 400 to 2500 nm. The raw spectral data were transformed using Standard Normal Variation (SNV) and De-trend using Unscrambler software. The transformed data was processed using SAS PROC Discrim.

Results and Discussion

Table 10 lists the the percentage of correct species classification for the three case studies. In each case, the pure species "parental" samples and the "hybrid" samples were independent observations not used in the development of the classification calibration model.

On average, the NIR models did reasonably well in correctly classifying foliage samples as one of the pure species or the "hybrid". The best performance was probably in Case 1, with the *P. taeda x P. greggii* hybrid. The model correctly classified 100% of the *P. greggii* samples as *P. greggii*, and 78% of the *P. taeda* samples as *P. taeda* (one *P. taeda* was mis-classified as *P. greggii,* and one as a hybrid). The model correctly identified 95% of the "hybrid" samples as hybrid.

The worst performance of the NIR model was probably Case 3, with the relatively closely related *P. patula* and *P. tecunumanii*. The NIR model made all possible misclassifications, calling a "hybrid" sample incorrectly as both parental types, and calling each parental type incorrectly as a hybrid or the other parental species. Nevertheless, the model still generally classified samples correctly, about 73% of the time (Table 10).

Outlook

Both the first phase (discrimination of paired pure species) and second phase (discrimnation of two pure species and a pseudo-hybrid) have produced encouraging results, suggesting that it might be possible to develop NIR models that would be useful in an operational hybrid breeding program. The third phase of this project will involve foliage samples from actual hybrids. In 2011, we will attempt to acquire foliage samples of the three "hybrids" studied in this report, plus others.

Table 10. Percentage of correct taxon classification using NIR models. Classification models were developed for 3-taxon data sets, two pure species and one simulated "hybrid" with mixed foliage from the two pure "parental" species.

Case Study	Actual Taxon	number of trees	Percent Classified by NIR Model		
			tae_x_gre	taeda	greggii (S)
1	tae_x_gre	20	95	0	5
	taeda	9	11	78	11
	greggii (S)	10	0	0	100
			ell_x_car	elliottii	hondurensis
2	ell_x_car	20	85	0	15
	elliottii	9	11	89	0
	caribaea	10	30	0	70
			pat_x_tec	patula_patula	tecunumanii
3	pat_x_tec	20	70	25	5
	patula	10	10	80	10
	tecunumanii	10	20	10	70

Baseline Nutrient Determination

In 2009, we began a multi-year project to develop baseline information about nutrient requirements of important species, starting with with *P. maximinoi* and *P. tecunumanii*. These two pine species have shown excellent potential for commercial plantation forestry in Brazil, Colombia and South Africa, with growth rates from 11 to 41 m^3/ha/yr, and 14 to 25 m^3/ha/yr for *P. maximinoi* and *P. tecunumanii* respectively.

The main objective of the project is to determine a target level of nutrients where the species will produce a healthy and productive forest stand on a particular site. *Pinus maximinoi* was sampled at five locations, high-elevation *P. tecunumanii* at three sites, and low-elevation *P. tecunumanii* at four sites (Table 11). Sampled stands averaged 11 years of age, and ranged from 7 to 16 years old. Foliage samples were taken from four sample points per site, and from 8 dominant and co-dominant trees at each sample point. The foliage samples were taken from the uppermost primary lateral branches (the top 1/3 of the live crown). Soil samples were also taken at each sampling point in order to correlate the nutrient levels from the foliage and soil analyses. The mean foliage nutrient concentration is listed in Table 12.

Table 11. Sites sampled for the baseline nutrient study for *P. maximinoi* and *P. tecunumanii.*

Species	Trial	Company	Country	Lat.	Long.	Precip. (mm)	Elev. (m)
P. maximinoi	150225C1	SKCC	Colombia	2° 28' N	76° 54' W	1891	2787
P. maximinoi	1502X02A	SKCC	Colombia	4° 50' N	75° 35' W	2037	2852
P. maximinoi	151002A2	KLF	South Africa	24º 55' S	30º 57' E	980	1316
P. maximinoi	151021B2	KLF	South Africa	25º 15' S	30º 56' E	1080	1194
P. maximinoi	Plantation Block	Klabin	Brazil	24º 16' S	50º 31' W	1473	880
P. tecunumanii HE	130246A2	SKCC	Colombia	2° 20' N	76° 36' W	2241	2512
P. tecunumanii HE	1302X04B	SKCC	Colombia	2° 31' N	76° 40' W	1744	2235
P. tecunumanii HE	131032A4	KLF	South Africa	25º 15' S	30º 56' E	1080	1194
P. tecunumanii LE	1602X00A	SKCC	Colombia	3° 47' N	76° 34' W	1552	1207
P. tecunumanii LE	1602X23F2	SKCC	Colombia	3° 41' N	76° 34' W	1613	1140
P. tecunumanii LE	161014B	KLF	South Africa	24º 56' S	30º 57' E	975	1316
P. tecunumanii LE	Plantation Block	Klabin	Brazil	24º 14' S	50º 31' W	1490	820

Table 12. Mean nutrient concentration from foliage samples of healthy stands of *P. maximinoi* (max) and high-elevation and low-elevation *P. tecunumanii* (tec HE and tec LE, respectively).

Nutrient	Mean Concentration (Baseline Target)		
	max	tec HE	tec LE
N (%)	1.43	1.48	1.25
P (%)	0.11	0.11	0.09
K (%)	0.58	0.63	0.55
Ca (%)	0.25	0.23	0.28
Mg (%)	0.10	0.11	0.13
Mn (ppm)	438.33	318.61	462.90
Zn (ppm)	20.47	23.45	28.13
Cu (ppm)	4.96	5.73	7.37
Volume (m^3)	0.64	0.46	0.48

Outlook

Average nutrient levels from a number of healthy stands around the world can provide a first approximation of the critical nutrient levels for the species. Forest managers considering operational fertilization can use these values as initial baseline targets for the stand.

The data from this project will be analyzed in more detail and written up for publication. In addition, similar work will be conducted with *Gmelina arborea* in 2011.

Forest Industries Best Practices

What are the most efficient ways to manage a pine seedling nursery, a eucalypt hedge garden, a site preparation program or a commercial thinning operation? Camcore members from around the world have worked together for the past 18 months to compile their "Best Practices" procedures for seedling nurseries, vegetative propagation programs, and post planting operations for pines, eucalypts, teak, and *Gmelina*. Even though the final report will not be available until mid-2011, below are some preliminary findings from the Camcore membership.

Pines

- 45% of all pine programs plant some cuttings
- 59% of all pine programs use some percentage of composted pine bark as nursery medium
- 14% sterilize their nursery medium
- 36% grow pine seedlings under shade cloth during some portion of the nursery season
- 20% bed the soil during site preparation
- 79% use herbicides for weed control
- 28% fertilize pines at time of planting

Eucalypts

- The average optimum shoot height for a eucalypt cutting at field planting is 26 cm
- 50% of all eucalypt growers use plant hormones to root eucalypts
- 33% use a hydroponic system to maintain hedges
- 45% subsoil before planting eucalypts
- 70% must use some form of insect control before planting eucalypts
- 33% use hydrogel at planting
- 67% fertilize at or near the time of planting

Teak and Gmelina

- The average optimum shoot height for a teak or *Gmelina* seedling at field planting is 21 cm.
- The optimum cutting ranges from 4 cm-7cm in height and 1-2mm in root collar diameter when initially stuck in the shade/misting house.
- The average spacing in a hydroponic hedge garden is 10 cm x 10 cm.
- 84% of all teak and *Gmelina* growers subsoil before planting.
- The average planting depth for teak and *Gmelina* is 20 cm.
- The average stocking ranges from 1000 to 1250 stems per hectare at time of planting.
- 100% of all programs pruned teak and *Gmelina* in the first year after planting.

Camcore will report the complete results in tabular form by subject area so that those involved in the survey can easily see how their practices compare to their fellow members. The Best Practices survey will be updated periodically as methods change. As we said in last year's report, the willingness to share methodologies in the Best Practice survey speaks well about the strength of the Camcore membership. There was a 97% response rate to the initial survey.

Pinus radiata nursery at MTO in the Cape region of South Africa. The Camcore "Best Practices" assessment examined seedling, cutting and hedge production, site preparation and post-planting establishment.

Forest Pests and Pathogens in Guatemala

Camcore (NC State University) and FABI (Forestry and Agricultural Biotechnology Institute, University of Pretoria, South Africa) are working together on a project in Guatemala to understand pest and pathogen threats to pine species. The project became possible through an alliance between NC State and the University of Pretoria, with funds provided by both institutions. A first visit to Guatemala was made in October 2010. Juan López and Elmer Gutiérrez from Camcore and Jeff Garnas and Irene Barnes from FABI met with administrative and technical personnel of the National Institute of Forests (INAB), representatives of Grupo DeGuate (an associate member of Camcore in Guatemala), and a professor of Entomology from the Universidad de San Carlos. The group made reconnaissance trips throughout the country to visit natural populations of different pine species, including *P. tecunumanii, P. maximinoi, P. oocarpa, P. pseudostrobus, P. hartweggii,* and *P. ayacahuite*. There was full support from the Manager of INAB, who is interested in continuous collaboration to facilitate research and monitoring for the detection of potential threats.

Overall, Guatemalan forests appear to be quite healthy, including both naturally-regenerated and plantation stands. However, some natural stands with poor management show high levels of damage due to bark beetles. Ongoing outbreaks of *Dendroctonus adjunctus* were observed on *P. hartwegii* in San Carlos Sija, Department of Quetzaltenango. *Cronartium* sp. was frequently observed countrywide attacking mainly the branches of trees of different species without causing economic damage. *Dothistroma* needle blight had a patchy distribution, but was abundant in a *P. oocarpa* stand planted at an unsuitably high elevation (2,500 m.a.s.l.) in Jalapa. A second trip to Guatemala is scheduled for 2011.

Three-year-old Camcore second-generation trial of *P. maximinoi* planted by FEDECOVERA and INAB in Cobán, Guatemala. Personnel from Camcore, FABI, INAB, FEDECOVERA and the Universidad de San Carlos visited the trial. *Photo by Jeff Garnas, FABI.*

Eucalyptus Wood Pellets for Energy

There is much attention in the media today on alternative non-fossil fuel sources for energy. Woody biomass, a renewable resource, can play an important role in this arena. Many eucalypt species are very fast growing and have a high potential for biomass production. Camcore has begun a joint project with the NCSU Wood and Paper Science (WPS) Department to assess the potential of eucalypt wood for producing wood pellets. In comparsion with other solid biomass fuels such as wood chips and firewood, wood pellets have a number of advantages, including higher energy density per volume, lower moisture content, and better handling properties. For these reasons, worldwide wood pellet production has been substantially increasing in recent years. The objective of this project is to produce pellets from different eucalypt species and then assess the pellets for combustion properties such as moisture content, volatiles content, ash content, fixed carbon content, high heating value, and C, H, N and O composition. The outcome of the results will be published by Camcore and WPS. WPS has already published similar papers on *E. benthamii* and *E. marcarthurii* grown in the US. Camcore members will collect samples of at least 8 different important eucalypts (including *E. dorrigoensis, E. pellita, E. dunnii, E. saligna, E. globulus, E. tereticornis, E. grandis, E. urophylla* , and *E. nitens)* and send the wood to NC State University for assessment.

Stratification Requirements for Hemlock Seeds

Since 2003, Camcore has worked in cooperation with the USDA Forest Service on a project for *ex situ* gene conservation of Eastern hemlock (*Tsuga canadensis*) and Carolina hemlock (*T. caroliniana*). These species are native to the eastern United States and are endangered due to attack by the hemlock woolly adelgid (*Adelges tsugae*), an exotic insect pest that has caused widespread mortality of both hemlock species. Our objectives are to make seed collections from across the natural range of each species, place seeds into long-term cold storage, and outplant seedlings into conservation banks in the United States and South America. The overall goal of this conservation effort is to maintain both hemlock species in perpetuity until effective hemlock woolly adelgid management strategies are in place and the species can be reintroduced into their native habitats.

Although both hemlock species are ecologically important, they are not economically viable for plantation silviculture. Therefore, relatively little information is available about optimum methods for seed stratification. Understanding the pre-germination requirements will help to improve germination percentage and speed (days to peak germination), and increase the number of high quality seedlings available for both conservation and restoration plantings. Camcore has addressed this issue in a seed germination experiment conducted in an environmentally controlled growth chamber at the N.C. State University Phytotron.

Three provenances of each species were used in the experiment. Seed was collected in August to October of 2009. Following collection, the seeds were extracted from cones, cleaned, catalogued, and placed into cold storage in the Camcore seed cooler at 4°C until used in the study. Seeds were placed into cold, moist stratification treatments at 4°C for different lengths of time (60 days, 30 days, 15 days, and 1 day), and there was a control non-stratified treatment. The 60-day treatment began on Feb. 1, 2010. Seed stratification was conducted in petri dishes (50 seeds per dish; 4 dishes per treatment per provenance) with a substrate consisting of white germination blotters moistened to saturation with distilled water. Stratification was carried out in the Camcore seed cooler and germination blotters were remoistened weekly during this phase of the experiment.

Germinating seed of *Tsuga canadensis*. This species responds favorably to cold, moist stratification.

On April 5, 2010 the petri dishes containing the stratified seeds were moved from the Camcore seed cooler to an environmentally controlled chamber at the NCSU Phytotron for germination. Environmental conditions in the chamber were a constant 22°C, 20-50% relative humidity, and 16:8 light:dark cycle with light provided by incandescent bulbs. The petri dishes were observed and remoistened daily from April 6 to May 5, 2010, and the number of newly germinated seeds in each dish was recorded during each day's observations. The germination rates (percentage) of *T. canadensis* and *T. caroliniana* seeds in each cold, moist stratification treatment are shown in Figure 3.

The results of the experiment indicate that the seeds of these two congeneric species respond differently to cold, moist stratification (Figure 3), and the responses observed correlate well with the habitats in which each species naturally occurs. The percent germination of *T. canadensis* seeds increased with increasing duration of cold, moist stratification, reaching a peak rate of 30.1% in the 60-day treatment. *Tsuga canadensis* is a typically riparian species occurring naturally along streams or in swampy areas, habitats in which water is plentiful and one would expect seed germination to benefit from some period of moist stratification. *Tsuga caroliniana*, however, typically grows in dry and rocky soils along northwest facing mountain ridges where water is scarce.

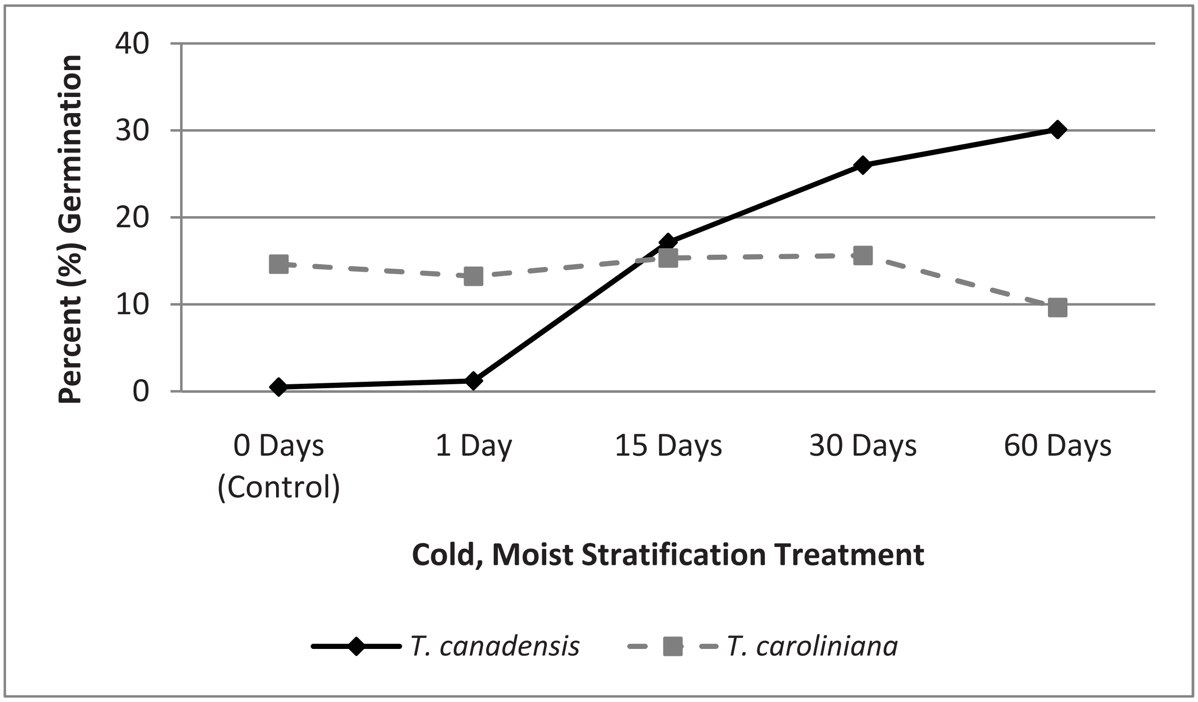


Figure 3. Germination of *T. canadensis* and *T. caroliniana* seeds after cold, moist stratification of varying duration.

Therefore, it is not surprising that cold, moist stratification treatments of 1, 15, and 30 days did not improve the germination rate of seeds compared to the control and appears to have been somewhat detrimental to germination success at 60 days.

Differences in the overall germination success of *T. canadensis* and *T. caroliniana* seeds were also observed at the provenance level (Figure 4), but the overall pattern observed for the species held true for each of the provenances within the species.

Based on the results of this experiment, Camcore recommends cold, moist stratification of at least 60 days prior to sowing in the nursery for *T. canadensis* seeds coming out of cold storage. *Tsuga caroliniana* seeds can be removed from cold storage and sown directly without any additional stratification treatment required. Whether or not cold, moist stratification beyond 60 days will further benefit *T. canadensis* or futher limit *T. caroliniana* seed germination is not currently known. Camcore is currently evaluating this in a second seed germination experiment testing the effect of 90 and 120 days of cold, moist stratification on seed germination in both species.

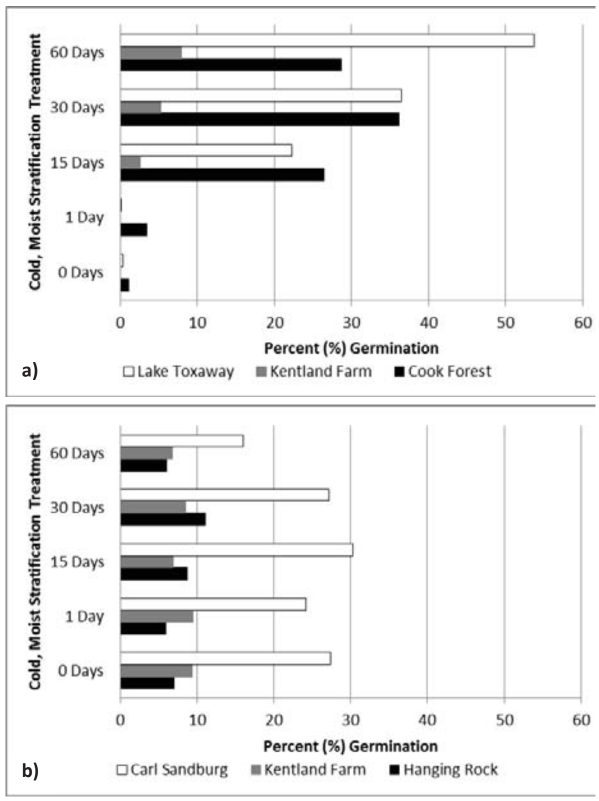


Figure 4. Provenance variation in germination (%) of *T. canadensis* (a) and *T. caroliniana* (b) seeds following cold, moist stratification of varying duration.

Shortcourses

Tree Improvement, Chile

Camcore continues to support and co-sponsor the tree improvement and biotechnology course hosted at the Universidad de Concepción in Chile every two years. The course in 2010 was successfully conducted between August 30 and September 15. Juan López give 3 lectures on hardwood and pine species, and the influence of eucalypt wood properties on the financial performance of a pulpmill. There were approximately 30 participants attending the course, many from the Camcore membership and others from forest organizations in Latin America. Other lecturers from NC State University and Camcore member companies included Barry Goldfarb, Bob Kellison, Steve McKeand, Claudio Balocchi, Christian De Veer, Pablo Ramírez, Carlos Contardo, Esteban Fuentealba, Verónica Emhart, and Jose "Pepe" Ordóñez.

Forestry Research, Venezuela

In March, Juan López and Jesús Espinoza gave a two-day workshop on “Forestry Research Programs” for the Camcore members in Venezuela: Smurfit Kappa Cartón de Venezuela, Terranova de Venezuela and PROFORCA. Four professors and four students from Univeridad de Los Andes in Merida were invited as special guests. The workshop was successfully hosted by SKCV in El Hierro farm, where approximately 20 attendees participated.

Data course participants from FOMEX were: Miguel Sánchez Gómez, Joel Ricardez Felix, Karina Obregón Torres, Sarai Ordas Vicente, Noemi Lanestosa Vidal, Eric Gordillo, Willi Woodbridge, Liliana Tiqué Reyna, Juan Carlos Chable Torres and Isidro Velázquez Ortiz. Not pictured: Lupe Grajales Gómez, Horacio Jimizez González and Ramón Aguilar Rodríguez.

Data Management

Camcore offered the annual data management course to personnel from member company FOMEX in August 2010; the first time the course has taken place in Mexico. The aim of the weeklong workshop is to instruct forestry staff in methods of collecting, recording, and validating data from progeny trials. The course consists of presentations, demonstrations, and explanations of concepts and techniques in data management ranging from strategies in computer file naming and organization to complex formulas and macro programming in Excel spreadsheets. The participants come from a variety of backgrounds and had different levels of experience, but all were interested in improving their skills and knowledge of computer techniques and data validation. The hands-on exercises are completed in class and have different levels of difficulty so that everyone can learn and practice something new. Some of the advanced spreadsheet functions learned and practiced include logical and lookup functions, text manipulation formulas, and pivot tables. The course was led in Spanish by Willi Woodbridge and was intense, fast-paced, and a challenge to all students.

Congratulations to the eleven participants from Fomex who worked diligently throughout the course, and thanks to the Fomex management staff, especially Eric Gordillo who made the preparations for the class and arranged work schedules to allow the workers to participate. Next year’s class is scheduled to be held in Kenya.

Willi Woodbridge looks over students working hard during the course

Camcore Hosts Meeting on Hemlock Genetics

On May 25, 2010 Camcore hosted the First Meeting of the Working Group on Genetics and Host Resistance in Hemlock at the Marriott Crabtree Valley Hotel in Raleigh, NC. This working group, organized under the USDA Forest Service Initiative for Management of the Hemlock Woolly Adelgid, is made up of university and federal researchers from throughout the United States who are interested in understanding the genetics of hemlock and the hemlock woolly adelgid and breeding adelgid-resistant genotypes for restoration. The purpose of the group is to identify priorities, assess progress, and set short-term and long-term goals for research on genetics and host resistance in hemlock. Robert Jetton (Camcore) serves on the steering committee for the group, and with Rusty Rhea (USDA Forest Service) and Andy Whittier (Camcore) helped to organize the meeting in Raleigh. This first meeting was attended by 18 people, had 10 scientific presentations on a variety of interesting topics, and ended with a thoughtful two hour discussion on developing strategies for breeding adelgid resistance into hemlock.

Attendees at the working group meeting included Dana Nelson (USDA FS), Jaime Zapata (NCSU/Bioforest-Arauco), Fred Hain (NCSU), Bud Mayfield (USDA FS), Nathan Havill (USDA FS), Rusty Rhea (USDA FS), Bill Dvorak (Camcore/NCSU), Richard Olsen (US National Arboretum), Robert Jetton (Camcore/NCSU), Randy Johnson (USDA FS), Steve McKeand (TIP/NCSU), Ron Overton (USDA FS), Barbara Crane (USDA FS), Gary Hodge (Camcore/NCSU), Kevin Potter (NCSU), Jesús Espinoza (Camcore/NCSU), Kelly Oten (NCSU), Willi Woodbridge (Camcore/NCSU), and Andy Whittier (Camcore/NCSU – not pictured).

Grants

Camcore continued its domestic conservation work in the United States utilizing funding for the second year of three-year projects with hemlock (*Tsuga* spp.) and Table Mountain pine *(Pinus pungens)*. The second year allotments totaled $103,333 from the USDA Forest Service - Forest Health Protection for hemlock and $16,184 from the USDA Forest Service - National Forest System for Table Mountain pine.

Camcore and FABI (South Africa) were awarded $10,000 to conduct a survey of pest and diseases in Guatemala. The grant was sponsored by NC State University and the University of Pretoria (South Africa).

Publications and Papers

Presentations

Dvorak, WS. 2010. Breeding for the Future: Improving Adaptability and Adding Value in Plantation Forests (invited presentation). 8th Southern African Plant Breeding Symposium, "Breeding for the Future". Stellenbosch, South Africa. March 15-17.

Jetton RM and WS Dvorak. 2010. Update on hemlock gene conservation in the eastern United States. Southern Appalachian Forest Entomology and Pathology Seminar, Crossnore, NC, USA. March 4-5, 2010

Jetton RM., GR Hodge and JR Rhea. 2010. Hemlock gene conservation, breeding, and restoration: planning for the future. 53rd Southern Forest Insect Work Conference, Wilmington, NC, USA. July 20-23, 2010

Jetton RM, WA Whittier, WS Dvorak, and JR. Rhea. 2010. Status of gene conservation for eastern and Carolina hemlock in the eastern United States. 5th Symposium on Hemlock Woolly Adelgid in the Eastern United States, Asheville, NC, USA. August 17-19, 2010

Potter KM, RM Jetton, WS Dvorak, VD Hipkins, WW Hargrove, R Rhea, and WA Whittier. 2010. "Of Microsatellites, HWA and Climate Change: Assessing Genetic Diversity, and Threats to It, Across the Range of Eastern Hemlock." 5th Symposium on Hemlock Woolly Adelgid, Asheville, North Carolina, August 18, 2010.

Potter KM, WW Hargrove, RM Jetton, WS Dvorak, VD Hipkins, R Rhea, and WA Whittier. 2010. "Of Microsatellites, HWA and Climate Change: Assessing Genetic Diversity, and Threats to It, in the Southern Appalachians." 20th Annual Southern Appalachian Man and the Biosphere Conference, Gatlinburg, Tennessee, November 16, 2010.

Whittier, WA and RM Jetton. 2010. Gene conservation of hemlock and Table Mountain pine in the eastern United States. Virginia Association of Forest Health Professionals, Staunton, VA, USA. February 1-2, 2010

Papers in Preparation

Jetton, RM and DJ Robison. Growth and biomass accumulation responses in short-rotation sweetgum following artificial defoliation. To be submitted to the Southern Journal of Applied Forestry.

Mitchell, RG, MJ Wingfield, ET Steenkamp, WS Dvorak and TA Coutinho. Reducing the risk of *Fusarium circinatum* by extending the planting range of *Pinus maximinoi* and *Pinus tecunumanii* in South Africa

Papers Submitted

Dvorak WS. The Strategic Importance of Applied Tree Conservation Programs to the Forest Industry in South Africa. Southern Forests.

Hodge GR, WS Dvorak & ME Tighe. Comparisons Between Laboratory and Field Results in Cold Tolerance of Southern US and Mesoamerican Pines Planted as Exotics. Southern Forests.

Wee AKS, C Li, WS Dvorak, & Yan Hong. Genetic Diversity in Natural Populations of *Gmelina arborea* (Lamiaceae): Implications for Breeding and Conservation. Tree Genetics and Genomes

Papers In Press

Jetton RM, JF Monahan and FP Hain. 2010. Laboratory studies of feeding and oviposition preference, developmental performance, and survival of the predator *Sasajiscymnus tsugae* on diets of *Adelges tsugae* and *Adelges piceae*. Journal of Insect Science. (In press).

Jetton RM, WA Whittier, WS Dvorak and JR Rhea. 2010. Status of gene conservation for eastern and Carolina hemlock in the eastern United States. Proceedings of the 5th Symposium on Hemlock Woolly Adelgid in the Eastern United States. (In press)

Potter KM, RM Jetton, WS Dvorak, J Frampton and JR Rhea. 2010. *Ex situ* seed collection represents genetic variation present in natural stands of Carolina hemlock. Proceedings of the 5th Symposium on Hemlock Woolly Adelgid in the Eastern United States. (In press)

Papers Published

Hodge GR and WC Woodbridge. 2010. Global near infrared models to predict lignin and cellulose content of pine wood. J. of Near Infrared Spectroscopy 18:367-380.

Schimleck LR, GR Hodge and WC Woodbridge. 2010. Toward global calibrations for estimating the wood properties of tropical, sub-tropical and temperate pine species. J. of Near Infrared Spectroscopy 18:355-365.

Poster Presentations

Potter KM, RM Jetton, WS Dvorak, J Frampton and JR Rhea. 2010. *Ex situ* seed collection represents genetic variation present in natural stands of Carolina hemlock. 5th Symposium on Hemlock Woolly Adelgid in the Eastern United States, Asheville, NC, USA. August 17-19, 2010

Other Publications of Interest

Brawner JT, DJ Bush, PF Macdonell, PM Warburton and PA Clegg. 2010. Genetic parameters of red mahogany breeding populations grown in the tropics. Australian Forestry; 73 (3) 177-183

Ladrach WE. Manejo Práctico de Plantaciones Forestales. (Practical Management of Forest Plantations). Editorial Tecnológica de Costa Rica. Cartago, Costa Rica. 660 p.

Leiva S. (editor) 2009. Propagación Vegetativa de La Teca *(Tectona grandis)* por el Método de Miniestacas. (Vegetative Propagation of Teak *(Tectona grandis)* using the Method of Mini-cuttings). Published by the Ministerio de Agricultura y Desarollo Rural, Refocosta y CONIF, Bogotá, Colombia. 77 p.

Solano F. GP. 2010 Caracterización Molecular de Clones de *Gmelina arborea* Mediante el Uso de Marcadores Moleculares AFLP (Amplified Fragment Length Polymorphism). (Molecular Characterization of Clones of *Gmelina arborea* using AFLP Molecular Markers) Tesis Profesional. Pontificia Universidad Javeriana, Facultad de Ciencias Básicas, Bogotá D. C. Colombia. 89 p.

Paim R. 2010. Efeito do uso da lama de cal e cloreto de potassio no solo, estado nutricional e crescimento do *Pinus taeda* L., sobre latossolo. (Effects of the use of mill white wash mud and potassium chlorate applied to the soil on the nutritional and growth status of *Pinus taeda* L. on latosols). Ph. D. thesis. Federal University of Curitiba, Curitiba PR, Brazil. 123 p.

Graduate Programs and Training

David Cerda Granados, a native of Nicaragua continues to work on his MS research, "The genetic inheritance of cold hardiness in pine hybrids". David is using the NC State Phytotron (environmentally controlled growth chambers) to conduct his study and is specifically looking at the cold resistance *P. patula x P. tecunumanii* (low elevation) hybrids versus the parents.

José Jiménez Madrigal, from Costa Rica, is working on better ways to use SNP markers to verify pine hybrid crosses. The title of his MS research is "Tropical pine hybrids identification through SNPs technology: Case studies and application to the forest industry". Results from his work will be very useful for Camcore as we move on with our pine hybrid projects.

Braden Ramage, a US native, made two trips to northern Mozambique in 2010 to gather information for his MS research project on, "The economic-social impacts of plantation forestry on local villagers in northern Mozambique". The research is partially sponsored by Camcore member Chikweti Forests and the Camcore membership. Braden hopes to complete his MS work in mid-2011.

Juan López, Camcore technical supervisor, continued his Ph. D. research on, "The economic value of pine hybrids". As part of his research Juan will be conducting pulping studies on the wood of pine hybrids from South Africa at NC State University to determine the additional potential revenue from planting hybrids vs. pure species.

Hannél Ham, will be working on a Ph. D. project entitled, "Protocol for the successful hybridization of *Pinus radiata* with other *Pinus* species" at Stellenbosch University, South Africa. Even though *P. radiata* exhibits good growth and wood properties in the Cape and it is an important commercial species in most Mediterranean climates, it also is susceptible to the Pitch canker disease *(Fusarium circinatum)*. Most problematic is that *P. radiata* seems to have strong reproductive barriers that hamper successful hybridization events with other pine species that might improve Pitch canker resistance. The goal of the thesis project is to understand why strong reproductive barriers exist, when they occur (pre-zygotic or post-zygotic stage), and to determine if there are practical ways to work around these. The project will be under the supervision of Ben Du Toit (Stellenbosch University), Arnulf Kanzler (Sappi Research) and Bill Dvorak (Camcore). All seven of the Camcore members in South Africa will be actively involved in the project. The Camcore membership will also contribute some funding to the project to partially support Hannél's work over the next two years.

University Committees and Service

Bill Dvorak, Professor of Forestry & Camcore Director was appointed "Professor Extraordinary" at the Department of Forest and Wood Science, Stellenbosch University, South Africa for the three-year period from 2011 to 2013. Bill will spend approximately 2 weeks per year at Stellenbosch mentoring graduate students and also serve as an advisor on graduate students' research projects. Bill continued as Associate Editor of Southern Forests (South Africa) and serves on the International Committee in the Department of Forestry and Environmental Resources, NC State University.

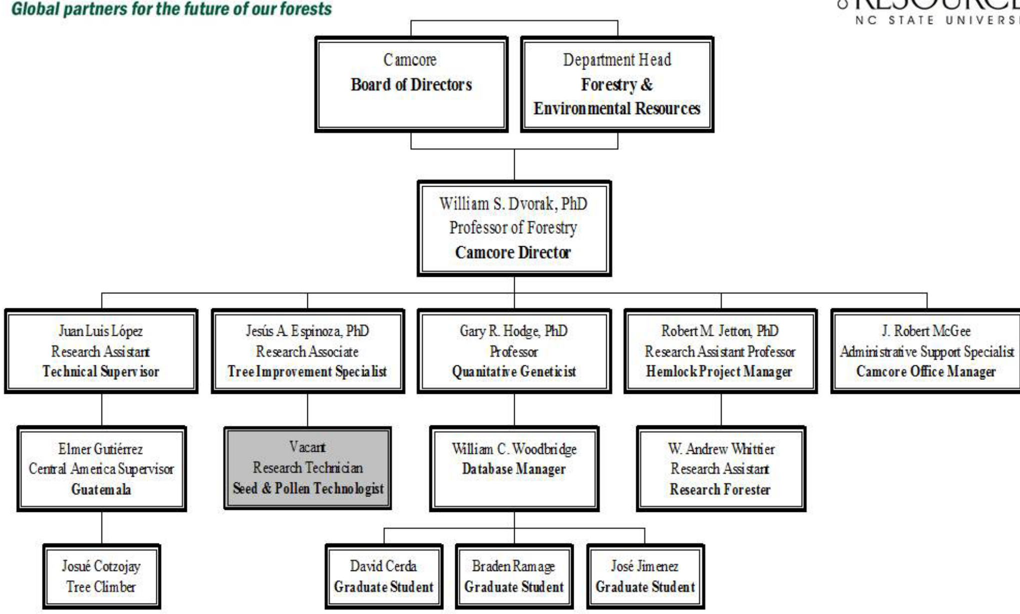
Gary Hodge continued to serve as Associate Editor for the *Canadian Journal of Forest Research,* and reveiwed articles for *New Forests* and *Tree Genomes and Genetics.* Gary also served on the Reappointment, Promotion and Tenure Committee and the International Committee in the NCSU Department of Forestry and Environmental Resources.

Robert Jetton, Research Assistant Professor & Camcore Hemlock Project Leader served as a peer reviewer for *Forest Ecology and Management, Functional Ecosystems and Communities,* and the *Journal of Insect Science.* Robert also 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.

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



Changes in Camcore

Darlon Orlamunder de Souza is the new Planning and Research Manager at Klabin and replaces **Carlos Mendes.** **Ivone Namikawa**, who has spent many years in the research section at Klabin, now focuses her efforts on Sustainability for the company.

Moacyr Fantini has been named as the Forestry Manager at Montes del Plata in Uruguay.

Andrew Morris, General Manager of Sappi Research, South Africa has now taken on the additional responsibility as Editor of "Southern Forests", an international journal of forest science.

Andrea Louw has been hired as tree breeder of cold hard eucalypts for Sappi Research. Andrea previously worked as a eucalypt breeder for the ICFR in Pietermartizburg, South Africa.

New Committee Members

Raul Schenone and **Raul Pezzutti** (Bosques del Plata), **José Romero** (Refocosta) and **Regiane Abjaud Estopa** (Klabin) were asked to serve on the Camcore technical committee beginning in 2011.

Passing of a Friend

Hennie Coetzee, a leader in promoting plantation forestry in South Africa and long standing friend of Camcore, died suddenly during a consulting visit when in the Sabie region in mid-2010. Hennie had a long career with government forestry organization in the country. With Rodney Fisk and Neville Denison, he made a pioneering seed collection trip to Mexico in the late 1960s to secure additional pine genetic material for South Africa. Hennie served as Camcore representative for SAFRI (South African Forestry Research Institute) for several years during the early 1980s and always exhibited a contagious enthusiasm for the Camcore effort. He urged Camcore to expand its seed collection work in Mexico for the benefit of southern Africa; work that was eventually completed by the year 2000. Hennie will most be remembered by his friends for his wonderful sense of humor. In many ways, he was "one of a kind" and will be greatly missed by all those who knew him.

Dr. Bruce Zobel, Founder and Friend

It is with much sadness that we report the passing of Dr. Bruce Zobel, an important and influential figure in the history of Camcore. Dr. Zobel was one of the founders of the Camcore program which was formed at NC State University in 1980. He hired his graduate student Bill Dvorak to run the fledgling program, and continued to be involved in Camcore for many years.

Dr. Zobel was a pioneer in the field of forest genetics, and his accomplishments were many. He directed tree improvement programs at Texas A&M and NC State University. He was a prolific writer, with several books and hundreds of journal publications to his credit. He was a mentor to multiple generations of forest genetics graduate students, and there is hardly a tree breeder in the world that has not been influenced by Dr. Zobel's teaching and writing. He was a wonderful communicator and teacher, and he had an ability to blend current pragmatism with a long-term vision for the future of the forest industry. In 1972, Dr. Zobel received the O. Max Gardner Award, the UNC Board of Governors' highest honor, given to recognize faculty who have "made outstanding contributions to the welfare of humankind."

Dr. Zobel on an exploration trip in Mexico in 1952. His desire to conserve forest genetic diversity led to the foundation of Camcore.

Even after his "retirement" in 1979, Dr Zobel never stopped working. He consulted for Camcore member companies for nearly two decades, always traveling with his wife Barbara, developing relationships and friendships with foresters around the world.

In this brief tribute, it is not our intention to list all of Dr. Zobel's publications, awards and achievements. We simply want to recognize and acknowledge the inestimable impact he had on tree breeding and gene conservation around the world, to marvel at his energy, perception and foresight, and to express our gratitude at having known him and of having been touched by his inspiration.

Dr. Zobel at the Camcore Annual Meeting in Guatemala in 1991.

Bruce and Barbara Zobel at Camcore's 25th Anniversary Celebration in Raleigh in 2005.

CAMCORE BOARDS AND COMMITTEES

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Germano Vieira, Masisa Brasil Empreendimentos Florestais, Brazil

Botha Maree, Merensky Pty Ltd, South Africa

Marius du Plessis, Mondi South Africa

Francisco Ferreira, Montes del Plata, Uruguay

Deon Malherbe, MTO Forestry, South Africa

Julian Moreno Chan, PG Bison Holdings, South Africa

Miguel Rodríguez, Pizano Monterrey Forestal, Colombia

Alí Francisco Peña, PROFORCA, Venezuela

Mr. David, PT Sumalindo Lestari Jaya, Indonesia

José Luis Romero, Reforestadora de la Costa, Colombia

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

Andrew Morris, Sappi Forests, South Africa

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Controlled pollination of eucalypts. In recent years, Camcore has expanded its work with eucalypts, and has projects in species testing, provenance / progeny testing, hybrids and wood quality.

Front Cover: Deon Malherbe visits the MTO - Camcore Conservation Park near Stellenbosch in South Africa. There are seven such conservation parks in South Africa, which will conserve important forest genetic diversity for the country.