camcore

Global partners for the future of our forests

2009 Annual Report

NC STATE UNIVERSITY

Front Cover: Hybrid hedges being grown at the Planfosur nursery in Concordia, Santa Catarina state, Brazil. These hybrids are the second series of the Camcore Hybrid Project, and will be used to establish tests at Rigesa, Masisa, and Klabin. In the foreground is *P. patula x P. oocarpa,* and in the background is *P. elliottii x P. taeda*.

2009 CAMCORE ANNUAL REPORT

International Tree Conservation and Domestication

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EXECUTIVE SUMMARY

1. Two new members joined Camcore in 2009. Border Timbers (Zimbabwe) became our 25th active member and CSIRO (Australia) became our 4th associate member.
2. Camcore embarked upon new initiatives to test both tropical and temperate eucalypts in South America and Africa. Collections were made of the tropical species *Eucalyptus pellita* in eastern Indonesia with the assistance of PT Sumalindo Lestari Jaya. CSIRO provided seeds of relatively obscure eucalypts which might have promise in regions that are cold and/or dry. Trials of both the tropical and temperate eucalypts will be established in 2010.
3. Camcore successfully initiated an exchange of Teak seed (more than 150 families) among several members. Seed will be distributed to members and an international series of trials will be established in 2010 on sites in Australia, Colombia, Guatemala, Indonesia, Mozambique, and Tanzania.
4. A number of new pine hybrid trials were established by Camcore members. Species-specific SNP markers have been identified to be used in the verification of putative pine hybrid seedlots. In a different study, NIR technology was successfully used on dried needle samples to distinguish among most of 16 pine species and varieties; this technology could possibly be a cheap alternative to molecular markers for pine hybrid verification.
5. The realized gains in second-generation trials of the Mexican and Central American pines have been remarkable at some test sites.
6. Camcore has begun work on the development of somatic embryogenesis protocols for tropical pines. We are collaborating with two very well known scientists in the area of SE research: Dr. Yill Sung Park of Natural Resources Canada, and Dr. Gerald Pullman of the Institute of Paper Science and Technology in Atlanta, Georgia.
7. The electrolyte leakage method was used to determine cold hardiness levels in different populations and landraces of *Pinus radiata* and *P. taeda* following artificial laboratory freeze studies. Results indicate that species have the ability to adapt to local climatic conditions in a relatively short time.
8. The timing of the development of pine strobili and cone production for temperate species planted in southern Africa and southern Latin America seems to be well correlated. However, the correlation between continents is less strong for subtropical species and relatively poor for tropical species. Generally, it appears that the pine flowering periods in southern African are more prolonged than in southern Latin America where rainfall is more evenly distributed throughout the year.
9. Genetic diversity results from a microsatellite study of *Gmelina arborea* indicate distinct differences between populations in China, Myanmar/Thailand, and India. The implications of the findings are discussed in the report.
10. The *Pinus taeda* GxE trials established across 14 sites in southern Latin America and South Africa have been or will be assessed at age 3 in late 2009 or early 2010. Survival at age 1 year was above 96% for most trials, and growth has been good (e.g., two trials in Argentina had average height of 4 m and dbh of 6 cm at age 3 years).
11. Camcore received $362,884 in grant money from the US Forest Service to continue its conservation activities with Eastern hemlock *(Tsuga canadensis)* and begin activities with Table Mountain Pine *(Pinus pungens)* in the eastern US over the next three years.
12. Camcore has three new graduate students from Costa Rica, Nicaragua and the US. Research projects will focus on hybrid verification using SNP markers, freeze resistance testing of *P. patula x P. tecunumanii* hybrids, and the economic benefits of plantation forestry to small rural communities in Mozambique.
13. The Camcore staff published 13 articles, gave 2 presentations at regional conferences, taught two graduate level classes at NC State University, gave four international short courses on tree improvement and data base management, and visited all of its 25 active members and three of its associate members in 15 countries in 2009.

RESUMEN EJECUTIVO (Español)

1. Dos nuevos miembros se vincularon a Camcore en el 2009. Border Timbers (Zimbabwe) se convirtió en nuestro vigésimo quinto miembro activo y CSIRO (Australia) en nuestro cuarto miembro asociado.

2. Camcore se embarcó en nuevas iniciativas para ensayar especies de eucaliptos tropicales y de la zona templada en Sur América y Africa. Se realizaron colectas de semillas de *Eucalyptus pellita* tropical en el este de Indonesia con la ayuda de PT Sumalindo Lestari Jaya. CSIRO aportó semillas de especies de eucaliptos relativamente desconocidas que podrían ser promisorias en áreas que son frías y/o secas. Ensayos de eucaliptos tropicales y de la zona templada, serán establecidos en el 2010.

3. Camcore inició exitosamente un intercambio de semillas de Teca entre los miembros, incluyendo más de 150 familias. Las semillas serán distribuidas a los miembros y una serie de ensayos internacionales serán establecidos en el 2010 en sitios de Australia, Colombia, Guatemala, Indonesia, Mozambique, y Tanzania.

4. Una cantidad de ensayos nuevos de híbridos de pinos fueron establecidos por los miembros de Camcore. Marcadores SNP específicos a las especies han sido identificados para asistir en la verificación de lotes de semillas de híbridos putativos de pinos. En un estudio diferente, la tecnología NIR fue utilizada exitosamente en muestras de acículas secas para distinguir entre la mayor parte de las 16 especies y variedades de pinos, lo cual posiblemente sería una alternativa barata para reemplazar los marcadores moleculares en la verificación de los híbridos de pino.

5. Las ganancias logradas en los ensayos de segunda generación de los pinos mexicanos y centroamericanos han sido notables en algunos sitios.

6. Camcore ha empezado a trabajar en el desarrollo de los protocolos de embriogénesis somática para los pinos tropicales. Estamos colaborando con dos científicos muy bien conocidos en esta área de investigación en embriogénesis somática: el Dr. Yill Sung Park quien trabaja con Recursos Naturales de Canadá, y el Dr. Gerald Pullman con el Instituto de Ciencia y Tecnología del Papel en Atlanta, Georgia.

7. El método de perdida de electrolitos fue usado para determinar niveles de resistencia al frío en diferentes poblaciones y razas locales de *P. radiata* y *P. taeda*, siguiendo estudios de congelación en laboratorio. Los resultados indican que las especies tienen la habilidad de adaptarse a condiciones climáticas locales en un tiempo relativamente corto.

8. Las épocas de desarrollo de los estróbilos y la producción de conos para las especies de la zona templada plantadas en el sur del Africa y el sur de Latinoamérica parecen bien correlacionadas. Sin embargo, la correlación entre continentes se torna menos fuerte para las especies subtropicales y relativamente pobre para las especies tropicales. Generalmente parece que los períodos de floración de los pinos en el sur del Africa son mas prolongados que los períodos de floración en el sur de Latinoamérica, donde la lluvia está distribuida mas uniformemente durante todo el año.

9. Los resultados de un estudio de diversidad genética de *Gmelina arborea* realizado con microsatélites indica diferencias muy grandes entre poblaciones de China, Myanmar/Tailandia, e India. Las implicaciones de los resultados son discutidas en el informe.

10. Los ensayos de Genotipo x Ambiente de *Pinus taeda* establecidos en 14 sitios en el sur de Latinoamérica y Sur Africa han sido o serán evaluados a la edad de 3 años a finales del 2009 o a principios del 2010. La sobrevivencia al año de edad estuvo por encima del 96% para la mayoría de los ensayos, y el crecimiento ha sido bueno (ejemplo: dos ensayos en Argentina tuvieron una altura promedio de 4 metros y un DAP de 6 cm a la edad de 3 años).

11. Camcore recibió $362,884 dólares del Servicio Forestal de los Estados Unidos para continuar sus actividades de conservación con el abeto del este *(Tsuga canadensis)* y empezar actividades con el pino de montaña de la mesa *(Pinus pungens)* en el este de los EUA durante los próximos tres años.

12. Camcore tiene tres nuevos estudiantes de postgrado de Costa Rica, Nicaragua y los Estados Unidos. Los proyectos de investigación se enfocarán en los sistemas de verificación de híbridos usando marcadores SNP, ensayos de resistencia a las heladas de híbridos de *P. patula x P. tecunumanii,* y los beneficios económicos de las plantaciones forestales en pequeñas comunidades rurales en Mozambique.

13. El personal de Camcore publicó 13 artículos, hizo 2 presentaciones en conferencias regionales, enseñó dos cursos a nivel de postgrado en la Universidad Estatal de Carolina del Norte, impartió cuatro cursos cortos internacionales en mejoramiento genético y manejo de bases de datos, y visitó todos sus 25 miembros activos y tres de sus miembros asociados en 15 países en el 2009.

RESUMO EXECUTIVO (Português)

1. Dois novos membros associaram-se à Camcore em 2009. Border Timbers (Zimbabwe) tornou-se nosso 25º membro ativo e CSIRO (Australia) nosso 4º membro associado.

2. A Camcore assumiu novas iniciativas para testar espécies de eucaliptos de zonas tropicais e temperadas na América do Sul e África. A coleta de *Eucalyptus pellita* tropicais foi feita no leste da Indonésia, com a assistência de PT Sumalindo Lestari Jaya. A CSIRO forneceu sementes de eucaliptos relativamente desconhecidas que possuem alta probabilidade de adaptação a regiões de clima frio e/ou seco. Testes com eucaliptos tropicais e temperados serão realizados em 2010.

3. A Camcore iniciou com sucesso uma troca de sementes Teak entre os membros, envolvendo mais de 150 famílias. As sementes serão distribuídas aos membros e uma série de testes internacionais será iniciada em 2010 na Austrália, Colômbia, Guatemala, Indónesia, Moçambique, e Tanzânia.

4. Vários testes foram estabelecidos pelos membros da Camcore com novos híbridos de *Pinus*. Marcadores especificos (SNP) foram identificadas para auxiliar a verificação de supostos lotes de *Pinus* híbrido. Em um estudo diferente, utilizou-se com sucesso a tecnologia de análise de Infra-vermelho próximo – NIR em amostras foliares secas para distinguir dentre mais de 16 espécies e variedades de *Pinus*. Esta pode ser uma alternativa econômica para a verficação de marcadores moleculares para *Pinus* híbridos.

5. Os ganhos obtidos com os testes da segunda geração de *Pinus* mexicanos e da América Central têm sido extraordinários em algumas áreas de teste.

6. A Camcore iniciou um trabalho de desenvolvimento de protocolos de embriogênesis somática – SE para pinheiros tropicais. Estamos colaborando com cientistas renomados na área de pesquisa de SE: Dr. Yill Sung Park da Natural Resources, Canadá e Dr. Gerald Pullman do Instituto de Ciência do Papel e Tecnologia de Atlanta, Georgia.

7. O método de vazamento eletrolítico foi utilizado para determinar os níveis de resistência ao frio em diferentes populações e espécies do *P. radiata* e *P. taeda* seguidos de estudos de congelamento em laboratório. Os resultados indicam que estas espécies têm habilidade de adaptação às condições climáticas locais em um tempo relativamente curto.

8. O tempo de desenvolvimento dos estróbilos e a produção de cones para as espécies de *Pinus* plantadas no sul da Africa e no sul da América Latina apresentam boa correlação. Entretando, a correlação entre os continentes torna-se menos forte para espécies subtropicais, e relativamente pobre para as espécies tropicais. Geralmente parece que a florescência do *Pinus* no sul da África é mais prolongada do que no sul da América Latina, onde as precipitações são distribuídas igualmente durante o ano.

9. Os resultados de diversidade genética obtidos a partir do estudo de *Gmelina arborea* com microsatélites mostram diferenças bastante distintas entre populações da China, Myanmar/Tailância e Índia. As implicações das descobertas são discutidas no relatório.

10. Os testes do *Pinus taeda* genotipo por ambiente, estabelecidos entre 14 locais no sul da América Latina e África do Sul foram ou serão avaliados nas amostras com três anos de idade, ao final de 2009 ou início de 2010. O índice de sobrevivência no primeiro ano ficou acima de 96% para a maioria dos testes e o crescimento tem sido bom (por exemplo, dois testes na Argentina mostraram uma altura média de 4 m e um DAP de 6 cm em amostras com três anos de idade).

11. A Camcore recebeu $362,884 em fundos de pesquisa do US Forest Service para continuar suas atividades de conservação da Cicuta Oriental (*Tsuga canadensis*) e iniciou atividades com o Pinheiro da Montanha Table (*Pinus pungens*) no leste dos Estados Unidos por mais de três anos.

12. A Camcore tem três novos estudantes de pós-gradução da Costa Rica, Nicarágua e Estados Unidos. Os projetos de pequisa focalizarão num sistema de verficação de hibrídos usando marcadores SNP, testes de resistência a congelamento dos híbridos *P. patula* x *P. tecunumanii* e dos benefícios da plantação de florestas em pequenas comunidades rurais de Moçambique.

13. A equipe da Camcore publicou 13 artigos, realizou duas apresentações em conferências regionais e criou dois cursos a nível de gradução para a Universidade da Carolina do Norte, lecionou quatro cursos internacioanis de curta duração em otimização de árvores e gerenciamento de banco de dados, e visitou todos os 25 membros ativos e três dos membros associados em 15 países em 2009.

RINGKASAN EKSEKUTIF (Bahasa Indonesia)

1. Dua anggota baru bergabung dengan Camcore di tahun 2009. Borders Timbers (Zimbabwe) menjadi anggota aktif kami yang ke-25 dan CSIRO (Australia) menjadi anggota associate kami yang ke-4.

2. Camcore telah memulai inisiatif-inisiatif baru di Amerika Selatan dan Afrika untuk mencoba berbagai jenis Kayu Putih dari daerah beriklim tropis dan sedang. Koleksi benih Eucalyptus pellita daerah tropis telah dilakukan di Indonesia bagian timur dengan bantuan dari PT Sumalindo Lestari Jaya. CSIRO menyediakan benih-benih Kayu Putih yang relatif belum banyak dikenal yang mungkin memiliki kecocokan untuk daerah dingin dan/ atau kering. Percobaan-percobaan berbagai jenis eucalytus dan Kayu Putih dari daerah tropis dan sedang ini akan diselenggarakan dalam tahun 2010.

3. Camcore telah berhasil memulai pertukaran benih Jati di antara para anggota yang meliputi lebih dari 150 famili/ tetua. Benih-benih akan dibagikan kepada para anggota dan serangkaian percobaan international akan diselenggarakan pada tahun 2010 di berbagai tapak di Australia, Kolumbia, Guatemala, Indonesia, Mozambik, dan Tanzania.

4. Sejumlah percobaan *Pinus* hibrida baru telah dilaksanakan oleh anggota-anggota Camcore. SNP markers yang spesifik untuk species ini telah berhasil diidentifikasi untuk membantu verifikasi benih-benih hasil putative hybrid pada *Pinus* hibrida ini. Pada studi lain yang berbeda, teknologi NIR telah berhasil digunakan pada contoh-contoh daun jarum kering untuk menentukan perbedaan jenis pada 16 spesies dan varitas *Pinus,* dan metode ini mungkin dapat menjadi suatu alternatif yang lebih murah daripada molecular makers untuk verikasi hasil hibrid pada *Pinus.*

5. Diperoleh hasil nyata yang sangat menggembirakan dari hasil percobaan-percobaan generasi kedua Pinus Meksiko dan Amerika Tengah yang dilakukan di berbagai tapak percobaan.

6. Camcore telah memulai penelitian untukpengembangan protokol-protokol Somatic Embryogenesis (SE) pada berbagai jenis pinus daerah tropis. Kami juga bekerjasama dengan dua ahli terkemuka di bagian penelitian SE. Dr. Yill Sung Park dari Natural Resource Canada, dan Dr. Gerald Pullman dari Institute of Paper Science and Technology di Atlanta, Georgia.

7. Metode 'electrolyte leakage' telah digunakan untuk menentukan tingkat resistensi terhadap suhu dingin dari berbagai populasi dan landrace *P. radiata* and *P. taeda* pada penelitian artificial freeze di laboratorium. Hasilnya menunjukkan bahwa berbagai spesies tersebut memiliki kemampuan untuk beradaptasi pada kondisi iklim setempat dalam waktu yang relatif singkat.

8. Diduga adanya korelasi yang erat antara waktu terbentuknya strobili pinus dan produksi biji pada spesies daerah iklim sedang yang ditanam di bagian selatan Afrika dengan bagian selatan Amerika Latin. Namun, korelasi antar benua pada spesies dari daerah subtropis tidak terlalu erat dan bahkan relatif lemah untuk spesies dari daerah tropis. Secara umum, tampaknya periode pembungaan pada pinus di bagian selatan Afrika lebih lama daripada di daerah selatan Amerika Latin yang mempunyai curah hujan merata sepanjang tahun

9. Hasil penelitan keanekaragaman genetik dengan microsatellite terhadap Gmelina arborea menunjukkan perbedaan yang sangat menyolok antara berbagai populasi di Cina, Myanmar/ Thailand, dan India. Implikasi yang diperolah dari hasil penelitian ini dibahas di dalam laporan tersendiri mengenai hal tersebut.

10. Berbagai percobaan *Pinus taeda* GxE yang dilaksanakan pada 14 tapak di daerah selatan Amerika Latin dan Afrika Selatan sedang atau akan diukur pada umur 3 tahun di akhir tahun 2009 atau awal 2010. Survival pada umur 1 tahun kebanyakan diatas 96% untuk hampir sebagian besar percobaan, dan pertumbuhannya juga bagus (sebagai contoh, dua percobaan di Argentina memiliki tinggi rata-rata 4 m dan dbh 6 cm pada umur 3 tahun).

11. Camcore telah menerima dana sebesar $362,884 dalam bentuk hibah dari Departemen Kehutanan AS untuk melanjutkan kegiatan konservasi pada Eastern hemlock *(Tsuga canadensis)* dan memulai kegiatan pada Table Mountain Pine *(Pinus pungens)* di bagian timur AS untuk periode tiga tahun ke depan.

12. Camcore memiliki 3 mahasiswa pasca sarjana baru dari Costa Rika, Nikaragua, dan AS. Proyek-proyek penelitian akan difokuskan pada sistem verifikasi hibrida dengan menggunakan SNP markers, percobaan resistensi terhadap suhu dingin pada hibrida *P. patula x P. tecunumanii,* dan manfaat ekonomi dari hutan tanaman pada komunitas petani kecil di Mozambik.

13. Staf Camcore telah menerbitkan 13 tulisan, memberikan 2 presentasi pada konferensi regional, mengajar di dua kelas pada tingkat pasca sarjana di NC State University, mengadakan empat kursus singkat internasional mengenai pemuliaan pohon dan pengelolaan database, dan mengunjungi seluruh 25 anggota aktif dan tiga dari anggota associate di 15 negara pada tahun 2009.

Message From the Director

There is a strong trend in forest industry in the tropics and subtropics to plant more eucalypts and fewer pines. This trend is driven in part by short-rotation economics and return on investment. Even in temperate climates, new attempts are being made to establish eucalypt trials in areas where they once failed - this time using improved gentetic material (hybrids and clones) and applying more intensive silviculture. At least one biotech company is working to develop genetically modified eucalypts that can withstand rapidly fluctuating temperatures. At the same time, the eucalypt genome is being sequenced, so in the future we may know the functions of individual genes. This will present opportunities and challenges as we try to integrate these technologies into traditional breeding programs.

At the other end of the spectrum, an increased incidence of insect attacks on eucalypts is becoming troublesome, especially in the tropics and subtropics. Some of the attacks involve introduced pests, others are local insects that have taken a sudden liking to eucalypt leaves. How much productivity is being lost due to these pests? To what extent does this negate the gains being made from improved clones and better tree nutrition?

There continues to be heated debate about the environmental effects of eucalypt plantations. These discussions will become more acrimonious if global climatic fluctuations spawn extended periods of droughts. With 14 to 18 million hectares of eucalypts planted worldwide, one would think these questions would have been resolved by now, but they have not.

In Camcore, we work with two tropical eucalypts that are known for good disease resistance and their ability to serve as good hybrid parents, *E. urophylla* and *E. pellita.* Our genetic material comes from natural stands in Indonesia, and we hope to find populations that are broadly adapted to a changing environment. We have also begun work with CSIRO, Australia, to test obscure species of eucalypts that may have good drought/cold resistance and ultimately might serve as a source of pulp, saw timber or bio-energy. Our first trials of these lesser known species will be established by members in Africa and South America in 2010.

With all the emphasis on eucalypts and short-fiber species in general, I wonder if many organizations are concerned about their future supply of long-fiber pines? Even as Camcore is expanding work in the eucalypts, we have not lost our focus on the development of pines (or Gmelina and Teak, for that matter), or the need to remain strong in the area of gene conservation. The number of second-generation pine progeny trials increases each year. The realized gains in some of these advanced-generation trials have been stunning and illustrates what we have been saying for years: the true value of many of the Mexican pine species can not be determined until we have selected and tested these for several cycles of breeding.

Our pine hybrid program has shown some very interesting early field results. A number of promising tangential projects have been generated, including the development of species-specific SNP markers, and the utilization of NIR technology to distinguish between pine species and possibly their hybrids. More in depth research is underway on how cold hardiness is genetically inherited in pine hybrids. Our proposed somatic embryogenesis project on tropical pines hopefully will give us opportunities to mass produce good hybrid combinations in the future.

In the conservation arena, the Camcore Conservation Park initiative in South Africa is rapidly becoming a model for forest industry to follow in many regions of the world. Reintroduction of seeds into Mexico and Central America and the subsequent establishment of field trials continues to be an energizing force that ties the original donors of genetic material to their receptor countries. Genetic diversity assessments of *Pinus oocarpa* and *Gmelina arborea* have been recently completed, and our efforts to conserve hemlock *(Tsuga)* species in the eastern US continues to be successful.

As all of us know, 2009 was a difficult year because of global economic problems. Despite the challenges, Camcore membership actually grew in 2009. The staff thanks all of the members for their support of the program.

Bill Dvorak, Director

2009 Camcore Membership

Active, Associate & Contributing Members

Argentina
- Alto Paraná
- Bosques del Plata

Australia
- CSIRO (Associate)

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

Chile
- Arauco Bioforest
- CMPC Forestal Mininco

Colombia
- 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)
- Gobierno del Estado de Veracruz (Associate)

Mozambique
- Chikweti Forests

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

United States of America
- USDA Forest Service (Associate)
- Weyerhaeuser Company (Contributing)

Uruguay
- Montes de Plata
- Weyerhaeuser Company

Venezuela
- 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 Genética Forestal
- Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP)

Nicaragua
- Instituto Nacional Forestal (INAFOR)

The 2009 Annual Meeting in Uruguay

In November of 2009 thirty-seven representatives from 21 international forestry companies travelled to Uruguay for the 29th Camcore Annual Meeting. Montes del Plata (formerly Stora Enso) and Weyerhaeuser Uruguay organized an exciting and informative mix of ten days filled with field visits and technical meetings. During our visit we saw a large cross section of Uruguay in our travels from Montevideo on the southern coast to Rivera along the northern border. Beautiful weather throughout our trip only helped to increase our appreciation of Uruguay. While this was the first Annual Meeting in Uruguay, it will hopefully not be the last.

We began our meeting in the capital city of Montevideo with a Technical Meeting that included presentations from local experts who provided us with an informative background on the soils, climate, and forestry history, legislation and issues in Uruguay. Our introduction to the ecology and current issues in Uruguayan forestry policy was followed by an update on some of the ongoing Camcore projects. This first day of meetings was capped off with an excellent meal and local wine tasting coupled with a humorous and intriguing magic performance.

At the conclusion of our first Technical Meeting we headed north to Rivera. Along the way we stopped in Tacuarembó for a visit to INIA (Instituto Nacional de Investigacíon Agropecuria). During our visit we learned about the history and current state of INIA as well as some of the research that they are involved in. After the presentations, we headed to the field for a presentation on INIA's clonal *Pinus taeda* orchard and their work on the Camcore hybrid project. Following our visit, we went a few kilometers north to Weyerhaeuser's new clonal nursery facility. There we were provided with some background on Weyerhaeuser's operations in Uruguay and a tour through their clonal pine and eucalypt seedling production facilities.

We spent the following day back in the Tacuarembó region where Weyerhaeuser showed us some of their research on eucalypt spacing and pine pruning. We also visited the nearby La Corona watershed, in which Weyerhaeuser is working with researchers from NC State University and INIA to better understand the hydrological

Juan Pedro Posse with Weyerhaeuser explains their eucalypt spacing trial.

and environmental effects of grassland conversion to forestry. These two days of field visits were wrapped up by a Weyerhaeuser sponsored evening of good food and great music in Rivera.

Following these two days of field visits we spent the next day in Rivera for our second Technical Meeting. There we heard more on some of the current and proposed Camcore projects as well as some of the exciting research

NC State hydrology professor Chip Chescheir inspects the instrumentation at the La Corona watershed.

Francisco Ferreira and Monica Heberling explain a Montes del Plata clonal *P. taeda* trial.

some of our member companies are developing.

After our stay in Rivera we headed back towards Tacuarembó to visit some Montes del Plata trials. There we learned about Monte del Plata's work with clonal *P. taeda*, eucalypt silviculture, and provenance / progeny testing of *Eucalyptus dunnii*. We then headed to Trinidad where Montes del Plata treated us to another night of phenomenal food and music.

Our travels next led us to Durazno where Montes del Plata showed us their work in evaluating the performance of different sources of *P. taeda* genetic material. We then visited a nearby *E. dunnii* trial where they were looking at the effect of different container shape, sizes, and material on seedling development in the field. This *E. dunnii* container study marked the end of our field visits before heading back to Montevideo

Our final day of the 2009 Annual Meeting began with a Business Meeting and ended with a farewell dinner held at Teatro Solis. This historic theater provided a stunning setting and view of the Plaza Independencia in the heart of Montevideo. There we reflected on the many things we experienced during our all too brief visit to Uruguay while making plans for years of collaboration to come.

Annual Meeting Participants at Weyerhaeuser's pine pruning trial.

Developments in Camcore

In 2009, Border Timbers (Zimbabwe) joined Camcore as an active member and CSIRO (Australia) joined as an associate member. Border Timbers plants mostly *Pinus patula* and *P. elliottii* for solid wood in the eastern highlands of the country and is interested in expanding its species selection to include *P. tecunumanii* and *P. maximinoi.* The company is also interested in participating in the Camcore pine hybrid program. CSIRO's interest in Camcore is to work jointly on scientific projects to promote knowledge of forest trees. Plans were developed in 2009 for the distribution of cold/drought hardy eucalypts as one of our first projects together (see article *Cold and Drought Tolerant Eucalypts* in this report).

The Camcore staff was very busy making technical visits and offering shortcourses in tree improvement and data base management in 2009. Below we summarize some of these activities.

Raúl Pezzutti of Bosques del Plata (Argentina) next to a hybrid of *P. patula x P. greggii.*

Argentina

Gary Hodge and Bill Dvorak visited **Alto Paraná (APSA)** and **Bosques del Plata (BDP)** in July. At both companies, the pine hybrid studies were in excellent condition, with some tropical varieties doing very well after about 1½ years of growth. In particular, *P. caribaea x P. tecunumanii, P. caribaea x P. oocarpa,* and pure species *P. tecunumanii* are all much bigger than the *P. taeda* controls. BDP has invested a substantial amount of work in establishing a clone bank with Camcore selections of *P. caribaea* and *P. maximinoi* made in APSA trials. Unfortunately, the *P. maximinoi* grafts are showing a great deal of graft incompatibility, which is typical for the species. BDP will test a number of alternative vegetative propagation techniques to try to keep all of the selections alive.

Brazil

At the end of April 2009, Gary Hodge and Juan Lopez visited **Masisa** in Paraná, Brazil. During the field visits, they gave recommendations to Mariana Schuchovski and her research team on strategies for the establishment of loblolly pine clonal trials and a clonal seed orchard. Camcore continues to work with Masisa to provide seeds and protocols for the establishment and management of first- and second-generation progeny trials with promising species of tropical pines. Two second-generation trials of *P. maximinoi* and two trials of *P. greggii* will be planted at the beginning of 2010 with seeds provided by the program. Rooted cuttings of Camcore pine hybrids will be delivered to Masisa by Rigesa for the planting of two new hybrid trials at Masisa in 2010.

Gary and Juan visited **Klabin** in Paraná, and Juan also traveled to Santa Catarina. Klabin is a long-time member of Camcore, and has made a great contribution to the program by providing seeds from selected families of *P. tecunumanii, P. maximinoi, P. greggii* and *P. patula* for second-generation Camcore trials throughout southern Latin America. As part of a seed exchange among members in different parts of the world, Klabin will receive seeds of the same species from members in South Africa and Colombia. Gary and Juan visited an interesting clonal trial of loblolly pine in Paraná, gave recommendations on the strategy to follow with vegetative propagation of pines, and discussed the current status of the Camcore initiative to work in the area of somatic embryogenesis. Klabin is continuing the establishment of pilot plantations of *P. maximinoi* in the state of Paraná, where the species has better growth than *P. taeda* and high commercial potential.

Gary also visited **Rigesa** where he saw very exciting development of the pine hybrids in the 1½-year-old trials of the first series of hybrids from the Camcore project. Several of the *P. patula* hybrids showed better height growth than the pure species *P. taeda* controls. He also saw much improved health in the Rigesa *P. patula* seed orchard following fertilization with calcium last year. As part of the visit, Gary and Laercio Duda travelled to the Planflora nursery in Concordia, where owner Laurindo Silva has been jointly contracted by the Brazilian Camcore members to produce hybrid cuttings of the second series of Camcore hybrids (see front cover photo). The hybrids include *P. greggii x P. tecunumanii, P. patula x P. tecunumanii, P. elliottii x P. taeda,* and *P. elliottii x P. greggii,* and others. The quality of the hedges was excellent, and the cutting production of most hybrids was quite good even with hedges just a few months old. We hope to be able to distribute cuttings for new hybrid trials sometime in 2010.

Chile

Gary Hodge visited Chile in September. At **Arauco Bioforest,** we discussed the new disease DFP (Daño Foliar de Pino) which has affected large tracts of *P. radiata* on Arauco land. In 2007, Arauco established a large field trial with 17 species (including many Camcore species), to try to identify some with resistance or tolerance to the disease. The spread of the disease was not as bad in 2009 as in 2008, perhaps indicating that DFP requires high humidity and temperature to produce high levels of infection.

Arauco has made a very good contribution to the Carolina hemlock program *(Tsuga caroliniana)* with the establishment of a conservation bank containing 56 families from 9 provenances. Field survival was quite good, 89% at age one year. It appears, however, that hemlock seedlings are very appealing to rabbits. Damage was significant, and Robert Jetton and Andy Whittier visited Arauco in October to evaluate the conservation bank and make recommendations for the use of rabbit repellent and continued monitoring of survival and growth.

At **CMPC Forestal Mininco,** Gary spent time with Veronica Emhart, Alex Medina and Jean Pierre Lasserre discussing the results of a *P. radiata* wood properties study conducted by Camcore. Gary and Alex also looked at some older *P. greggii* progeny trials. Using unimproved native material, the species has grown well enough to demonstrate its value as an alternate species. It is important to test second-generation material as soon as possible to see the true potential of the species. Gary also had discussions with Rebeca Sanhueza and Edgardo Velilla Ponce regarding eucalypt data analysis and breeding.

Colombia

Jesús Espinoza visited the three Camcore members in Colombia in July. At **Pizano Monterrey Forestal,** he evaluated the progress being made by the Pizano research program with the species *Gmelina arborea* and *Pachira quinata.* He also assessed the possibility of establishing a base line nutrient study in *Gmelina arborea* in 2010 (see article *Baseline Nutrient Determination* in this report). The installation of a new covering and watering system in the greenhouses to control temperature and moisture content has been fundamental in improving rooting percentage for these species.

Jesús also visited **Refocosta** to discuss various aspects of nutritional and silvicultural management of Camcore trials including Teak, a new species in our program. The company has begun to consolidate its research department, and is working with Camcore to develop short-, medium- and long-term tree improvement programs for *Eucalyptus tereticornis, P. caribaea,* and *Tectona grandis.*

Hugo España and Marta Salas of Smurfit Kappa Cartón de Colombia with a cutting of hybrid *P. caribaea x P. tecunumanii* planted at 1700 m elevation showing excellent growth after 1½ years.

Gary Hodge visited the Refocosta project at Villanueva in the Llanos region in August. The focus was on tree improvement strategies for *P. caribaea,* and it was recommended that the company acquire a seed orchard site suitable for *P. caribaea* (as well as *P. oocarpa* and *P. tecunumanii).* The company also has a number of good selections of *E. pellita,* and we recommended clonal testing designs.

Jesús visited **Smurfit Kappa Cartón de Colombia (SKCC)** to begin foliage collections for the baseline nutrient project for *P. tecunumanii* and *P. maximinoi.* This information can be used by companies to help resolve possible nutrient problems in the future and identify minimum nutrient levels necessary for good survival and growth in plantations. Gary also visited SKCC in August. The control crossing program in *P. tecunumanii* and *P. maximinoi* has produced about 3000 CP seed in both species. These full-sib families should eventually replace the current operation hedges in the nursery which are derived from OP seed. In 2008 and 2009, Camcore worked with SKCC to develop an NIR model to screen *E. grandis* samples for pulp yield. This model can be used for future selection projects with a huge time and cost savings for the company.

East Africa

Bill visited the organization members of **East Africa** in Kenya, Uganda and Tanzania with Benson Kanyi in February 2009. In Kenya and Uganda, members established Camcore trials of *P. tecunumanii* and *P. maximinoi,* and in Tanzania, trials of *E. urophylla* were established. Discussions with our Tanzanian colleagues at TAFORI dealt with the upcoming exchange of Teak seeds (see article *Teak Seed Exchange* in this Annual Report). In Uganda, Bill and Benson met with representatives of the Kilimo Trust that supports Camcore's effort in the region.

Guatemala

Juan Lopez visited **Grupo DeGuate** in July. During the visit there was a field tour around the country in which he gave technical recommendations on forestry species and tree improvement strategies. The establishment of provenance/progeny trials and a *P. maximinoi* clonal seed orchard are priorities for genetic improvement in

Seedling of Camcore *E. urophylla* being grown for progeny trials by TAFORI (Tanzania).

Guatemala. Grupo DeGuate is taking good care of several pine reintroduction studies in Guatemala. Grupo DeGuate is also taking part in the Camcore Teak seed exchange (see article *Teak Seed Exchange*), and sent seeds from Guatemala and Costa Rica to North Carolina. Two Teak progeny trials will be planted in Guatemala in 2010.

Juan also met with Mr. Josué Ivan Morales Dardón, the new Director of the Guatemala **National Institute of Forests (INAB),** to discuss opportunities for collaboration between Camcore and the Government of Guatemala. The tree improvement plan for Guatemala developed by Camcore in 2005 will be reviewed by Camcore, and Josué will continue looking for international funding through the International Tropical Timber Organization (ITTO).

Indonesia

Bill Dvorak visited **PT Sumalindo Lestari Jaya** in March. The Sumalindo research team has made advances in the establishment of its second clonal orchard of *Gmelina* using Camcore material. The composition of the newest orchard includes progeny trial selections of *Gmelina* from southwestern China, Myanmar and India. Sumalindo was also instrumental in making seed collections of *Eucalyptus pellita* in natural stands in Papua (Indonesia) for Camcore (see article *2009 Seed Collections* in this report).

Mexico

Juan Lopez visited **FOMEX** at the end of August. Juan visited the two main zones of the company's forestry project to make recommendations on species trials. New tests of *P. tecunumanii* and *P. maximinoi* were shipped to Fomex by Camcore in 2009. Five hundred grams of Teak seeds were also sent by Camcore for an operational trial in the Municipality of Tatlaya where the species has commercial potential. Camcore will help Fomex to assess two *E. urophylla* trials, one on spacing and one on site preparation recommended by Bill and Juan in 2005. A new spacing trial of *E. nitens* recommended by Camcore was established this year.

Juan also visited the **Veracruz Government** in Xalapa where he gave recommendations to the nursery manger regarding seedlings of *P. patula* that will be used for the establishment of two second-generation studies. One of the planned sites for the test establishment is at 2,000 m elevation with ideal environmental conditions for the optimal growth of the species. Camcore will provide the statistical design of the tests once the seedlings are ready to be planted in the field in 2010. Juan also gave a presentation about Camcore research work in Mexico around the world to representatives of the forestry sector in the state of Veracruz.

Production of teak seedlings in Pilones' nursery in Petén, Guatemala, one of the companies in Grupo DeGuate.

Mozambique

Bill visited **Chikweti Forests** in northern Mozambique to see the development of the new forestry project. Seed stands of *P. tecunumanii, P. oocarpa,* and *P. caribaea* have been established by the company, as have the first Camcore trials of *P. tecunumanii* and *P. maximinoi.* Camcore also sent the Chikweti Group some *E. urophylla* seed to test at lower elevations. Chikweti Forests (Tectona Forests of Zambizia Ltd.) is also participating in the Camcore Teak exchange and should be planting these trials in the field in 2010.

South Africa

Gary Hodge visited four South African members in February. At **Hans Merensky**, much time was focused on developing an improvement strategy for their elite *E. grandis* breeding population. The Camcore *E. urophylla* provenance/progeny tests established by the company are doing well, and the *E. urophylla* conservation park material is healthy and was ready to be outplanted at the Weza Conservation Park sometime in late 2009.

At **PG Bison**, most of the visit was spent discussing the internal PG Bison breeding strategy for all tree species. One high priority that was identified was to thin *P. patula* and *P. greggii* progeny tests to convert them into seedling seed orchards in order to provide the company with its own seed source of selections made in the North Eastern Cape.

At **MTO Forests**, the second-generation *P. tecunumanii* and *P. maximinoi* progeny tests look outstanding. Relative to *P. radiata,* these species offer potential improvements in growth, wood quality, and *Fusarium* resistance. They have not been previously tested in the Cape region, and we are very interested to see how they will perform over the next few years. MTO also has assessed a number of *P. elliottii x P. caribaea* var. *hondurensis* hybrid trials with the Tree Sonic acoustic tool. Some of those measured trees have been felled and are being utilized for wood strength testing. The results will help us evaluate how to properly interpret Tree Sonic measurements.

Andre van der Hoef next to an improved *P. radiata* control, and Deon Malherbe next to a second-generation *P. tecunumanii* in an MTO test in the Cape Region of South Africa.

At **Komatiland Forests (KLF)**, the hedges for the second series of hybrid hedges were developing nicely. We very much appreciate the contribution of KLF to the Camcore hybrid program. KLF has also made very good progress on the Conservation Park, despite the loss of some trees due to deer browse. In the Camcore hybrid trials and the second-generation progeny tests, a number of the tropical species and hybrids have much better first-year survival than *P. patula.*

The first attempts by Hans Merensky and KLF in grafting *P. maximinoi* and *P. tecunumanii* did not meet with great success. Overall survival was only around 10% or less. Other Camcore members in South Africa are also having much difficulty with pine grafting. We must work together as a group to improve our techniques in this vital area.

In 2009, we did not make our normal technical visit to **Sappi** or **Mondi.** Instead, Bill Dvorak and Gary Hodge spent two weeks in South Africa in late May and early June participating in the Southern Africa Tree Improvement Shortcourse hosted by Mondi, with technical and logistical support by Sappi and KLF. The course was attended by representatives of all six Camcore members in South Africa as well as Mozambique, Zimbabwe and East Africa (see the article on *Shortcourses* in this Annual Report).

Uruguay

Gary Hodge visited **Montes del Plata** and **Weyerhaeuser** in March. Much of the visit focused on planning for the 2009 Annual Meeting, however there was also time to discuss other Camcore projects and company breeding and testing strategies. Second-generation seed of *P. maximinoi* and *P. greggii* from Brazil have been shipped to Uruguay for both Montes del Plata and Weyerhaeuser to establish progeny tests. Both companies are relatively new members of Camcore, and there are a number of alternative species of pines and eucalypts that should be investigated. Pine species with good potential include temperate species *P. patula* and *P. greggii* var. *australis*, and subtropical species *P. maximinoi* and *P. tecunumanii.*

Venezuela

During his visit to Venezuela at the end of June, Juan Lopéz met with Adriana Marín and the research team of **Smurfit Kappa Cartón de Venezuela (SKCV)** to discuss some important steps to develop the breeding strategies for *E. urophylla, G. arborea* and *P. caribaea*. Juan emphasized the importance of land acquisition for the establishment of a *P. caribaea* clonal seed orchard, where the company can continue developing its breeding program. Camcore received seeds of 38 families of *P. caribaea* from the seed orchard of PROFORCA in Santa Cruz de Bucaral this year that will be used by SKCV in the establishment of second-generation progeny trials. SKCV is growing the pine hybrid hedges from the seeds sent by Camcore for the establishment of the hybrid trials in SKCV and Terranova.

Terranova continues developing its vegetative propagation protocols of *P. caribaea* through the construction of new facilities, following the recommendations of Camcore. Terranova built a small greenhouse with an intermittent mist irrigation system that will allow the company to establish trials testing different substrates, cutting sizes, hormones, etc. The company is also progressing with a tree improvement strategy for *P. caribaea.* Camcore continues to assist the company with the establishment of first- and second-generation progeny trials.

2009 Seed Collections: *E. pellita* and various pines

Eucalyptus pellita

Eucalyptus pellita is a lowland tropical species native to Indonesia (the Papua province), Papua New Guinea, and Australia (the state of Queensland). Some taxonomists refer to the Indonesian and Papua New Guinean provenances as *E. biterranea*. *Eucalyptus pellita* is a major plantation species in Indonesia. It can be used as a hybrid parent with a whole host of other eucalypts for high rainfall areas of the tropics and for regions where there is a high incidence of disease or pests. Past seed collections in natural stands destined for international trials have been concentrated mainly in Australia and Papua New Guinea.

In 2009, Camcore, in collaboration with Indonesian member PT Sumalindo Lestari Jaya, made its first conservation collection of *E. pellita* in remote areas of eastern Indonesia. Six populations and 99 mother trees were sampled in the initial collection (Table 1). The seeds are destined for progeny trials and conservation banks in Australia, Colombia, Mexico, Mozambique, South Africa, and Venezuela. In addition to looking at productivity of *E. pellita,* Camcore wants to quantify levels of disease resistance of *E. pellita* particularly in tropical Latin America in collaboration with FABI (Forestry and Agricultural Biotechnology Institute, South Africa).

Collectors measuring the DBH of an *E. pellita* tree in a natural stand in Papua, Indonesia.

Table 1. Summary of seed collections completed in Central America and Indonesia in 2009.

Country	Species	Provenance	Status	Latitude	Longitude	Trees
Indonesia	*E. pellita*	Muting	Low Risk	07º 26' S	140º 39' E	3
	E. pellita	**Bupul**	Low Risk	07º 30' S	140º 47' E	15
	E. pellita	Kweel	Vulnerable	07º 58' S	140º 50' E	13
	E. pellita	Caruk	Endangered	07º 55' S	140º 59' E	21
	E. pellita	Jagebob	Endangered	07º 58' S	140º 45' E	22
	E. pellita	Okaba	Endangered	07º 49' S	140º 44' E	25
Guatemala	*P. chiapensis*	Barrillas	Vulnerable	15º 48' N	91º 19' W	15
	P. tecunumanii high elev.	San Jerónimo	Vulnerable	15º 03' N	90º 18' W	15
	P. caribaea var. *hondurensis*	Poptun	Vulnerable	16º 20' N	89º 25' W	17
Honduras	*P. oocarpa*	Tablazon	Vulnerable	14º 07' N	87º 37' W	15
	P. oocarpa	Pimientilla	Low Risk	14º 54' N	87º 32' W	15
	P. maximinoi	Tatumbla	Vulnerable	13º 58' N	87º 05' W	15

Camcore would like to thank the administration and research team of PT Sumalindo Lestari Jaya for their assistance in making the seed collections. In particular, we would like to make special mention of Mr. Arif Purwanto at Sumalindo for his dedicated effort to make the project a success.

Pine Collections in Central America

Camcore also made seed collections in Central America in 2009 for conservation and tree improvement purposes from three natural populations in Guatemala and three in Honduras (Table 1). In recent years, we have made repeat collections of seed for conservation purposes for provenances which are poorly represented in the Camcore genetic tests. The seeds are sent to Camcore members in different countries where they are used for the establishment of additional progeny tests and *ex situ* conservation banks.

Elmer Gutiérrez, the field coordinator for Camcore in Central America, also coordinated and took part in seed collections of Teak *(Tectona grandis)* in Guatemala and Costa Rica this year. These are described in more detail in the article *Teak Seed Exchange* in this report.

South African Conservation Parks Continue to Develop

After several years of severe fires in plantations and research trials in South Africa, and against a backdrop of potential corporate buy-outs and mergers within forest industry, in 2006 Camcore and its members made a decision to move genetic material to common holding areas called Conservation Parks. The strategy called for each tree population sampled by Camcore to be represented by minimum of 10 open-pollinated families that would be planted in quarter-hectare plots on two sites. Our goal was to conserve alleles with a frequency of 5% or greater in the base populations.

Each of the six South African Camcore members identified a 20 to 25 hectare area of land for the establishment of the Conservation Parks in different climatic/ecophysiological zones in the country. Each member was assigned the responsibility of protecting approximately 6 to 7 tree species. In the last two years, there has been great progress in the development of the Conservation Parks.

Komatiland Forests completed grafting on a large portion of the *P. oocarpa* provenances assigned to them. Unfortunately, a large percentage of the grafts were heavily browsed by deer, and some mortality occured. We discussed the option of field grafting onto 1 or 2-year-old rootstock grown in place in the park as a possible way to increase survival and make the trees less susceptible to browsing.

Hans Merensky successfully established a large number or *E. urophylla* seedlings in the Weza conservation park in late 2009. Sappi has also succesfully established most of the *E. urophylla* provenances assigned to them into the park in Zululand. The MTO park near their office in Stellenbosch is already generating positive publicity for the company and for Camcore. A field day with local officials was a big success (see back cover photo). PG Bison identified and secured an area for their conservation park in the Northeast Cape. It is well situated for visibility and good publicity, sitting directly across the highway from the PG Bison mill. Mondi has also located their park at the Mountain Home research station, and the site is prepared for planting. In in addition to being well located for public relations, it will be easy for research staff to keep a close eye on these valuable genetic resources.

There remains much to be done - the conservation of hundreds of provenances from 21 different species is a huge task. But the first steps have been taken, and we are on our way.

Julian Moreno Chan of PG Bison with rootstock of *P. patula* and *P. greggii* for grafting into the Camcore Conservation Park in NE Cape, South Africa

Reintroduction Studies in Mexico and Guatemala

In 2009, Camcore staff visited all of the reintroduction studies planted in Mexico and Guatemala. These studies are extremely important because 1) they reintroduce genes into areas where the natural forest does not exist anymore or is very deteriorated, 2) they allow a comparison of reintroduced trees and trees produced with local seeds, and 3) after the final measurement, the studies can be converted to seed production areas to be used as a seed source for reforestation projects in the country.

The oldest reintroduction study in the Camcore program is a *P. maximinoi* trial planted in Cobán, Alta Verapaz, Guatemala in 2004. Seeds were sent to the **National Institute of Forests in Guatemala (INAB),** and the trial was planted by Refinsa in an agreement with INAB. The seeds for this study were collected in Colombia from stands that were originally derived from seeds collected in the natural forests of Cobán, San Jerónimo and San Juan Sacatepequez (Guatemala), Marcala, Dulce Nombre de Copán and Tatumbla (Honduras), and La Cañada and San Jerónimo (Mexico). The five-year data from this trial are under analysis at Camcore.

In Mexico, the **Postgraduate School (Colpos)** planted two trials of *P. patula* in 2004, one in the state of Hidalgo at 2,200 meters above sea level and the other at 2,720 meters in the state of Puebla. The seeds for these studies were collected in Camcore trials in Colombia and South Africa from trees originating in the natural forest of the states of Hidalgo, Puebla, Veracruz, Tamaulipas, Guajaca, Querétaro, Tlaxcala and Guerrero (Mexico). The scientists at Colpos have managed the trials very well. A boron deficiency detected during the Camcore visit was to be corrected with the application of a fertilizer. The data from the five-year measurement of the trial will be sent to Camcore.

Colpos also planted a reintroduction trial of *P. greggii* var. *greggii* in the state of Guanajuato this year with seeds collected by Sappi in South Africa. The original seed used for the trials in South Africa was collected in the states of Nuevo León and Coahuila (Mexico). Three of the *P. greggii* families had been included in another genetic trial planted by the Antonio Narro Autonomous Agrarian University in Coahuila.

Through an agreement between INAB and **Grupo DeGuate** (an associate member of Camcore), several reintroduction studies were established in Guatemala in 2007 with seeds delivered by Camcore to INAB in 2006. The seeds were collected from Camcore trials in South Africa and Colombia. Grupo DeGuate planted one study of *P. tecunumanii* in La Lagunilla farm in the municipality of Jalapa, and two studies of *P. maximinoi*, one in Santa Anita farm in Cobán and another in Sacouyou farm in San Pedro Carchá. The original material of *P. tecunumanii* used for the Camcore studies in South Africa and Colombia had been collected in the natural forest in various departments of Guatemala: Quetzaltenango, El Quiché, Jalapa, El Progreso, Totonicapán, Alta Verapaz, Baja Verapaz, Zacapa and Petén. The original material of *P. maximinoi* had been collected in the departments of Alta Verapaz and Baja Verapaz. Grupo DeGuate is measuring the studies and will send the data to Camcore for statistical analyses.

FEDECOVERA is a federation of forestry cooperatives with land in Cobán, Guatemala. In an agreement with INAB, FEDECOVERA planted a reintroduction study of *P. maximinoi* at 1,400 meters above sea level with the same genetic material described above. The trial has been very well managed and the growth of the trees is excellent, with individuals reaching 3.9 meters height at 1.5 years of age.

A reintroduction trial of *P. maximinoi* (age 1½ years) established by FEDECOVERA in Coban, Guatemala. From left: Juan Lopéz, Geovani Hernandez, Francisco Escobedo, and Fernando Enríquez.

Genetic Structure of *Gmelina arborea*

In the 2007 Camcore annual report, we reported that Camcore and Temasek Life Sciences Laboratory (TLL), Singapore, were working together to assess the genetic structure of *Gmelina arborea* in natural stands in China, Thailand, Myanmar, and India. The microsatellite work, conducted by Professor Hong Yan and his team at TLL, used DNA from leaf samples collected in Camcore trials by Sumalindo (Indonesia) and Pizano (Colombia) and from seedlings grown in the greenhouse at NC State University by Camcore (USA). All together, 19 provenances and 534 trees were included in the study and assessed using 11 microsatellite markers. A cluster analysis indicated three relatively distinct groups: a) China, b) Thailand/Myanamar and c) India (Figure 1). A practical application that these results suggest is that Gmelina growers should include representatives from all three groups in breeding populations to maximize genetic diversity. A possible breeding strategy could include maintenance of each group in sublines for several generations before outcrossing to maximize outcrossing vigor. At Sumalindo, an open-pollinated orchard that contains 15 clones from Thailand selections and 10 clones from Costa Rica selections is exhibiting productivity gains of about 25% over local seed stand material.

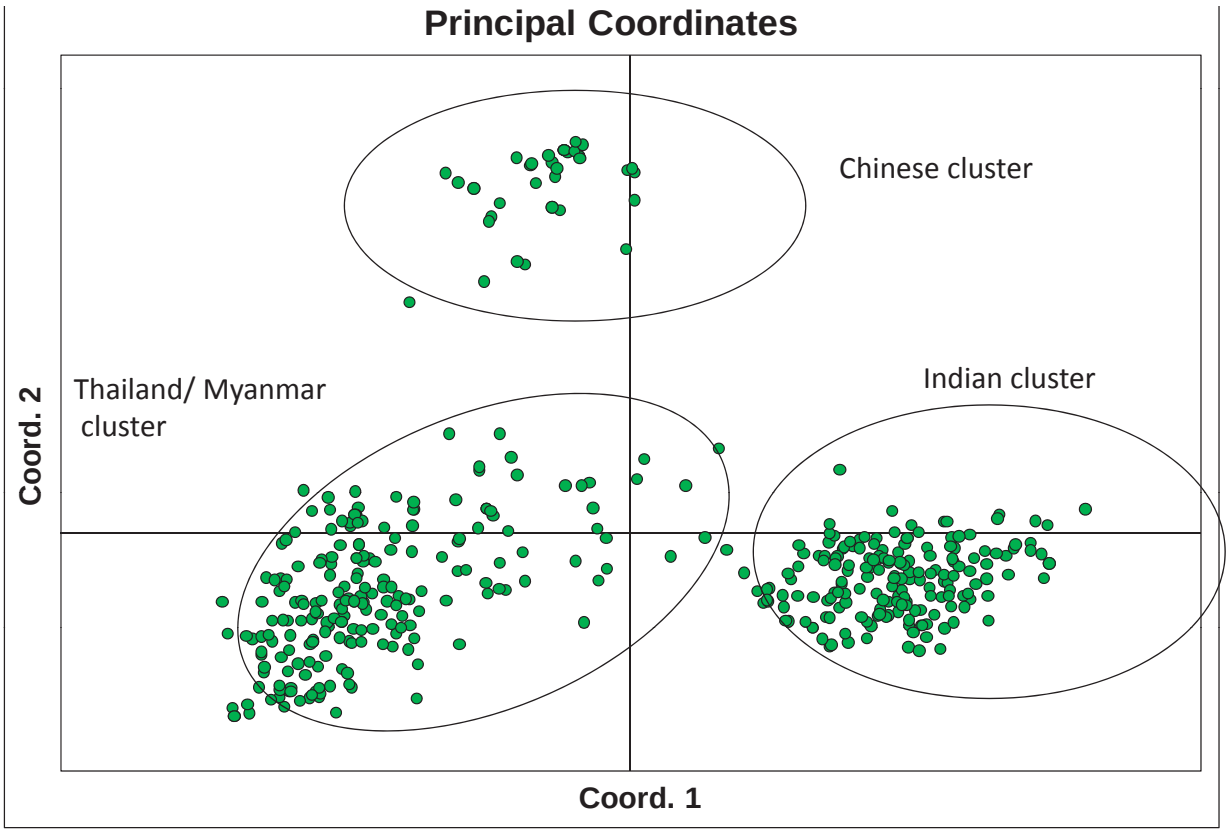


Figure 1. PCA (Principal Coordinate Analysis) indicates that the 534 Gmelina samples from 19 provenances are clustered into 3 distinct groups. (Figure courtesy of Prof. Hong, TLL).

Conservation of Hemlock Species in the Eastern US

Introduction

For the past seven years, Camcore has been working to conserve the genetic resources of Eastern and Carolina hemlocks *(Tsuga canadensis* and *T. caroliniana,* respectively*)*. These ecologically important species native to the eastern US are critically endangered due to attack by the exotic hemlock woolly adelgid *(Adelges tsugae).* This three-phase project, co-sponsored by the USDA Forest Service and Camcore, began in 2003 with the *ex situ* conservation of Carolina hemlock (Phase 1). In 2005, the program was expanded to include the conservation of Eastern hemlock from the southeastern US portion of its distribution (Phase 2).

Camcore has accomplished much during the first two phases of this important conservation effort, including seed collections from 232 families in 34 Eastern hemlock provenances and 126 families in 18 Carolina hemlock provenances, establishment of Carolina hemlock conservation banks in Chile and the US, and publication of 8 technical and peer-reviewed research publications on hemlock ecology, genetic diversity, and gene conservation. In total, Camcore has received $852,384 in grant funding from the USDA Forest Service to support the hemlock program. This includes $314,321 received in 2009 to fund the third phase, a 3-year effort to conserve the genetic resources of Eastern hemlock populations in the northeastern and Midwestern regions of the US (see text box for details).

2009 Seed Collections

In 2009 Camcore made seed collections from 40 families in 11 Eastern hemlock provenances and 31 families in 7 Carolina hemlock provenances (Table 2). This includes our first northeastern US seed source for Eastern hemlock from Cook Forest State Park in Pennsylvania. As always, we are indebted to our federal and state cooperators for helping to arrange collections. We would also like to thank Emily Woodall for providing access to the Mountain Lake Conservancy and Bill and Sherry Minnick for allowing Camcore to collect seeds from their property on Lake Toxaway.

Eastern Hemlock Genetic Diversity

Robert Jetton, Bill Dvorak, Andy Whittier (NCSU Camcore), and Valerie Hipkins (USDA Forest Service) continue work on their genetic diversity study in Eastern hemlock. This study is funded by a $47,500 grant awarded to Camcore in 2008 by the USDA Forest Service to utilize microsatellite (SSR) molecular markers to study the genetic structure and levels of diversity in Eastern hemlock populations distributed across the species' natural range in the eastern US and Canada. Population selection and foliage sample collection were coordinated by Camcore while sample preparation, laboratory analysis, and genotyping are being conducted by Dr. Hipkins and her staff at the USDA Forest Service National Forest Genetics Laboratory (NFGEL) in Placerville, CA. Data from this study

Camcore Receives a 5th Grant from the USDA Forest Service for Hemlock Gene Conservation

Camcore was awarded a $314,321 grant from the Forest Health Protection division of the USDA Forest Service to continue our gene conservation and genetic diversity program with hemlock *(Tsuga)* species native to the eastern US. The funding is for 3 years (2009-2012) with the goal of expanding our population explorations and seed collections for Eastern hemlock *(T. canadensis)* into the northeastern and Midwestern portions of the country. We will identify 60 populations in 17 states (Connecticut, Delaware, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin) and sample 10 mother trees per population for *ex situ* conservation. Our USDA Forest Service collaborators on this work are Rusty Rhea and Bradley Onken. Robert Jetton and Andy Whittier will lead the field work for Camcore.

Table 2. Summary of hemlock seed collections completed in the eastern United States in 2009.

Species	Provenance	State	Latitude	Longitude	No. Trees
Eastern Hemlock	Braley Pond	Virginia	38º 17' N	79º 18' W	3
	Cook Forest	Pennsylvania	41º 19' N	79º 12' W	2
	Guest River	Virginia	36º 55' N	82º 27' W	3
	Helton Creek	Georgia	34º 45' N	83º 54' W	1
	Hemlock Bluffs	North Carolina	35º 43' N	78º 47' W	3
	Jones Gap	South Carolina	35º 07' N	82º 34' W	4
	Kentland Farm	Virginia	37º 13' N	80º 34' W	4
	Mountain Lake	Virginia	37º 21' N	80º 32' W	10
	Todd Lake	Virginia	38º 22' N	79º 13' W	4
	Toxaway Lake	North Carolina	35º 08' N	82º 57' W	5
	Whiteside Mountain	North Carolina	35º 05' N	83º 08' W	1
Carolina Hemlock	Caesar's Head	South Carolina	35º 06' N	82º 38' W	4
	Carl Sandburg	North Carolina	35º 16' N	82º 27' W	6
	Hanging Rock	North Carolina	36º 24' N	80º 16' W	7
	Kentland Farm	Virginia	37º 13' N	80º 34' W	6
	Sinking Creek	Virginia	37º 21' N	80º 22' W	6
	Upper Whitewater Falls	North Carolina	35º 02' N	83º 01' W	1
	Whiteside Mountain	North Carolina	35º 05' N	83º 08' W	1

will be used to guide ongoing Eastern hemlock seed collections and design conservation plantings.

Foliage samples were collected from a total of 1,182 individual trees representing 61 Eastern hemlock populations for this study (Figure 2). Samples from 400 of the trees representing the 20 populations in the southeastern US were collected by Robert Jetton and Andy Whittier (Camcore) in 2006. Samples from the remaining 782 trees representing the 41 northeastern, Midwestern, and Canadian populations were collected in 2009 by Camcore and numerous federal and state cooperators to whom we owe a large debt of gratitude.

Laboratory work for the study is currently ongoing at the NFGEL. In total, 13 microsatellite loci are being used to describe Eastern hemlock's genetic structure. SSR data for all 13 loci have been generated for the 400-tree sample from the southeastern US, and, as of this report, SSR data for 4 loci have been compiled for the 782-tree sample from the northeast, Midwest, and Canada. We anticipate that the microsatellite analysis will be completed in April 2010 and that a final analysis and report will be ready for presentation at the Fifth Symposium on Hemlock Woolly Adelgid in the Eastern US to be held August 2010 in Asheville, NC.

Robert Jetton prepares to measure the diameter of an Eastern hemlock along the Wisconsin River at Council Grounds State Park, Wisconsin.

Raúl Schenone (BDP) and Gary Hodge (Camcore) with a 1½-year-old cutting of *P. tecunumanii* in Corrientes province of Argentina.

Ana Milena Salazar (Refocosta) inspects hedge plants of Teak in La Gloria nursery in Colombia.

Foresters with Bosques Arauco prepare to plant Camcore's first Carolina hemlock *(Tsuga caroliniana)* conservation bank in the Los Alamos zone of Chile.

Benson Kanyi (East Africa) in a eucalypt trial in Kenya.

Laercio Duda (Rigesa) and Gary Hodge (Camcore) in a 15-month-old hybrid trial in southern Brazil. On the left is *P. patula x P. elliottii* hybrid, and on the right is *P. taeda.*

Miguel Rodriguez looks at *Pachira quinata* and Gmelina arborea hedges in the new misthouse belonging to Pizano/Monterery Forestal (Colombia).

Vouranis Coetzee and Nico Olivier (Komatiland Forests) in a second-generation trial of *P. tecunumanii* in Sabie, South Africa.

Juan Schapovaloff and Monica Gelid (Alto Paraná) in the Camcore *P. taeda* GxE study in Misiones, Argentina.

Victor Manuel Castillo (FOMEX) stands beside a 3-year-old *P. patula* tree in a species trial in Michoacán, Mexico.

Elmer Gutiérrez working on a seed collection of Teak in Costa Rica in a 12-year-old plantation owned by Interforest, one of the companies with Grupo DeGuate.

Alba Rosales takes care of *P. caribaea* seedlings in Terranova's nursery for the establishment of second-generation progeny trials in eastern Venezuela.

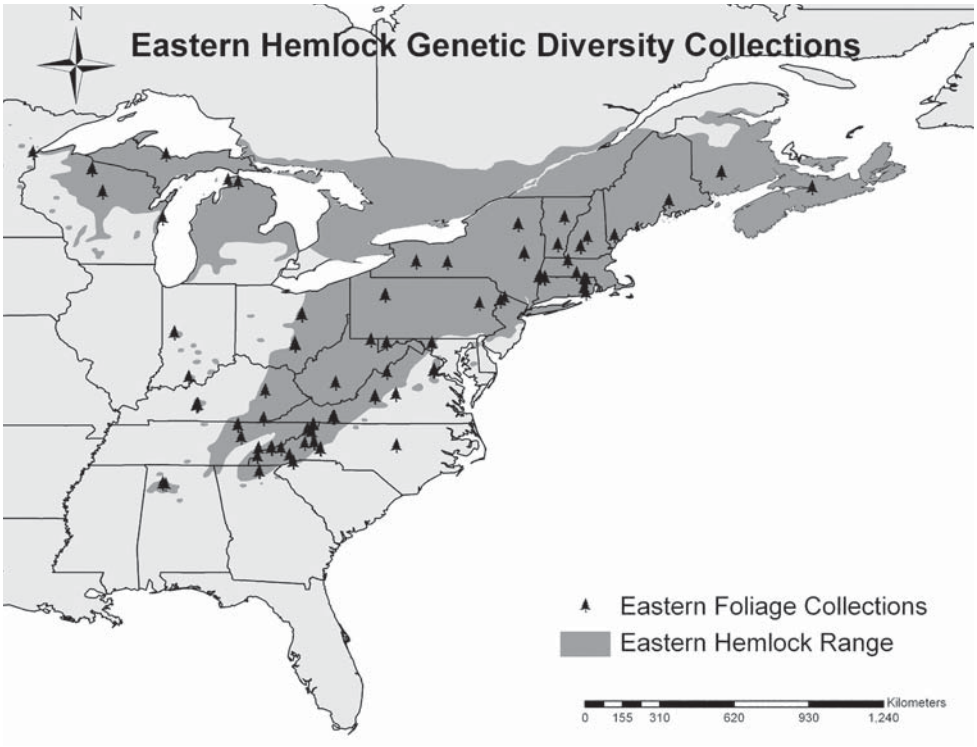


Figure 2. Map of foliage collection sites for the Eastern hemlock genetic diversity study.

Camcore Receives Funding from the USDA Forest Service for a New Project on Gene Conservation of Table Mountain Pine

Camcore was awarded a $48,563 grant from the US Forest Service National Forest System to start a new program on gene conservation of Table Mountain Pine (TMP, *Pinus pungens*). TMP is native to the Appalachian Mountains of the eastern US where its range extends from central Pennsylvania south to northern Georgia. It is threatened by wild-fire suppression programs and periodic attacks by the southern pine beetle *(Dendroctonus frontalis).* This funding is for three years (2009-2012) with the goal of collecting seeds from populations located on national forests in the 8 state area of Georgia, Maryland, Pennsylvania, Tennessee, Virginia, West Virginia, and North and South Carolina. *Ex situ* conservation banks will be established at locations around the southeastern US. Our USDA Forest Service collaborator on this project is Barbara Crane (Regional Geneticist for the National Forest System in the southeastern US). Robert Jetton and Andy Whittier will lead the field work for Camcore. We are still in the early planning stages for this project, and a more detailed program description and update will appear in the 2010 Camcore Annual Report.

Andy Whittier with a mature specimen of Table Mountain Pine at Hanging Rock in Stokes County, NC.

Progress in Tree Improvement

Throughout the program, the Camcore membership had a very good year in 2009 in the area of domestication and improvement. In addition to work on first- and second-generation progeny tests of Camcore species, the staff assisted members in various special projects and consultations regarding their internal tree improvement programs. Some of the advances in 2009 are summarized here.

Second-Generation Pine Breeding

Smurfit Kappa Cartón de Colombia (SKCC) was one of the original four members of Camcore when the program began in 1980. Because of this, SKCC has some of the oldest first-generation and second-generation progeny tests in the program. Currently some 5-year and some 8-year measurements are available from second-generation trials of *P. maximinoi, P. tecunumanii,* and *P. patula*. Comparisons of growth rates observed in first-generation progeny tests (containing unimproved material from native stand seed collections) and improved second-generation seed from seed orchards shows realized genetic gains ranging from 30 to 100% depending on species and elevation. These figures are really quite impressive, and they illustrate the importance of taking the Camcore species to the next generation of breeding. Dr. Bruce Zobel, one of the "founding fathers" of the science of forest genetics and tree improvement, always emphasized that when working with exotic species it was vital to develop a "landrace", a population selected in and adapted to the local environment. An introduced unimproved species may grow reasonably well, but perhaps may not be competitive with improved seed from the normal commercial species. But, as Dr. Zobel anticipated, the situation might change drastically after one cycle of selection. And in the case in Colombia, one cycle of selection produced a remarkable 30% to 100% faster growth. An alternative species might also offer advantages in areas like wood quality or disease resistance.

SKCC has made significant advances in getting improved material out into plantations. Their nursery expansion is complete and the current capacity is sufficient for 50,000 hedges. With 85 to 90% rooting, this is sufficient to plant about 1500 ha/year. The control crossing program in *P. tecunumanii* and *P. maximinoi* has produced about 3000 CP seed in both species. These full-sib families should eventually replace the current operation hedges in the nursery which are derived from OP seed, generating an additional 5 to 8% genetic gain for the company.

Good progress was made in second-generation testing in South Africa and southern Latin America. In South Africa in 2009, seed from 70 seed orchard families was distributed for second-generation tests of *P. patula.* Komatiland Forests and Hans Merensky planted their trials in 2009, and Sappi, Mondi and PG Bison will establish tests in 2010. In the future, other Camcore members Chikweti (Mozambique), Border Timbers (Zimbabwe), and East Africa will also plant tests with this material. Second-generation seed of *P. greggii* was collected by Mondi and PG Bison, and seed distribution and test establishment is scheduled for 2010.

We also saw impressive growth in the 13 second-generation tests of *P. tecunumanii* and *P. maximinoi* that were planted in South Africa in 2008. Even with unimproved material, these species have shown growth rates equal to or better than the commercial species used in many regions, and in the future they will have an increasing presence in plantations throughout southern Africa.

The South African Camcore members are also cooperating in the establishment of a country-wide series of species-site interaction trials. There will be 19 of these tests and they will include the best available genetic material of an array of species, including *P. taeda, P. elliottii, P. patula, P. maximinoi,* low- and high-elevation *P. tecunumanii,* northern and southern *P. greggii*, *P. radiata, P. pseudostrobus*, and the *P. elliottii x P. caribaea* hybrid. Seed has been distributed to HM, KLF, Sappi, Mondi, PG Bison, and the first tests were planted in November 2009, and all tests will be planted by end of 2010.

In southern Latin America, Camcore members in Brazil, Argentina, and Uruguay are planting second-generation progeny tests of four species: *P. maximinoi* (125 families), *P. patula* (85 families), *P. greggii* (51 families), and *P.*

Pinus taeda GxE Study in Southern Latin America

In 2006, Camcore coordinated the establishment of a large trial series designed to examine genotype x environment interaction (GxE) in *P. taeda.* Six organizations in Latin America and one in South Africa participated in the study. Each organization contributed 20 seed orchard families for a total of 140 families in the study. Each organization then planted two trials on sites selected to maximize environmental variability (climate and soils) across the whole experiment. Single-tree plot designs were used to maximize precision of family rankings so that we might better understand the environmental factors contributing to GxE in this species. All of the tests have received excellent management, have good survival, and are growing well. In 2009 and 2010, 3-year data from all tests will be available and will be analyzed for the first time.

Gary Hodge (Camcore) and Gleison dos Santos (Klabin) in a 2½-year-old *P. taeda* GxE trial in Paraná state, Brazil.

tecunumanii (13 families). Additional families of *P. tecunumanii* will be collected in 2010. Most of the seedlots for these trials are coming from seed production areas converted from Camcore progeny trials belonging to Klabin, and we offer many thanks to our friends at Klabin. Seed of all four species was received at Camcore in 2009, and will be distributed among the seven members.

There was also an exciting development regarding *P. caribaea* var. *hondurensis.* In 2009, we received seedlots of 38 second-generation families from PROFORCA (Venenzuela), a former Camcore member. PROFORCA has a productive *P. caribaea* seed orchard in northwestern Venezuela, and the 38 families we received were Camcore selections that were grafted into the PROFORCA orchard (along with many of their own plantation selections) in the late 1990s. These *P. caribaea* seedlots will be of great interest to current Camcore members such as Refocosta (Colombia), BDP and Alto Paraná (Argentina), KLF and Hans Merensky (South Africa), and others.

Other Species and Projects

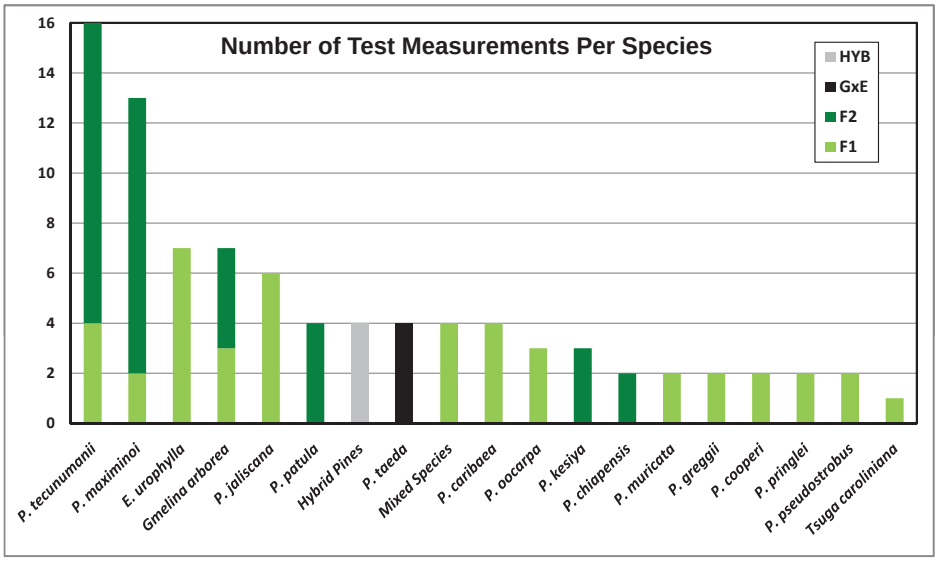
PG Bison joined the Camcore program in 2007. The company landbase is the large ex-Mondi afforestation project in the Northeast Cape region. Some selections had been made in progeny tests in this region and were included in the Camcore breeding populations. In 2009 we worked with the company to identify additional selections of *P. patula* and *P. greggii* in order to augment PG Bison's genetic base with selections specifically adapted to the NE Cape. PG Bison will certainly benefit most from these additional selections, but of course they are Camcore material and are available to the entire membership.

We continue to conduct special data analyses for members as time permits. In 2009, we completed BLUP analyses of the *E. grandis* elite population belonging to Hans Merensky, a large data set of *E. dunnii* for Stora Enso, a data set of 9 tests and 320 families of *P. caribaea* var. *hondurensis* belonging to KLF, and a clonal analysis of 8 plantings of *E. tereticornis* for Refocosta. Also, in 2009 we completed two special projects in the area of wood properties. One project was an assessment of wood properties of 426 increment cores of *P. radiata* for CMPC Forestal Mininco. This included lignin-cellulose assessments using the Camcore NIR model, pith-to-bark X-ray densitometry, and pith-to-bark MFA and MOE predictions using the Chile-specific NIR model developed in the Wood Properties Species Characterization Study. A second NIR project was done in conjunction with Sappi to predict lignin-cellulose content for 501 *P. patula* samples.

Test Measurements and Data Analysis

Members sent a total of 111 measurement data sets from 88 trials in the period from July 2007 to November 2009. There are more measurements than trials because we received data from multiple ages simultaneously for a number of tests. These trials are of 19 different species established in 7 countries by 13 members. These statistics are similar to previous years but there has been an important change in the types of trials that companies are measuring. This was the first year that we received growth data from the Camcore hybrid trials and from the loblolly pine G x E study. Furthermore, the number of second-generation trials (F2) measured made a big jump to 36, 41% of the total 88 trials.

The prominent species in the 2009 data were *Pinus tecunumanii* and *P. maximinoi*. These two species comprised a third of the measurements, most of which were from F2 trials in Colombia and South Africa. *Eucalyptus* and *Gmelina* were also frequent in the data, but much less so than in previous years since many of the trials of these fast-growing species have been "retired" from measurements after age 3 data was received. Also of note in this year's data, from Chile, is the first survival assessment of a hemlock *(Tsuga)* test.



Juvenile Age - Harvest Age Genetic Correlations in Pines

Juvenile-mature correlations are very important for tree breeders - we want to know that when we select at young ages, e.g., 1/3 or 1/2 rotation, we are identifying the genotypes that will produce the most wood at harvest age. Unfortunately, measurements at harvest age from well-maintained genetic trials are rare.

Growth measurements at ages 5, 8, and 15 years were available for 10 tests of three species *(P. maximinoi, P. tecunumanii, and P. patula)* belonging to Smurfit Kappa Cartón de Colombia. These data offered a valuable opportunity to estimate juvenile age - harvest age genetic correlations. Averaged over all 10 tests, the age-age genetic correlations were:

- r_g(5-8) = 0.93
- r_g(5-15) = 0.79
- r_g(8-15) = 0.86

Age 5-8 genetic correlations from many other Camcore trials are around 0.90 or higher, so these SKCC data are right in line with those results. The current data now show that age 5-15 and age 8-15 correlations are around 0.80 to 0.85. Since the heritibility is similar at the three ages, these values essentially mean that selection at age 5 or age 8 years will achieve approximately 80 to 85% of the genetic gain that would have been possible if selection were done at age 15 years. However, that gain is available in 1/2 to 1/3 of the time, making the genetic gain per unit of time much higher.

Teak Seed Exchange

During the Camcore annual meeting in Indonesia in 2008, it was decided to include Teak *(Tectona grandis)* as an official species of Camcore. There are currently 5 members of Camcore establishing commercial plantations of Teak: East Africa in Tanzania, Chikweti in Mozambique, Grupo DeGuate in Guatemala, Refocosta in Colombia and Sumalindo in Indonesia. The agreement among the companies was to collect one kilogram of seeds per tree from 20 selected trees in their plantations, genetic trials and/or seed orchards. In 2009, CSIRO Australia joined the program and decided to take part in the Teak seed exchange, providing seeds from Laos and Thailand. In 2009, these members made the seed collections and sent the material to Camcore in Raleigh (Table 3), where the fruits were cleaned and germination tests conducted.

From these seedlots, Camcore will send sufficient material to each company to establish two trials with the following objectives: 1) test the performance of approximately 150 families of different sources on sites in different countries, and 2) test the response of genotypes to several fertilization regimes under different environmental conditions. Trial establishment is planned for 2010.

Each trial will have 10 replicates, with 6-tree row-plots. After the first thinning, some fertilizer treatments will be applied to half of the replicates to assess the response of different genotypes to nutrient additions. Understanding how families vary in growth and response to different levels of resource availability should be a very important factor in forest management decisions. Camcore will send a trial design to participating members. The field tests will be measured at different ages, there will be at least two thinnings per trial, and a final evaluation will be done at 10 years of age.

Camcore will work with the members in their breeding program to make early selections at 5 years of age, and to establish multiple clonal trials on different sites.

Additional seed sources will come from new Teak companies joining the program and/or seed collections in natural stands. Camcore will also conduct research studies oriented to learn about the genetic architecture of the species, the heritability of important wood properties, and find more efficient ways to do breeding with the species. For example, Camcore was invited to take part in a Teak genetic diversity study to be conducted by the Danish government in 2010. The main objective of this study is understand the relationship between native populations in South East Asia and land races in Africa and Central America. Twenty-five populations from the natural distribution area in India, Thailand, Laos and Indonesia will be tested and compared to fourteen land races from Tanzania, Ghana, Ivory Coast, Costa Rica, Nicaragua and Panama. The study will require 30 trees per population. Camcore has offered to provide seeds of Teak populations from Guatemala, Colombia, Venezuela, Indonesia and Mozambique. From this study, we should learn interesting things about the level of genetic diversity present in the Camcore progeny trials. This is an exciting development for the Camcore program, and we look forward to many years of succesful research and breeding.

Table 3. Teak seed collections by Camcore members for seed exchange and testing

Member	Country	Collection sites	Trees
Refocosta	Colombia	Seed stand and seed orchard	20
Grupo DeGuate	Costa Rica	Twelve-year-old plantation	30
Grupo DeGuate	Guatemala	Seven- and ten-year-old plantations	40
East Africa	Tanzania	Seed stand, Provenance and Progeny trials	20
Chikweti	Mozambique	Commercial plantations	20
CSIRO	Australia	Seed orchard in Thailand and plantations in Laos	20
Sumalindo	Indonesia	Commercial plantations	28

Cold and Drought Tolerant Eucalypt Species Testing

In efforts to meet the needs of our members who have forest plantations in climatic zones where freezing temperatures and/or droughts occur, Camcore, in association with CSIRO (Australia), plans to establish a number of species/provenance/progeny trials to test relatively unknown eucalypts to determine their potential. The plantings will also serve as future conservation areas to ensure the protection of these species, most of which have very small geographic ranges in Australia. There are two specific projects planned: a) a progeny trial of *E. dorrigeonsis* and b) species/site trials of subtropical and temperate eucalypts and corymbias.

Eucalyptus dorrigeonsis is closely related to *E. benthamii* and probably crosses with it. Those interested in *E. benthamii* could use *E. dorrigoensis* to expand the genetic base of the species complex. *Eucalyptus dorrigoensis* has good cold hardiness and very acceptable wood properties. CSIRO is working with Camcore to provide approximately 40 open-pollinated families of the species. These will be tested in southern Brazil, Chile, Mexico, South Africa and Uruguay.

Gleison dos Santos (Klabin) stands next to a *E. dorrigoensis* tree established in a small plot in Santa Catarina state, Brazil. Camcore hopes to expand the genetic base of this potentially important species with its joint tree improvement project with CSIRO.

The species-site interaction trials will include a whole host of subtropical and temperate species (see table 4). Camcore members will look for marginal sites that are very cold or subject to drought or both. We hope to have approximately 20 trials established by the Camcore membership in southern Africa and South America. Even though good survival and growth are always important traits to assess, particular attention will be paid to disease and insect resistance and potential uses for bio-energy. Camcore/CSIRO will jointly publish on the results of these trials.

Table 4. Proposed list of obscure eucalypt species that Camcore/CSIRO will test to assess growth, cold and drought resistance, disease resistance, wood quality and bio-energy potential.

Temperate	
1	*E. benthamii*
2	*E. cladocalyx*
3	*E. leucoxylon*
4	*E. sideroxylon*
5	*E. tricarpa*
6	*E. occidentalis*
7	*E. badjensis*
8	*E. globulus ssp bicostata*
9	*E. microcarpa*
10	*Corymbia maculata*
Sub-Tropical	
1	*E. benthamii*
2	*E. longirostrata*
3	*E. major*
4	*E. argophloia*
5	*E. moluccana*
6	*E. cloeziana (Inland)*
7	*E. drepanophylla*
8	*E. siderophloia*
9	*E. crebra*
10	*E. dorrigoensis*
11	*E. raveretiana*
12	*E. thoetziana*
13	*Corymbia citriodora var variegata*

Somatic Embryogenesis of Camcore Pine Species

For many years, pine breeders have theorized about the potential benefits of clonal forestry. The economic advantages of being able to establish plantations of a particular genotype with proven superiority in growth rate, wood properties, disease resistance, and cold or drought tolerance would be substantial. However, clonal forestry with pines has never really developed. The limitation is that it is not possible to take cells from adult pine trees (in which we can precisely measure important traits) and generate new plants with all necessary root and shoot structures. Somatic embryogenesis (SE) is a vegetative propagation technique where normal vegetative plant cells (somatic cells) are induced to form embryogenic tissue which can be multiplied to form hundreds, thousands or millions of embryos. These embryos are all exact genetic duplicates or clones of the original plant, and can be germinated and grown more or less like normal seeds. With most pine species, this can only be done by starting with an embryo in a seed, which would also limit a breeder's ability to select genotypes with an outstanding combination of commercial traits. However, combined with the technique of cryopreservation (long term storage of biological tissue at temperatures of -196°C), pine breeders may be able to develop clonal plantations through the following four steps: 1) use SE to produce clonal lines, 2) cryopreserve some tissue from each line, 3) use some of the embryogenic tissue to test the clones in field trials, and 4) select the best clones and extract those from cryopreservation for commercial plantation establishment.

Around the world, there are a number of organizations developing and testing clones using SE for species like *Pinus taeda, P. radiata, Pseudotsuga menziesii* (Douglas fir), and *Picea alba* (white spruce). But because the technique is expensive and has a medium to long time frame for payoff, there has been little interest or investment in working on SE protocols for some of the Camcore species like *P. maximinoi* and *P. tecunumanii.* In 2009, Camcore took the first steps toward developing these 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, and the Advisory Board approved funding for a another project with Dr. Jerry Pullman of the Institute of Paper Science and Technology in Atlanta, Georgia. Both of these researchers are very well regarded scientists with a great deal of experience in SE of pines and other conifers.

Embryogenic tissue of *P. maximinoi* produced by Dr. Yill Sung Park of Natural Resources Canada.

The project with Dr. Park was initiated in August and September of 2009. Camcore members Klabin (Brazil) and Smurfit Kappa Cartón de Colombia (SKCC) provided plant material. Klabin research staff collected immature cones from 10 different mother trees of *P. maximinoi* in August and shipped those to Canada to begin the extraction of embryos. About a month later, the research staff of SKCC collected cones of both *P. maximinoi* and *P. tecunumanii* for shipment to Canada. With the first shipment of cones from Klabin, Dr. Park tested 10 different SE "recipes" using different combinations of chemicals and plant hormones. The initiation percentages ranged from 0 to 3.3% (mean = 1.4%), with the standard protocol in the lab (a modified Litvay medium, designated LPGR), giving 3.2% initiation (Table 5). The LPGR protocol was subsequently, the only medium used on the SKCC material.

With both the Klabin samples of *P. maximinoi* and the SKCC samples of both *P. maximinoi* and *P. tecunumanii,* there were large effects of maternal genotype. In the Klabin experiment, initiation by family ranged from 0% to 8.5% (Table 6). In the SKCC experiment, using only the LPGR me-

dium, *P. maximinoi* families had a mean initiation percentage of 8.5%, with a range from 0% to 32% (Table 7). The *P. tecunumanii* families from SKCC had a mean initiation percentage of 3.5%, and ranged from 0% to 11% initiation (Table 7). Overall, these iniation rates are quite acceptable, and we are very encouraged about the long-term prospects of SE with these species. Embryogenic tissue has been placed in cryopreservation, and subsequently removed to examine those steps of the SE process.

The project with Dr. Pullman of IPST should begin in 2010. This project will focus on the use of mature seed embryos for initiation, versus immature seed embryos which is typically used in pine SE. If successful, this approach would offer many logistical advantages, and circumvent the need to harvest developing immature cones in a very narrow time window.

Table 5. Mean embryogenic tissue initiation percentage for *P. maximinoi* on 9 different media. Immature cones collected in southern Brazil in August 16, 2009.

Protocol	Mean	St.Dev.
LPGR	3.2	6.5
LPGR+CPPU	1.1	3.2
LPGR+BRSS	0	0
1/2 LV	1.3	3.5
Pullman D.F.	0	0
LPGR+pic	2.1	5.8
LPGR+TDZ	0	0
LPGR 6 x PLC	3.3	6.2
Cedar media	1.4	3.6

Table 6. Mean embryogenic tissue initiation percentage for 10 *P. maximinoi* families (averaged across 9 different media). Immature cones collected in southern Brazil in August 16, 2009.

Species	Family	Mean	St.Dev
P. maximinoi	1	8.5	9.1
	2	3.3	6.2
	3	2.4	5.2
	4	1.5	3.7
	5	1.4	3.5
	6	0.8	2.7
	7	0.7	3.8
	8	0.4	2
	9	0	0
	10	0	0
	MEAN	**1.9%**	

Table 7. Mean embryogenic tissue initiation percentage for 19 *P. tecunumanii* families and 15 *P. maximinoi* families. Initiation medium was LPGR (a modifieid Litvay medium), and immature cones were collected in Colombia on Sept 17-18, 2009.

Species	Family	Mean	St.Dev
P. maximinoi	1	31.9	18.1
	2	20.2	14
	3	17.1	13.8
	4	10.4	7.1
	5	8.3	14.4
	6	7.5	9.6
	7	6.3	8.8
	8	5.7	7.9
	9	4.7	6.5
	10	4.0	5.5
	11	3.1	6.3
	12	1.9	5.6
	13	1.7	4.1
	14	0	0
	15	0	.
	MEAN	**8.2**	
P. tecunumanii	1	11.1	.
	2	10.9	12.8
	3	9.6	6
	4	9.6	10.2
	5	5.4	5.9
	6	4.8	7.4
	7	4.7	6.5
	8	3.5	5.5
	9	2.9	6.4
	10	2.1	5.1
	11	2.0	4.5
	12	0	0
	13	0	0
	14	0	0
	15	0	0
	16	0	0
	17	0	0
	18	0	0
	19	0	0
	MEAN	**3.5%**	

Frost Resistance -- How Quickly Do Species Adapt?

In the 2008 Camcore annual report, we reported on a cold hardiness study that was being conducted on a number of Mexican pines grown in the phytotron (environmentally controlled growth chambers) at NC State. Also included in that study were 6 different seed sources of *Pinus taeda* and 4 sources of *P. radiata.*

Our interest in testing so many different sources of *P. taeda* and *P. radiata* was to see how quickly they adapted to their new environment with respect to cold hardiness when no artificial selection pressure for this trait was placed on the populations in breeding programs. This information is important for two reasons. First, it gives us an indication of how fast trees might adapt to new environments as exotic species in a period when global climate fluctuations are being predicted for the future. Second, natural differences among seed sources in cold hardiness might influence our decisions on which ones to select for creating pine hybrids.

The origin of the *P. taeda* and *P. radiata* natural seed sources or land races used in the study are shown in Table 8. Seedlings were grown in the phytotron for 9 months using temperature and photoperiods found in Brazil and South Africa at approximately 25° S latitude. At 9 months, needles were removed from the seedlings and subjected to different freezing temperatures in the laboratory, and an injury index was calculated using the electrolyte leakage method. The relative rank in cold hardiness of the seed sources/land races is shown in Figures 3 and 4.

The results of the study with *P. radiata* indicate that the mainland populations of the species in California are more cold hardy than trees on Guadalupe Island, even though the island source is found at higher altitude than the mainland provenances. The fact that the island is surrounded by warmer water probably mitigates the severity and duration of freezing temperatures. The local Chilean source appears to be slightly more cold resistant than the California mainland sources. It is assumed that the majority of *P. radiata* plantations in Chile are derived from California populations.

The differences among the 6 *P. taeda* sources were more pronounced than for *P. radiata.* There were large differences in cold tolerance between the North Carolina and Florida sources, as expected. Sandwiched in between these were the sources of *P. taeda* planted as exotics. The *P. taeda* sources established in relatively warm subtropical areas at Aropoti, Brazil and the South African landrace

Table 8. Origin of the seed sources of *P. radiata* and *P. taeda* used in the cold hardiness study.

Species	Provenance-Region-Country	Original Provenance(s)	Latitude	Altitude (m)
P. radiata	California, US	Año Nuevo, Monterrey, Cambria, California	35° to 37° N	8-283
P. radiata	Guadalupe Island, Mexico	-----	28° to 29° N	275-800
P. radiata	Coastal, Chile	Various seed orchards in Chile	37° 28' S	30-150
P. taeda	Florida, USA	Seed orchard, Marion Co.	29° 39' N	46
P. taeda	South Africa	Various selections of unknown origin	25° 10' S	1200
P. taeda	Aropoti, PR, Brazil	Local selections in PR & SP States, Brazil	24° 08' S	845
P. taeda	Lages, SC, Brazil	South Africa and local sources in Brazil	27° 30' S	890
P. taeda	Misiones, Argentina	Central Florida	25° 41' S	54
*P. taeda**	Costal Plain, NC, USA	-----	35° 47' N	121

*seed source donated by the NC *P. taeda* tree improvement program, NC State University

grouped closer to the Florida material while those planted in more temperate regions in southern Brazil and northern Argentina grouped closer to the North Carolina material. It is apparent the absolute cold hardiness of *P. taeda* trees change with the environment in a relatively short time (one generation) after being relocated to a different climate. We are not sure if these differences in cold tolerance are biologically important when choosing hybrid parents. For this reason, plans are to develop a second study to determine how cold hardiness is inherited in pine hybrids (see text box *The Genetic Inheritance of Cold Hardiness in Pine Hybrids*).

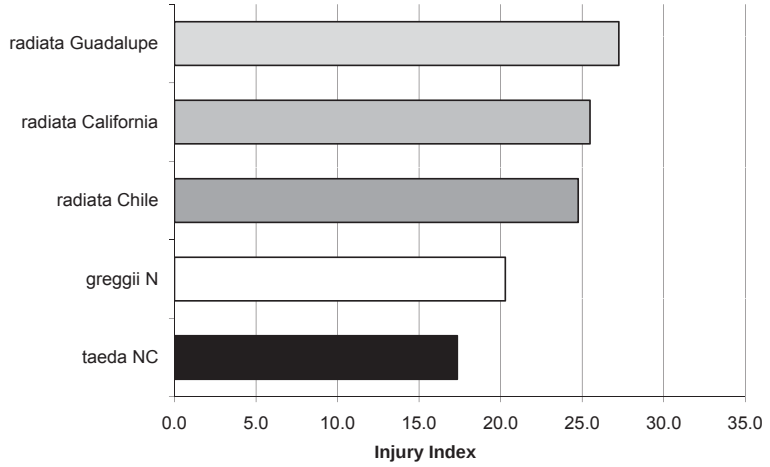


Figure 3. Cold hardiness injury index of 3 *P. radiata* sources and two control species at -21°C. The longer the bar, the greater the cold susceptibility.

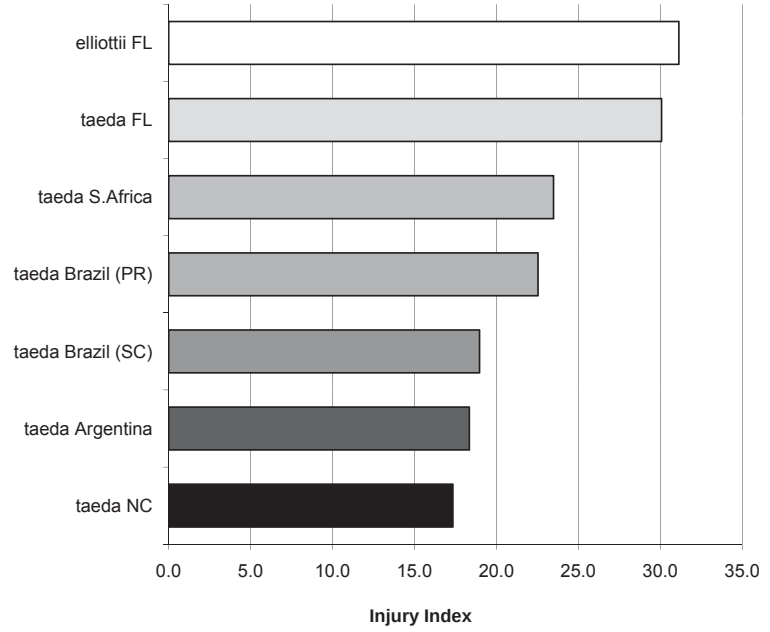


Figure 4. Cold hardiness injury index of 6 *P. taeda* sources and one control species at -21°C. The longer the bar, the greater the cold susceptibility.

The Genetic Inheritance of Cold Hardiness in Pine Hybrids

David Cerda Granados, a student from Nicaragua studying at NCSU with Camcore, will examine how cold hardiness is inherited in pine hybrids. Sappi (South Africa) will donate seeds from a 4 x 4 diallel cross of *P. patula x P. tecunumanii,* and this material will be grown in the phytotron at NC State under environmental conditions that reflect 25° S latitude. The parents of the hybrid crosses will also be included in the study. Komatiland Forests (South Africa) might also be able to contribute some seeds from their *P. patula x P. tecunumanii* crosses. The goal is to examine whether cold hardiness is an intermediate trait or tends more toward one parent. The actual cold assessment will be done in the Camcore seed and pollen laboratory using the electrolyte leakage method. In a second study, David will look at provenance variation in cold hardiness of *P. patula* populations.

Baseline Nutrient Determination

One of the four Camcore Working Groups is Species Characterization. Projects in this category are focused on increasing our knowledge about all aspects of the management and breeding of the species in our program. For many of our species, we have a portfolio of information on genetic resources, nursery and silvicultural management, and wood quality. In 2009, we began what will be multi-year effort to develop baseline information about nutrient requirements of important species, starting with *P. maximinoi* and *P. tecunumanii*.

The main objective of this study is to determine foliage and soil nutrient levels for stands of the target species that are healthy and growing well in various regions around the world. The idea is that this information will provide some idea of the minimum nutrient levels required for good plantation growth.

For each species, a number of sites in different countries or regions will be identified. At each site, soil samples and foliage samples from dominant and co-dominant trees will be taken. There will be four sample points per site, and at each sample point, foliage samples will be collected from 8 dominant or co-dominant trees. The foliage samples will be taken from the uppermost primary lateral branches (1/3 of the live crown), using needles from the first flush of the past season's growth (full year's complement of foliage).

Soil samples will also be taken at each sampling point in order to correlate the nutrient levels from the foliage and soil analyses. In order to reduce temporal variations, sampling will be confined to periods with low biological activity, e.g. winter or dry season.

Currently, samples of *P. tecunumanii* and *P. maximinoi* have been taken at sites belonging to Smurfit Kappa Cartón de Colombia and Komatiland Forests (South Africa). Additional sampling is planned for sites in Paraná state in Brazil on Klabin land.

Expected Outcomes

This project will provide important information about the nutrients required by *P. maximinoi* and *P. tecunumanii* for healthy growth in intensively managed plantations. This information should be useful to companies in site-species matching, and in determining the silvicultural management appropriate to maintain healthy plantations. The nutrient baseline may also help resolve possible nutrient problems in the future, and give some indication as to appropriate fertilizer applications and doses. The work with *P. tecunumanii* and *P. maximinoi* is expected to be completed by September 2010.

Needles from the first flush of the past season's growth will be sampled for the baseline nutrient study.

Results of the Flower and Cone Survey

Camcore conducted a survey to ascertain the flowering and cone maturation times of Mexican pine species growing in South America and southern Africa within its membership. Specifically, the goal was to determine if flowering and cone production periods in southern and eastern Africa were well synchronized with those in South America for the same species growing at similar latitudes and altitudes. Southern Africa experiences distinct wet and dry seasons while most of Latin America experiences precipitation that is evenly distributed through out the year. The information is important to optimize our cooperative breeding programs in the timing of pollen and cone collection.

Fifteen Camcore members participated in the survey. Results were obtained for 15 Mexican pines species, varieties, and subpopulations plus the commercial species of *P. taeda, P. elliottii* and *P. radiata.* The results indicated the following:

- Strong correlations in flowering and cone production times for a species were found between southern Latin America & southern Africa for temperate species like *P. taeda, P. elliottii* and *P. radiata;* moderate but useful correlations existed for species grown in the subtropics, and relatively poor correlations were exhibited for species grown in the tropics (see table 9).
- There were extended flowering periods for pine species in Africa with distinct wet and dry seasons versus more compacted flowering times in subtropical areas of Brazil where annual rainfall is more evenly distributed.
- Camcore still has limited information on some of the secondary and tertiary pines of economic potential either because of poor flower and cone production or insufficient observations.

The flower and cone survey will be amended annually as we obtain more information.

Table 9. Times for Flower production (F) and Cone harvest (C) for *Pinus patula.* Results from temperate regions are relatively stable across continents. Results for Mexico are for natural stands in the species geographic origin.

Country	Location	Lat.	Alt (m)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mexico	natural stands	20° 30' N	2000	F/C	F/C	F	F								C
Uganda	Mafuga	01° 45' N	2160		C						F	F			
Colombia	Peñas Negras	02° 15' N	2560							F/C	F/C	F/C			
Tanzania	Kihanga	08° 25' S	1820		F	F	F	C	C	C	C	F	F	F	
Tanzania	Matanana	08° 25' S	1400					C	C	F	F	F			
S.Africa	Sabie	25° 10' S	1120							C	C	F/C	F		
S.Africa	Sabie	25° 10' S	1120							C	C	F	F		
Brazil	Otacilio Costa	27° 30' S	890										F/C		
S.Africa	NE Cape	31° 14' S	1400						C	C	F	F			
S.Africa	De Rust	29° 01' S	1230						C	C	F	F			
S.Africa	Pine Woods	29° 39' S	1400						C	C	F	F			
Chile	Malven & SJ	37° 35' S	85										F	F/C	C

Camcore Members Compile List of Best Practices

In an effort to improve the quality of tree seedlings being planted in the field and subsequent maintenance, the Camcore membership agreed to share their best practices procedures. The genera being highlighted are *Pinus, Eucalyptus, Gmelina* and *Tectona.* A survey was created by the Camcore research team that includes six components: Species and Environment, Seedlings, Cuttings, Hedge Gardens, Site Preparation and Post Planting Practices. The information collected in the surveys will be summarized and presented to the membership at the 2010 annual meeting.

The survey highlights one of the best examples of why industrial programs like Camcore are important: by sharing information all of us have the opportunity to learn how to do things better.

Wood Properties Data Available on Camcore Data CD

In 2008, Camcore completed a multi-year project characterizing the wood properties of 20 pine species, varieties, and hybrids on 17 sites in Argentina, Brazil, Chile, Colombia, Venezuela, and South Africa. The project generated a tremendous amount of data on chemical properties and pith-to-bark profiles for density, microfibril angle, modulus of elasticty, and cell dimensions. The data has been presented at Annual Meetings in 2007 and 2008, and summarized in the 2008 Annual Report, but there is certainly more that could be learned with further in-depth analysis. The 2009 Camcore Data CD distributed to all active members contains data on all 3250 trees sampled in the study. The data is available in an Excel file with 12 different sheets listing all of the data for the different traits at the ring, tree, and site-species level. We hope that data will continue to provide valuable insights, and we look forward to learning more from company research teams!

Economic Benefits of Plantation Forestry to Small Rural Communities in Northern Mozambique

Braden Ramage, a graduate student at NC State is working with Camcore and its member Chikweti Forests to examine the economic benefits of plantation forestry near Lichinga in northern Mozambique. Most of the people in the area are poor subsistence farmers. The region is still recovering from the aftermath of a long civil war; it under-populated, and malaria is still one of the main causes of child mortality in the area. Chikweti Forests, a Swedish-based equity fund, leases land not used for agriculture from the communities and hires people in these same villages to plant trees and maintain the plantations. It plants 6000 ha of pines annually and employs over 2500 people from the local communities. Braden's MS thesis will try to quantify the benefits of plantation development to these small communities.

Progress in Hybrid Testing

The Camcore pine hybrid program continues to advance. Six new trials were planted in 2009 by members in Argentina and South Africa, reaching a total of 27 trials planted since 2007 (Table 10). For 2010, the estimate of new hybrid trials to be planted by the members is over 15. The rooted cuttings for these trials are already in production in the nurseries of the regional coordinators who are doing a wonderful job.

Several members sent data of the first trial measurements at 1 year of age to Camcore in Raleigh. KLF and Mondi in South Africa reported survival of 99% and 93% respectively. The survival of 2 trials in Rigesa, Brazil was 98 and 99%, while in Alto Paraná, Argentina, survival was 71%.

Camcore has verified the authenticity of 15 hybrid crosses using genetic markers in tests conducted in 2005 and 2007. At the beginning of 2010, Camcore will test 35 new crosses with SNP markers (see article *Species-Diagnostic SNPs for Hybrid Verification* in this report). The seeds of these crosses have been received from 7 members in Argentina, Chile, Colombia and South Africa during the last 2 years. More new field trials will be established with the cuttings produced from this genetic material in 2011 and 2012.

During 2009, several members continued making controlled crosses with mother trees of *P. taeda* in Argentina, Brazil and Uruguay, *P. radiata* in Chile and South Africa, *P. oocarpa* and *P. tecunumanii* in Colombia, and *P. patula* and *P. greggii* in South Africa. Pollen collections were done by Camcore from selected families of *P. tecunumanii* and *P. oocarpa* in the natural forests of Guatemala, and more collections will be done in 2010.

We appreciate the hard work and dedication of all the members who have invested valuable resources to make the hybrid tests a reality, with the expectation to find additional alternatives to the pure species. Great job!

Table 10. Establishment of pine hybrid trials by Camcore members

Region	Member	2007	2008	2009
Argentina	Bosques del Plata	1	1	0
	APSA	1	0	2
Brazil	Klabin	0	2	0
	Rigesa	2	0	0
	Masisa	0	2	0
Colombia	SKCC	3	0	0
Uruguay	Montes del Plata	0	0	0
	Weyerhaeuser	0	0	0
South Africa	Hans Merensky	0	1	1
	KLF	0	4	1
	Mondi	0	1	0
	MTO	0	1	1
	PG Bison	0	2	0
	Sappi	0	0	1
Zimbabwe	Border Timbers	0	0	0
Mozambique	Chikweti	0	0	0
Kenya, Tanzania, Uganda.	East Africa	0	0	0
Total		7	14	6

Wood, Pulp and Paper Properties of Hybrid Pines

During the annual meeting in Uruguay, funding was approved to test wood, pulp and paper properties of pine hybrids. As part of the Camcore's project on "Economics of Pine Hybrids", wood samples of *P. patula x P. tecunumanii, P. taeda x P. tecunumanii* and the parent species will be taken from trees in South Africa and shipped to Camcore in Raleigh. Wood density profile, chemical composition of wood, modulus of elasticity, modulus of rupture, pulp yield, fiber length, cell wall thickness, coarseness, caliper, basis weight, tensile strength and tear strength will be tested in the NCSU laboratory. Differences among some of these properties will be measured for juvenile and mature wood.

Species-Diagnostic SNPs for Hybrid Verification

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. Graduate student George Khan did much of the lab work and data analysis for the project under the supervision of principal investigators Drs. Ross Whetten and Gary Hodge.

A total of 16 species and varieties were included in the study. Seedlings of each species were grown and DNA samples were taken from a total of 576 trees, with 20 to 30 individuals representing the native range of each species. Nine genes were sequenced: three genes related to lignin synthesis, two related to water processing, and four related to signalling and cellular responses. PCR primers that amplify 300 to 400 base pair fragments for each of the eleven genes were developed. DNA from all 576 trees was processed by the Genome Sequencing Laboratory at NC State University. The sequence data was then visually inspected and cleaned, and a consensus sequence for each species identified. The data was then analyzed to find species-diagnostic SNP markers, i.e., uniform differences across all individuals sampled for the two species. For example, consider *P. taeda* and *P. greggii.* At a specific position of the Cad gene (a lignin-related gene), all *P. greggii* trees sampled have one specfic type (T) of the four possible nucleic acids (A, C, T, G). On the other hand, all *P. taeda* trees sampled carry a different nucleic acid (C). Any putative hybrid of *P. taeda* x *P. greggii* should carry both the T and C markers at that location, as it must inherit the T from the *P. greggii* parent, and the C from the *P. taeda* parent.

The results are summarized in Table 11. For each species pairing, the number of diagnostic SNP markers is enumerated. Across all possible species pairings (i.e., any possible hybrid combination), there were an average of 60 diagnostic SNP markers found. The maximum number of diagnostic markers was 119 for the pair of *P. oocarpa* and *P. pseudostrobus.* The minimum number of diagnostic markers found was 7, for the closely related *P. greggii* var. *greggii* and *P. greggii* var *australis* (the northern and southern varieties of the species, respectively). However, the next lowest number of diagnostic SNP markers was 25 between *P. maxi-*

Table 11. Number of species-diagnostic SNP markers for different *Pinus* species pairs found in 300 to 400 base-pair sequences from each of 9 different genes.

SNP Markers	herr	max	ell	pring	car	greg N	greg S	ooc	tec	pat	teo	tae	jal	leio	rad
herrerae															
maximinoi	25														
elliotti	42	47													
pringlei	47	58	68												
caribbaea	28	39	44	52											
greggii N	31	48	56	62	36										
greggii S	31	48	54	61	35	7									
oocarpa	45	56	66	75	49	42	44								
tecunumanii	36	54	66	73	43	39	43	42							
patula	44	54	59	69	46	34	37	35	39						
teocote	38	52	60	73	48	40	45	44	30	41					
taeda	46	53	58	65	40	38	43	52	42	44	39				
jaliscana	31	41	55	57	36	42	42	54	54	48	59	51			
leiophylla	66	78	78	82	64	65	67	84	82	73	74	63	41		
radiata	70	79	79	79	63	63	65	81	80	74	74	61	72	71	
pseudostrobus	113	115	118	116	97	98	103	119	117	110	114	101	101	94	83

minoi and *P. herrerae*. Even for the closely related species of *P. oocarpa* and *P. tecunumanii*, 42 diagnostic markers were found. Using other molecular marker methods such as RAPDs, it has been quite difficult to separate these two species, so this illustrates the power of the SNP marker methodology.

It now seems as though we have the ability to clearly identify pine hybrids. An immediate application of this technology will be to verify a set of 35 different putative hybrids made as part of the Camcore Hybrid Project in order to ship out a third set of pine hybrids for field testing in 2010 (see text box immediately below).

Optimatization of a SNP Marker System for Verification of Pine Hybrids

José Jimenez Madrigal is an MS student from Costa Rica here at NC State University on a Fulbright Fellowship. Jose will work with Camcore to use the newly identified SNP markers to verify a large set of 35 different putative pine hybrids. Since there are many potential markers and many hybrids, one goal of this project will be to select a combination of primers and markers that will give conclusive results for a low cost. There are a large number of interesting putative hybrids in this third set, including many with *P. taeda* that we have been unable to verify using isozyme markers. The schedule is for the verification to be completed and verified hybrid seedlots to be ready for shipment by mid-2010. Jose will aslo have a second phase of his MS research that will use the SNP makers to address a research question more in the area of population genetics or phylogenetics.

The Potential Use of NIR for Hybrid Verification

Near-infrared (NIR) spectroscopy is a rapid analytical technique that reduces laboratory time considerably when compared to conventional laboratory analysis techniques. Depending on the exact numbers and types of C-H, N-H and O-H bonds in the material being analyzed, the reflectance and absorption of different wavelenghts of near-infrared light can be used to determine chemical composition of the sample material. Camcore has some experience with NIR analysis, having used the methodology to predict important wood properties such as lignin and celluse content of woodmeal, and microfibril angle of increment core samples. NIR can also be used to classify samples into distinct groups; for example, in forestry, NIR has been used to discriminate between seedlings of *Eucalyptus globulus, E. nitens* and their hybrids (Humphreys et al., 2008), and between *Betula pendula* and *B. pubescens* and their hybrids (Atkinson et al., 1997).

Camcore has been working with both pine hybrids and NIR for a number of years, and the potential for developing a hybrid verification system using NIR is intriguing. Many members have NIR technology available to them, so a rapid and inexpensive method that could be used on site would have value to many members.

Based on these factors, Camcore conducted a preliminary study to determine if seedlings from different tropical pine species could be discriminated or distinguished from subtropical pine species using pine needles and near-infrared spectroscopy techniques.

Material and methods

The study was conducted on seedlings from 16 different pine species (Table 1) from tropical, subtropical and temperate regions which were raised in the greenhouse for a cold hardiness test established by Camcore in 2008. Five replicates of 5 seedlings of each species (one-year-old plants) were transplanted and placed randomly within each replicate in the green house. Foliage samples were collected from the 5 seedlings in each replicate for each species and were analyzed individually. The foliage samples were dried in a forced-air oven at 70°C until constant weight was achieved. The samples were ground, and then scanned with a FOSS 6500 spectrometer with wavelengths every 2 nm from 400 to 2500 nm.

Data analyses

The raw data (393 samples and 1050 wavelength variables) were transformed using Standard Normal Variation (SNV) and De-trend using Unscrambler software. The transformed data was processed using SAS PROC Discrim. Every possible species pair was examined, with 15 trees/species from three replicates used to develop an NIR classification model, and then 10 trees/species from two different replicates used as an independent verification data set to examine whether the model could correctly assign them to one of the two species.

Results and Discussion

Table 12 lists the the percentage of correct species classification for the independent data sets of some specific pairwise combinations for four selected species (*P. taeda, P. elliottii, P. tecunumanii* low elevation, and *P. caribaea* var. *hondurensis)*. To illustrate how to read the Table, consider the combination of *P. taeda* and *P. caribaea* var. *bahamensis* (the upper-left corner cell of the table). There were 10 *P. taeda* and 10 *P. caribaea* var. *bahamensis* seedlings in the independent data set. The value 90 indicates that 18 of 20 seedlings (90%) were given the correct species classification by the NIR model.

On average across all possible pairwise combinations, the NIR models correctly classified 95% of the seedlings in the independent data sets. This clearly indicates that NIR spectroscopy can be used to develop a species classification model, and suggests that perhaps models could be developed which would distinguish hybrids from both of their parental species.

Outlook

Application of this technique in an operational hybrid program will require further testing and refinements in the methodology. A number of research questions remain; for example, how robust are the NIR models for foliage samples produced at different ages, or under different growing regimes? Nevertheless, the use of NIR to distinguish pine hybrids from pure pine species is very promising. The next step will be to see if we can use NIR to distinguish differences in spectral signatures between specific pine hybrids and their parents.

Table 12. Percentage of correct species classification using NIR models. Classification models were developed for paired-species data sets with 15 trees of each species, and then tested on an independent data set with 10 trees of each species.

Species	*caribaea* var. bahamensis	*caribaea* var. *hondurensis*	*maximinoi*	*oocarpa*	*pseudostrobus*	*herrerae*	*leiophylla*	*radiata*	*elliottii*	*taeda*	*tecunumanii* (high elev.)	*tecunumanii* (low elev.)	*gregii* var. *greggii* (N)	*gregii* var. *australis* (S)	*patula* var. *patula*	*patula* var. *longipedunculata*	MEAN
taeda	90	100	90	95	100	80	100	100	90		95	95	85	100	95	90	94
elliottii	80	95	100	100	100	100	80	90		90	100	100	90	100	100	100	95
***tecunumanii* (low elev.)**	95	100	90	75	100	90	95	95	100	100	60		95	100	100	85	92
caribaea* var. *hondurensis	90		90	90	100	85	85	85	95	100	90	95	85	95	100	100	92

Shortcourses

Tree Improvement

Bill Dvorak, Gary Hodge and a group of senior researchers representing the Camcore membership in South Africa taught a two-week tree improvement shortcourse in South Africa, in June 2009. The shortcourse was organized by Mondi with technical and logistical support from Sappi and KLF. The course included 35 attendees from all 9 of the Camcore members in southern and eastern Africa.

The course was divided into two sections; the first week on pines and the second week on eucalypts. The pine section of the course was held in Pietermaritzburg and the eucalypt section was held near Kwambonombi. Representatives from FABI also gave two lectures on insect problems. In addition to lectures, there were several days of field visits to orchards, nurseries, and research trials.

One goal of the shortcourse was to train young professionals in tree improvement. Another objective was to give experienced management people some exposure to tree improvement practices. The short course was very well run by the organizers; we think it was an excellent experience for all the attendees.

Data Management

A record three sessions of the Camcore Data Management course were offered in 2009. A total of 39 participants representing 10 member companies from 5 countries attended one of the week-long courses to learn more about computers and genetic trial data management. Refocosta hosted one session in Bogotá, Colombia that had students from Refocosta, Pizano-Monterrey Forestal and Smurfit Kappa Cartón de Venezuela. Komatiland Forests and Sappi Forests hosted respective sessions in Sabie and Tweedie, South Africa. The students ranged in background and previous skill level but all worked hard at learning and improving skills in trial design and measurement; data coding, recording and validation; spreadsheet formulas, column filtering, and pivot tables; and general computer use, file management, and keyboard shortcuts. Advanced topics such as macro recording and Visual Basic editing were also introduced. The students listened to presentations and demonstrations by instructor Willi Woodbridge, but spent most of the time completing hands-on exercises in spreadsheets using actual measure-

Gathering for the Camcore/South Africa tree improvement shortcourse. There were approximately 35 attendees from the 9 African Camcore members in the region.

ments from Camcore trials. A few students had time to apply newly learned techniques to solve their own data management issues. The days were long, fast-paced, and mixed with frustration and accomplishment, but the participants remained motivated and professed to have learned much from the workshop. The work was so focused that a temporary power outage at one session did not stop the progress as the group crowded around the laptops that had remaining battery power.

Congratulations are due to the students who traveled from their posts in Colombia, Venezuela, South Africa, Mozambique, and Zimbabwe to attend the course. And thanks are due to the host members, Refocosta, Komatiland, and Sappi who provided the venue and organized the equipment for the courses, and also took care of the instructor during his pleasant visits.

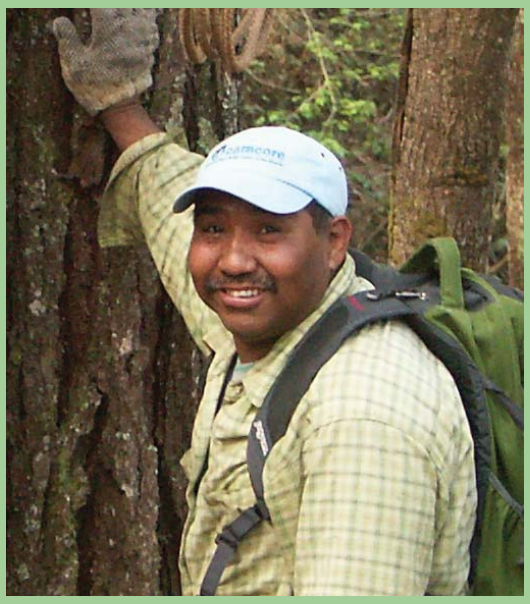
Willi Woodbridge works with Clement Thabethe of Komatiland during the course at Sabie.

Data Management Course participants at the three course locations: (from top to bottom) Refocosta's office in Bogotá, Colombia; Komatiland's Forest Industry Museum in Sabie, South Africa; Sappi's Shaw Research Center in Tweedie, South Africa.

Changes in Camcore

Mauro Gómez Retires from Camcore After 14 Years of Service

After 14 years working as a tree climber with Camcore in Central America, **Mauro Gómez** left the program in June of 2009. Mauro now has his own business in Guatemala selling clothes. We want to thank Mauro for all his hard work and dedication during his field trips with Elmer Gutiérrez to make seed collections in native stands of pines and hardwoods in Guatemala, Belize, Salvador, Nicaragua, Honduras and Costa Rica. We will always remember him with gratitude, and wish him all the best in the future.



Mauro at work!
Seed collections of *P. cariabea* in Honduras (left) and *P. tecunumanii* in Guatemala (right).

Mike Tighe, Seed & Pollen Lab. Manager for Camcore, left the program after working at NC State for 9 years. He and his family moved to the state of Oregon on the west coast to be closer to relatives. We very much appreciated Mike's contribution to Camcore and wish him and his family well as they start a new life on the west coast.

Jesús Espinoza was hired as the Tree Improvement Specialist at Camcore. Jesús is a native of Venezuela and worked for Smurfit Kappa Cartón de Venezuela for 14 years. He will assume some of the trial design work currently being handled by Gary Hodge. Jesús has also taken over the seed and pollen management responsibilities of Mike Tighe. We welcome Jesús to the Camcore research team.

Josué Cotzajay replaces Mauro Gomez as the tree climber in Guatemala. Josué worked on seed and pollen collections with Elmer during the second semester of the year. We welcome Josué as part of the Camcore team in Central America.

Glen Mitchell has left KLF to become the research manager at York Timbers in South Africa. Since York Timbers will join Camcore in 2010, Glen will continue to be involved with Camcore and will continue to assist us in the development of our technical programs.

Rebeca Sanhueza, eucalypt tree breeder for CMPC, has left her position with the company to work on her own. Rebeca was always a strong supporter of Camcore. We wish her well in her new job.

Juan José Acosta, tree breeder for Smurfit Kappa Cartón de Colombia has begun his graduate program at the University of Florida. Camcore wishes Juan José much success at graduate school.

Gert Van den Berg, eucalypt researcher, Sappi has moved to Mondi to work on the breeding of the tropical/subtropical eucalypts.

Raúl Pezzutti, Head of Silvicultural, Bosques del Plata returned to the company after being away for a year in Brazil taking classes for his Ph. D. program.

Graduate Programs and Training

Jesús Espinoza, Camcore Tree Improvement specialist, was awarded his Ph. D. degree at NC State University in January. His research topic was, "Genetic and nutrition effects on stem sinuosity in Loblolly pine". His thesis project was under the direction of Drs. Steve McKeand and Lee Allen.

David Cerda Granados, a Fulbright recipient from León, Nicaragua, began his studies with Camcore in August 2009. The proposed title of his MS Thesis will be "The Genetic Inheritance of Cold Hardiness in Pine Hybrids".

José Jimenez Madrigal, a Fulbright recipient from San José, Costa Rica, also began his studies with Camcore in autumn 2009. Even though his MS research has not been defined, it will contain some aspect of furthering our knowledge of how to best utilize SNP species-diagnostic markers for the assessment of pine hybrids.

Braden Ramage, from the west coast of the US, is a graduate student at NC State studying with Camcore. The title of his MS research is, "The economic benefits of plantation forestry to small rural communities in northern Mozambique" (see species characterization section). He will be traveling to Mozambique twice under the sponsorship of Chikweti Forests in 2010 to complete the data collection for his research project.

Juan Luis Lopez, Camcore Technical Supervisor, is continuing his Ph. D. research on "The economic value of pine hybrids". He is balancing his Camcore duties with the rigors of classes but hopes to complete his project in the next several years. Juan will be traveling to South Africa in 2010 to determine which pine hybrids to assess for his economic study. The project will involve some comprehensive wood analysis. Juan is studying under Dr. Robert Abt.

Publications and Papers

Dvorak, W. S. 2009. How Private Industry has met the Challenge of Conservation of Forest Genetic Resources of Tropical and Subtropical Tree Species. *International Technical Association of Tropical Timber* (ATIBT), Paris, France.

Dvorak, W.S., Potter, K.M., Hipkins, V.D., Hodge, G.R. 2009. Genetic Diversity and Gene Exchange in *Pinus oocarpa*, a Mesoamerican Pine with Resistance to the Pitch Canker Fungus *(Fusarium circinatum)*. *International Journal of Plant Sciences.* 170(5): 609-626

Espinoza, J.A. 2009. Genetic and Nutritional Effects on Stem Sinuosity in Loblolly Pine. PhD. Dissertation, NC State University, Raleigh, NC

Jarkko Koskela, Barbara Vinceti, William Dvorak, David Bush, Ian Dawson, Judy Loo, Erik Dahl Kjaer, Carlos Navarro, Cenon Padolina, Sándor Bordács, Ramni Jamnadass, Lars Graudal and Lolona Ramamonjisoa. 2009. The use and movement of forest genetic resources for food and agriculture. Preliminary report. FAO. Rome, Italy (in press)

Jetton, R.M., Dvorak, W.S., Potter, K.M., Whittier, W.A., Rhea, R. 2009. Genetics and Conservation of Hemlock Species Threatened by the Hemlock Woolly Adelgid. *Proceedings of the 30th Southern Forest Tree Improvement Conference.* (In press).

Jetton, R.M., Dvorak, W.S., Whittier, W.A., Potter, K.M., Rhea,R. 2009. Genetics and Conservation of Hemlock Species Threatened by the Hemlock Woolly Adelgid. *Proceedings of the 20th USDA Interagency Research Forum on Invasive Species.* (In press).

Jetton, R.M., Hastings, F.L., Hain, F.P. 2009. Arthropod Diversity Associated with Old and Secondary Growth Eastern hemlock *(Tsuga canadensis)* in the Great Smoky Mountains. *National Park Journal of the North Carolina Academy of Sciences.* 125(2): 70-77

Leibing, C., van Zonneveld, M., Jarvis A., Dvorak, W. 2009. Adaptation of tropical and subtropical pine plantation forestry to climate change: realignment of *Pinus patula* and *Pinus tecunumanii* genotypes to 2020 planting site climates. *Scandinavian Journal of Forest Research* 24:483-493.

Lopez, J., De La Torre, R., Cubbage, F. 2009. Effect of Land Prices, Transportation Costs, and Site Productivity on Timber Investment Returns for Pine Plantations in Colombia New Forests. Online: 16 pages.

Lopez, J., Gomide, J., Phillips, R. 2009. Influence of Eucalyptus Wood Properties on the Financial Performance of a Modeled Brazilian Pulp Mill. *O Papel.* Vol.70, num 07: 53-71.

Mullin, T.J., Andersson, B., Bastien, J.-C., Beaulieu, J., Burdon, R.D., Dvorak, W.S., King, J.N., Kondo, T., Krakowski, J., Lee, S.D., McKeand, S.E., Pâques, L., Raffin, A., Russell, J., Skrøppa, T., Stoehr, M., and Yanchuk, A.D. 2009. Economic importance, breeding objectives and achievements. Chapter 2. In: *Genomics of Conifers.* Edited by: C. Plomion and J. Bousquet. Volume in Genomics of Industrial Crops, Series editor: C. Kole. Science Publishers, Inc., New Hampshire; Edenbridge Ltd., UK. (submitted).

Zonneveld, M., Jarvis, A., Dvorak, W.S., Lema, G., Leibing, C. 2009. Climate Change Impact Predictions on *Pinus patula* and *Pinus tecunumanii* Populations in Mexico and Central America. *Forest Ecology and Management.* 257: 1566-1576.

Other Publications of Interest

Mitchell, G. 2010. Camcore protecting endangered populations of important forest species. *Wood SA & Timber Times.* South Africa, Jan. 2010, pp 8-9.

University Committees and Service

Bill Dvorak was asked by FAO/Bioversity to participate with other international authors to compile a paper on "The Use and Movement of Forest Genetic Resources for Food and Agriculture". The group of authors met at the headquarters of Bioversity, Rome, Italy to edit the work. Bill continued his work as Associate Editor for *Southern Forests* (South Africa). He reviewed scientific articles for *Silvae Genetica*, the *Native Plant Journal* and *New Forests.* He served on the International Committee in the Department of Forestry and Environmental Resources, NC State University. Bill taught his graduate level class on Tropical Forestry this autumn at the university.

Gary Hodge continued to serve as Associate Editor for the *Canadian Journal of Forest Research,* and reveiwed articles for *Tree Genomes and Genetics.* Gary also co-taught a graduate level course on Forest Quantitative Genetics Methods, and served on the Reappointment, Promotion and Tenure Committee and the International Committee in the NCSU Department of Forestry and Environmental Resources.

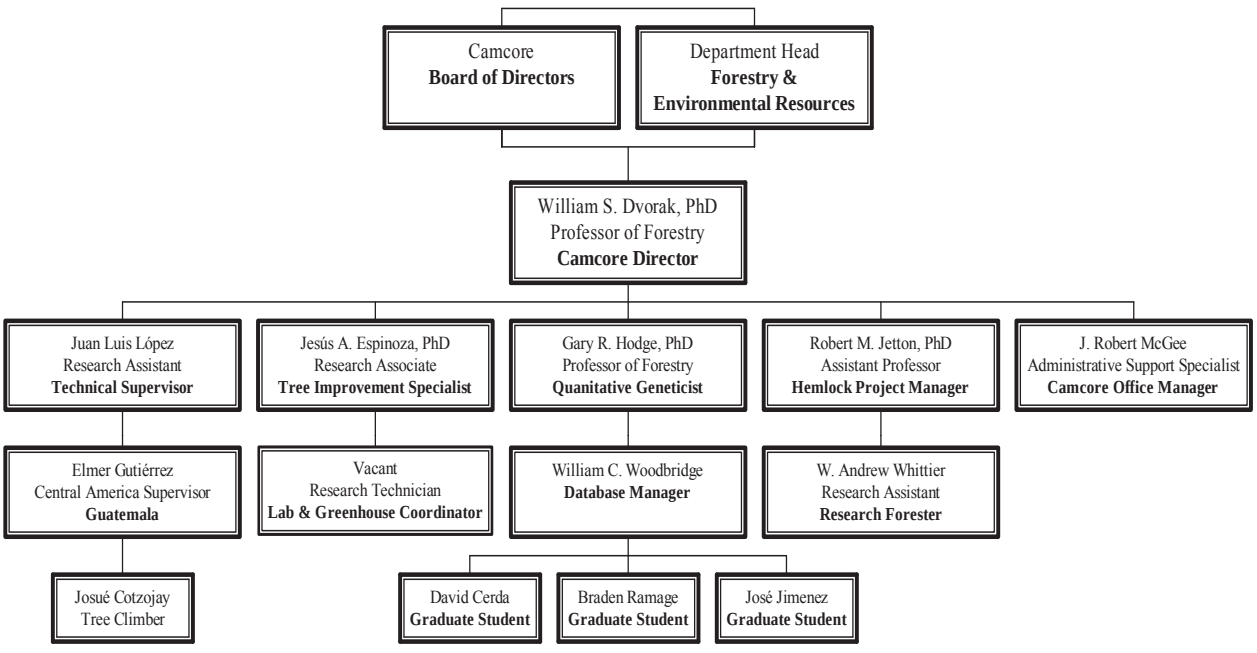
Robert Jetton served as reviewer for the Journal of Insect Science, and Steering Committee Member for the Hemlock Genetics Working Group with the USDA Forest Service.

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.

New Committee Members

Åsamaria Tham from Chikweti Forests was added to the technical committee and **Ricardo Paím** from Rigesa was named as an alternate when **Laercio Duda** (also from Rigesa) was not able to be present at the meetings.

Camcore Personnel



CAMCORE BOARDS AND COMMITTEES

The 2009 Camcore Advisory Board

Ricardo Austin, Alto Paraná, Argentina

Claudio Balocchi, Arauco Bioforest, Chile

Raúl Pezzutti/ Raúl Schenone, Bosques del Plata, Argentina

Åsamaria Tham, Chikweti Forests, Moçambique

Daniel Contesse, CMPC Forestal Mininco, Chile

Benson Kanyi, East Africa

Eric Gordillo López, Forestaciones Operativas de México

Botha Maree, HM Timbers, South Africa

Carlos José Mendes, Klabin, Brazil

Jan van der Sijde/ Nico Oliver, Komatiland Forests, South Africa

Germano Vieira, Masisa Brasil Empreendimentos Florestais, Brazil

Marius du Plessis, Mondi South Africa

Francisco Ferreira, Montes del Plata, Uruguay

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Miguel Rodríguez, Pizano Monterrey Forestal, Colombia

Mr. David, PT Sumalindo Lestari Jaya, Indonesia

José Romero, Reforestadora de la Costa, Colombia

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

Andrew Morris, Sappi Forests, South Africa

Rudolf Rhan, Smurfit Kappa Cartón de Colombia

Alberto Ramirez, Smurfit Kappa Cartón de Venezuela

José Quiariagua, Terranova de Venezuela

Robert Purnell, Weyerhaeuser Company, USA

The 2009 Camcore Associate Members

Jeremy Brawner, CSIRO, Australia

Héctor Hernández, Gobierno del Estado de Veracruz

Francisco Escobedo, Grupo DeGuate, Guatemala

Barbara S. Crane/ Rusty Rhea, USDA Forest Service

The 2009 Executive Committee

Chair: Andrew Morris, Sappi Forests, South Africa

Daniel Contesse, CMPC Forestal Mininco, Chile

Jan van der Sijde, Komatiland Forests, South Africa

Carlos José Mendes, Klabin, Brazil

Miguel Rodríguez, Pizano Monterrey Forestal, Colombia

Mr. David, PT Sumalindo Lestari Jaya, Indonesia

Rudolf Rahn, Smurfit Kappa Cartón de Colombia

Robert Purnell, Weyerhaeuser Company, USA

The 2009 Technical Committee

Chair: Claudio Balocchi, Arauco Bioforest, Chile

Bill Dvorak, Camcore, USA

Gary Hodge, Camcore, USA

Juan Luis López, Camcore, USA

Rebeca Sanhueza/ Veronica Emhart, CMPC Forestal Mininco, Chile

Ivone Satsuki Namikawa, Klabin PR, Brazil

Glen Mitchell, Komatiland Forests, South Africa

Mariana Schuckovski, Masisa Brasil Empreendimentos Florestais, Brazil

Laercio Duda, Rigesa-Mead Westvaco, Brazil

Arnulf Kanzler, Sappi Forests, South Africa

Byron Urrego, Smurfit Kappa Cartón de Colombia

Robert Purnell, Weyerhaeuser Company, USA

The 2009 Camcore Honorary Members

Hernán Ever Amaya, CENTA, El Salvador

Asdrubal Calderón, ESNACIFOR, Honduras

Josué Morales, INAB, Guatemala

Bernabé Caballero, INAFOR, Nicaragua

Pedro Brajcich Gallegos, INIFAP, México

Juan Alba, Instituto de Genética Forestal, México

Osmany Salas, Ministry of Natural Resources, Belize

College of Natural Resources, North Carolina State University

Robert Brown, Dean

Dan Robison, Associate Dean for Research

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

Group gathers to celebrate the establishment of the Camcore Conservation Park and Arbor Day with Camcore member MTO near Stellenbosch on the South African Cape. (Photo courtesy of MTO).